3. ECOSYSTEM PROCESSES

3.1. Hydrology and Hydrodynamics

3.1.1 Central Valley Streamflows

Introduction

Streamflow refers to the amount of fresh water flowing in rivers and Bay-Delta channels. Central Valley streamflows are a combination of natural surface water and groundwater discharges and managed releases from reservoirs. Streamflow varies seasonally and annually with rainfall, run-off, and water-supply management. The volume and distribution of water in the Bay-Delta and its watersheds support important ecological processes and functions. Human activities have had a significant influence on the natural streamflow patterns.

California is divided into hydrologic regions which reflect runoff and drainage basins. Three major hydrologic regions are contained within the ERPP Study Area: Sacramento River, San Joaquin River, and San Francisco Bay.

Streamflows in Central Valley watersheds are extremely variable. Total annual unimpaired streamflow into and through the Central Valley varies from a low of about 5 million acre-feet (MAF) to a high of about 38 MAF. Most of the flow occurs in December through June. A large part of the total flow volume comes during relatively short periods of time, caused either by rainfall or snowmelt.

Streamflow can be thought of as the life-blood of the tributary watersheds that link together to form the Sacramento and San Joaquin rivers. Groundwater and surface runoff generate flows into the stream networks in each tributary basin. Streamflow provides the geomorphic forces (energy and materials) needed to create and maintain stream channels and riparian corridors (floodplains). Streamflow controls the erosion, transport, and deposition of sediment in the stream channel and floodplain. Streamflow also transports and cleanses river gravels that support invertebrate production and fish spawning.

Natural flow patterns maintain natural sediment erosion, deposition, transport, and cleansing patterns, and thus natural stream channel and floodplain configurations. Reduced streamflow can lead to excessive sediment deposition in gravel beds and armoring the channel with cobble.

Streamflows transport nutrients, as well as dissolved and particulate organic material, from rivers upstream to the Delta and estuary. These materials are important to planktonic and benthic foodweb organisms. Streamflows maintain soil moisture and

transport seeds that contribute to the regeneration of riparian and riverine aquatic habitats.

Streamflow is needed to flood stream channel pools and riffles and riparian wetlands that provide habitat for fish and other wildlife. Flows transport fish eggs and larvae (e.g. striped bass, delta smelt) from spawning to nursery areas and may assist in the movement of juveniles from upstream spawning and rearing areas to the Delta (e.g. juvenile splittail and Chinook salmon).

The following are general ecological processes and functions sustained with natural streamflow patterns:

- Channel-forming processes create and sustain the pools, riffles, meanders, sand and gravel deposits, banks, side channels, and floodplain areas. These elements are the physical framework for the stream, wetland, riparian corridor, and floodplain habitats.
- Streamflow transports nutrients and organic materials to downstream aquatic habitats where they provide the necessary components for primary (plant) and secondary (bacterial and invertebrate) foodweb production. Transport processes also move larval and juvenile fish and other aquatic organisms to downstream rearing habitats.
- Filling and flooding of channel and floodplain areas at high streamflows provide aquatic, wetland, and riparian habitat and sustain botanical processes (i.e. seed dispersal, soil moisture replenishment) within the floodplain, flood bypass, and riparian stream corridor.

Applicable ERP Vision

The vision for Central Valley streamflows is to protect and enhance the ecological functions achieved through the physical and biological processes that operate within the stream channel and associated riparian and floodplain areas. This vision is to assist in the recovery of at-risk species, biotic communities, and overall health of the Bay-Delta.

Two strategic objectives for streamflows are, first, to establish hydrological regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities. A second objective is to create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

Stage 1 Expectations

Various Stage 1 expectations were identified for Central Valley streamflows. Studies were to be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains were to be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations were to be developed and instituted where feasible. Surveys were to have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel were to evaluate and consider flow regimes favorable for native fishes.

Changes Attributable to ERP

Central Valley streamflows was the primary focus of 18 ERP projects funded in Stage 1, totaling approximately $26.5 million (Table 1). A few of the key projects are described in more depth below.

Focused Action to Develop Ecologically-based Hydrologic Models and Water Management Strategies in the San Joaquin Basin (**ERP-00-B04**) was designed to identify flow regimes that have a widespread effect on the entire length of the San Joaquin River tributaries, Delta and San Francisco Bay through analysis and modeling of hydro-biologic issues and water management. The study states that enhancing instream flows need not require costly water purchases or complex regulation. But rather, changes in the reservoir operations can improve flow conditions without reducing water deliveries for water users (Cain et al 2003).

Environmentally beneficial flows can be achieved by reshaping long duration wet year events. Lowering reservoir levels in this manner increases the capacity to capture water is subsequent flood events and spillover is reduced. Re-operating reservoirs to enhance instream flows does, however, increase the risk that existing users will face a shortage under certain conditions. The authors suggest that programs to increase flows through reservoir re-operation should focus on minimizing risks to users through improved forecasting, projection, and compensation for the risk assumed, not the increased water release. The report also discussed groundwater banking as a promising strategy for reducing re-operating risks. The authors state that expanding floodway capacity and changing existing flood rules is critical. Overall, ERP-00-B04 demonstrated a range of methods for identifying the high flow regimes necessary to achieve ecological restoration objectives; identified and modeled integrated management strategies designed to achieve high flow restoration targets without creating water supply impacts in the SJ basin; and developed criteria for optimizing compensated water acquisitions to achieve hydrological restoration targets beyond those already evaluated.

Two projects titled *Real-Time Flow Monitoring* (**ERP-01-C02** and **ERP-04D-S07**) provided funds for continued operation and maintenance of flow monitoring stations on five Sacramento River tributaries (Antelope, Mill, Deer, Big Chico, and Butte Creeks). These stations provided data on minimum instream flows and water quality for the recovery of at-risk fish species in the creeks. The creeks have been significantly altered and recent restoration plans have identified the need to provide adequate base flows dedicated for instream use. Analysis of flows and diversions shows that the exercise of legal water rights often exceeds instream flows critical for spring-run salmon and steelhead migration. The goal was to this information to improve the recovery and long-term survival of spring-run Chinook salmon and steelhead in these creeks.

Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River (**ERP-02D-P61**) was designed to quantify the key aspects of a "naturalized' flow regime that are compatible with flood damage reduction, agriculture, diversions, storage and conveyance. The project was able to conduct workshops to develop hypotheses for ecosystem flow requirements and initiate field studies to reduce scientific uncertainties such as the relationship between flows and sediment transport; cottonwood root growth rates; fluvial geomorphic processes that create and maintain off-channel habitats; bank protection for habitat; meander migration model; and the extent of cottonwood recruitment. The project also developed a flow-sediment transport model and test criteria and designed future water related experiments and modeling plans.

Narrows 2 Powerplant Flow Bypass System Project (**ERP-02-P47**) provides a structural remedy to eliminate flow and temperature fluctuations from emergency and maintenance shutdowns at the Narrows 2 Hydropower Plant on the Yuba River by constructing a 3,000 cfs synchronous bypass system to maintain stable flow releases. Specific actions included: procuring large diameter hydraulic valves; constructing bypass and install valves; conducting power plant modifications and installing turbine shutoff valve at Narrows 2.

Project Summary Table

Table 1. Central Valley Streamflows Project Summary

Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-00-B04	**Focused Action to Develop Ecologically-based Hydrologic Models and Water Management Strategies in the San Joaquin Basin** Identified flow regimes that have a widespread effect on the entire length of the San Joaquin River tributaries, Delta and San Francisco Bay through analysis and modeling of hydro-biologic issues and water management.	3/30/2003	$295,925	Complete.

Table 1. Central Valley Streamflows Project Summary

Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-01-C02	**Real-Time Flow Monitoring** Provided funds for continued operation and maintenance of flow monitoring stations on five Sacramento River tributaries to provide data on minimum instream flows and water quality for the recovery of at-risk fish species in the creeks.	9/30/2005	$518,200	Complete.
ERP-01-N36	**Traveling Film Festival and Exhibition/San Joaquin River Oral History Film** Produced an oral history film to enhance public awareness and understanding of current and planned San Joaquin River restoration projects. Expanded the impact and reach of the "Traveling Film Festival & Exhibition" by booking additional screenings in the Bay Area and further east into the Central Valley through a unique collaboration with the California Council for the Humanities and produced a short film for television broadcast, the "San Joaquin River Oral History Film." Phase I was ERP-98-B31 and Phase II was ERP-99-B24.	12/30/2003	$310,642	Complete.
ERP-01-N39	**Adopt-A-Watershed Leadership Institute** Provided teacher training on environmental education and science focused on long-term restoration of the ecosystem; thus allowing teachers to provide classroom training/education for grades K-12.	9/30/2004	$616,734	Complete.
ERP-02D-P55	**Physical Modeling Experiments to Guide River Restoration Projects** Supported construction of a flume at the UC Richmond's Field Station. This flume is used in experiments regarding the potential effects of river restoration projects, especially spawning gravel augmentation projects, dam removals, and channel reconstruction projects. Data from these experiments can be used to test river restoration designs and evaluate their potential effects.	9/30/2007	$2,498,453	Complete.
ERP-02D-P61	**Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River** Seeks to quantify key aspects of a "naturalized' flow regime that are compatible with flood damage reduction, agriculture, diversions, storage and conveyance. (was ERP-02-P15-D)	3/31/2008	$1,571,438	Ongoing
ERP-02-P01	**Adopt-A-Watershed Leadership Development, Next Phase** Provided leadership development for 25 teams from the Sacramento River, San Joaquin River, and Delta regions, greater team support from two additional regional coordinators and implement new student and community outreach activities.	6/30/2006	$1,566,810	Complete.

Table 1. Central Valley Streamflows Project Summary

Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-02-P30	**Hydroclimatic Reconstruction and Ancient Blue Oak Mapping over the Drainage Basin of San Francisco Bay** Development of a high quality climate and hydrologic reconstructions up to 500 years using an unparalleled network of 50 tree-ring chronologies from moisture-sensitive blue oak trees in the drainage basin of the San Francisco Bay. Development of 50 moisture-sensitive tree-ring chronologies from ancient oaks, to reconstruct a suite of precipitation and hydrological variables, and to map ancient blue oak forests in the drainage basin of San Francisco Bay.	11/30/2008	$747,741	Ongoing
ERP-02-P47	**Narrows 2 Powerplant Flow Bypass System Project** A structural remedy to eliminate flow and temperature fluctuations from emergency and maintenance shutdowns at the Narrows 2 Hydropower Plant on the Yuba River by constructing a 3,000 cfs synchronous bypass system to maintain stable flow releases.	6/30/2008	$8,535,567	Complete.
ERP-04D-S06	**Juvenile Anadromous Salmonid Emigration Monitoring on the Sacramento River at the Glenn-Colusa Irrigation District (GCID) Fish Screen Bypass Channel** Continuation of a DFG juvenile salmonid monitoring site (screw trap).	4/1/2008	$90,072	Ongoing
ERP-04D-S07	**Real-Time Flow Monitoring** Operate and maintain 13 flow monitoring stations with temperature sensors.	9/30/2008	$330,000	Ongoing
ERP-98-B31	**Arrange, Publicize and Produce a Six-Film Environmental Festival and Exhibit Highlighting the Bay-Delta Environment** A three-part educational outreach project, which used the Independent Documentary Group's extensive film/video holdings about the Bay and Delta, its wildlife, habitats, urban/suburban threats, and restoration activities.	12/31/2001	$54,000	Complete.
ERP-98-E05	**Cottonwood Creek Watershed Group Formation** Created a comprehensive, community-based organization to develop and implement a watershed stewardship plan for the Cottonwood Creek Watershed. Project tasks included identifying the watershed's geographic boundaries, and sub-regions' boundaries, identifying stakeholders, determining the organization's structure, collecting input from stakeholders, researching literature from resource management agencies, and listing the watershed's needs.	12/31/2001	$161,000	Complete.
ERP-98-F15	**Lower Clear Creek Floodway Restoration Project (Phase II)** Improved salmon spawning and rearing habitat by implementing the Lower Clear Creek Watershed Management Plan and restoring 2.9 miles of floodplain and riverine aquatic habitat.	6/30/2006	$4,561,940	Complete.

Table 1. Central Valley Streamflows Project Summary

Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-99-B15	**Duncan/Long Canyon Paired - Watershed Project** Conducted a paired-watershed evaluation of watershed process and function in the very important high elevation headwater areas of the Sierra Nevada with the goal of improving the health of the upper American River.	6/30/2002	$83,600	Complete.
ERP-99-B24	**Arrange, Publicize and Produce a Six-Film Environmental Festival and Exhibit Highlighting the Bay-Delta Environment** A three-part educational outreach project, making use of the Independent Documentary Group's extensive film/video holdings about the Bay and Delta, its wildlife, habitats, urban/suburban threats, and restoration activities.	8/31/1999	$50,000	Complete.
ERP-99-B30	**Agreement for the Acquisition of Water Between the United States and the Oakdale and South San Joaquin Irrigation Districts** During water year 1999, US Bureau of Reclamation acquired up to fifty thousand (50,000) acre-feet of surplus water from the Oakdale Irrigation District and the South San Joaquin Irrigation District that the Districts made available to Reclamation upon notification of the Districts.	9/30/1999	$3,000,000	Complete.
ERP-99-N06	**Linked Hydrogeomorphic-Ecosystem Models to Support Adaptive Management - Cosumnes-Mokelumne Paired Basin Project** Collected long-term multidisciplinary, monitoring data to be used to develop ecologically based models to predict the combination of factors that will maximize ecosystem benefits in ways that are compatible with other water uses.	6/30/2003	$1,546,016	Complete.

Other Programs Contributing to ERP Vision

The vision for streamflow intends for ERP actions to complement other existing streamflow management programs. There are several environmental water management programs affecting Central Valley streamflows. Each program complements the others, while having differing goals and priorities due to specific authorization, purpose, and funding source. Several agencies are directly or indirectly responsible for streamflow management. Agencies with important streamflow management responsibilities and programs include:

- USACOE's flood control operations of reservoirs and management of flood control facilities (e.g. levees, overflow channels and bypass weirs);
- DWR programs to provide water supplies SWP, flood protection facilities, water quality monitoring, and multipurpose management of California water resources;
- USBR's operation of the CVP (and several other independent water projects in the Central Valley) to provide for multiple beneficial water uses, including fish and wildlife protection and habitat restoration (e.g. CVPIA);

- FERC regulation of minimum flows below hydropower projects;
- SWRCB administration of water rights for storage and diversions, including decisions about required instream flows for fish, water quality, and public trust resource protection;
- CDFG responsibility to study and recommend streamflows and temperature requirements for fish protection and propagation in streams and at hatcheries;
- USFWS and NMFS programs to recommend flows and other measures needed for mitigating impacts from federal projects and protecting endangered species, including the Anadromous Fish Restoration Program and the Water Management Program; and
- USGS water resources division programs to measure streamflow and water quality, providing the information necessary for adaptive management of streamflows. Their monitoring and modeling activities for Central Valley groundwater and Bay-Delta hydrodynamics are also important contributions to water resources management.

Streamflows in Central Valley streams are being addressed under several provisions of the CVPIA that offer sources of water for environmental purposes. The combined sources of water are to be managed under a Water Management Plan being developed for selected individual rivers under FERC licensing requirements, negotiated settlements between stakeholders and agencies, SWRCB water rights and water quality plans, and court ordered settlements such as that for the American River (Water Forum).

The EWA, one of the tools within the CALFED Water Management Strategy, was established to provide water for the protection and recovery of at-risk fish species beyond water available through existing regulatory actions related to the operations of the SWP and the CVP (CALFED 2000). The EWA has been focused on the ERP's objective to reduce adverse impacts of diversions at State and Federal pumps in the Delta (refer to the Stage 1 Milestone Report for an in-depth summary of EWA operations and the effects of the EWA on targeted species).

Sections 3406(b)(2) and 3406(b)(3) of the CVPIA provide water with the primary purpose of implementing fish restoration measures that contribute to doubling anadromous fish production. The so-called "(b)(2) water" has a secondary purpose of assisting in meeting the 1995 WQCP and post-1992 ESA requirements, including those affecting the Delta. Fish actions using (b)(2) water are implemented on Clear Creek, the Sacramento, American, and Stanislaus Rivers, in addition to the Delta. Pursuant to the CALFED ROD, (b)(2) water and VAMP, which gets its supplemental water from CVPIA section 3406(b)(3) (Water Acquisition Program), are considered part of the Tier 1 baseline level of protection provided by existing regulations and operational flexibility. Tier 2 is defined as the EWA assets combined with the benefits of the ERP.

The EWA, (b)(2) water, and WAP have integrated each year since 2001 to help implement the San Joaquin River Agreement (SJRA), a consensus-based approach to implementing the State Water Resources Control Board 1995 Water Quality Control Plan for the lower San Joaquin River and the Bay-Delta. VAMP is a key part of the SJRA and is designed to protect juvenile Chinook salmon migrating from the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) through the Delta, and to determine how salmon survival rates change in response to alterations in San Joaquin flows and SWP/CVP exports with the installation of the Head of Old River barrier (HORB). The VAMP provides for a 31-day pulse flow (target flow) in the San Joaquin River at Vernalis from approximately April 15 – May 15, along with a corresponding reduction in SWP/CVP exports, with the HORB in place. VAMP supplemental water releases are integrated and coordinated with releases of (b)(2) water on the Stanislaus River. While operating pursuant to VAMP, the EWA is used to implement SWP export curtailments beyond the CALFED ROD baseline and (b)(2) water is used to implement CVP export curtailments beyond the CVPIA baseline.

EWA fish actions are coordinated and integrated with other water management actions as well. For example, annually in October, the SJRA and the WAP release 15,000 AF of water on the Stanislaus River and 12,500 AF of water on the Merced River to improve upstream migration of adult Chinook salmon and increase available salmon spawning and egg incubation habitat. In fall 2001, the EWA and WAP river releases were integrated on the Merced River. The EWA and (b)(2) river releases were integrated on the American River in fall 2001 and 2002. The EWA is coordinated with SWP operations on the Feather River and EWA water has been acquired and released from the Yuba River each year. The EWA fish actions will continue to be integrated and coordinated with (b)(2) fish actions and VAMP implementation. All water management programs will consider additional opportunities for integration and coordination with the other environmental water management efforts and ERP restoration measures. Each integration and coordination opportunity is unique yet, in the context of the overall CALFED Program, contributes to the overall goal of ecosystem restoration.

The EWA was successful at assuring no uncompensated water costs to the projects' water users; however, CALFED's fish protection and restoration/recovery goals are not being met. Although EWA actions were expected to contribute to the recovery of at-risk fish species dependent on the Bay-Delta ecosystem, many of these species have declined in abundance in the past 5 years. It is apparent that the combination of regulatory requirements, ecosystem restoration, and water management actions carried out in recent years were not adequately addressing the needs of many species dependent on the Bay-Delta Estuary. Refer to the Stage 1 Milestone Report for an in-depth summary of EWA operations and the effects of the EWA on targeted species.

Status of Topic Today

Integrated water management actions, by the various responsible entities (e.g. USBR, CVPIA, VAMP, etc.), to provide water for environmental purposes will likely continue into the foreseeable. However, the continuing ecological issues in the Delta, including decline of Delta smelt and longfin smelt, among other species, is evidence that flow management in the Delta needs to be improved. In May, 2007, the USFWS and USBR agreed to reduce pumping to a minimum to protect Delta smelt, and filed a plan with U.S. District Court for the Eastern District of California for the immediate protection of the threatened Delta smelt at two major CVP export pumps in the south Delta. The other major export system, the SWP, also reduced pumping from the south Delta. In December 2007, the U.S. District Court (Judge Wanger) issued an interim order directing potential pumping limits and other actions to protect the delta smelt until a new biological opinion (BO) for the CVP Long-Term Operational Criteria and Plan (OCAP) could be completed by USFWS. The court found that the "OCAP BO is unlawful and inadequate," in part because it "does not provide a reasonable degree of certainty that mitigation measures will take place."

Several ERP contracts and funds from other sources (AFRP, Science Program, and the Watershed Program) were awarded to develop methodologies for evaluating delta flow and hydrodynamic patterns, needed to plan and conduct ecologically based restoration of Delta rivers and sloughs. This work included research on sedimentation, hydrodynamics/flow, floodplain dynamics, geomorphology, hydroclimate, shallow water habitat, and ecological processes (e.g. tidal action and productivity). Further synthesis of this work, including use of conceptual models, is needed to plan and implement ecologically based restoration actions.

Stream flows continue to be an important factor for ecosystem health and species recovery in the Delta and its tributaries. Historic flows are known and could be released or allowed to pass through the reservoirs, for example allowing a fall or early winter outflow that emulates the first "winter" rain through the Delta. This has not yet occurred because there has been little or no coordination with the agencies responsible for operating the reservoirs, nor has there been consideration of how, and if, lost storage or forgone power would be addressed.

Several ERP, AFRP, CVPIA, and Watershed Program contracts have, addressed inadequate instream flows within the Eastside Delta tributaries for steelhead and Chinook salmon. Construction projects directly contributed to improved instream flows on the Cosumnes River. Restoration of ecosystem processes along the Mokelumne River was funded through the Watershed Program. A UC Davis research and planning project on the Cosumnes-Mokelumne River Basins may provide the basis for developing and implementing a program to address inadequate flows for targeted fish species. Although considerable effort has gone into improving flows, a global plan has not been developed. A great deal of coordination among agencies and stakeholders is still

needed in order for this plan to progress. As the effect of hydrology on various species and processes becomes better understood, it will likely remain a relevant topic and high priority among many Delta-related efforts.

In the Sacramento Valley, projects were implemented that improved the scientific basis for flow-related actions, which in turn improves our ability to effectively manipulate and manage supplemental flows within the Sacramento Valley Region. Studies with mechanistic models continue to identify how the Sacramento River's current flow regime (i.e. the magnitude, timing, duration, and frequency of flow) and management actions (such as gravel augmentation and changes in bank armoring) influence habitats, species, and hydrogeomorphic processes in the riverine areas and riparian corridor. Additional research will support the development of ecologically-based plans to aid restoration of conditions in the rivers, sloughs and floodplains sufficient that will help restore Chinook salmon, steelhead, sturgeon, and splittail.

Instream flow studies were implemented that improved our understanding of the effects of flows and flow regimes on ecological and physical processes, especially their effects on fish populations in the Sacramento Valley. For example, projects were implemented on the Yuba River to eliminate or substantially reduce potentially catastrophic flow fluctuations and associated biological impacts on fish habitat for at-risk species in the lower Yuba River and to provide continuous release of cold water in Englebright Reservoir during such events. Conceptual proposals were developed for Clear Creek to assess the benefits that a flushing flow event would have on the floodplain, on instream habitat condition, and reactivating fluvial geomorphic processes lacking since the completion of Whiskeytown Dam in 1963. These processes are fundamental for creating and maintaining the habitats of the Clear Creek ecosystem for the support and recovery of aquatic and riparian species, particularly fall-run, late-fall-run and spring-run Chinook salmon, steelhead trout, resident salmonids and native floodplain vegetation.

A variety of projects were implemented to address this priority, with an emphasis on some of the major tributaries to the Sacramento River. SacEFT was also developed to facilitate the analysis of ecological tradeoffs associated with different suites of management actions. The Sacramento River Ecological Flows Study sought to identify how the river's flow regime (i.e. the magnitude, timing, duration, and frequency of flow) and management actions (such as gravel augmentation and changes in bank armoring) influence habitats, species, and hydrogeomorphic processes in the riparian corridor. The study distilled existing information and presented conceptual models and hypotheses about ecological flow needs in the Sacramento River. Field investigations and modeling applications were designed to address data gaps and refine estimates of ecological flow needs, including:

- gravel quality, mobilization, and routing;
- sediment deposition and terrestrialization of off-channel habitats;

- effects of natural and rip-rapped banks on aquatic habitat;
- a model to predict the flows required to create a chute cutoff;
- a refined meander migration model; and
- a sediment transport model.

Planning projects resulting in restoration implementation and watershed management plans have been completed for the Upper Yuba River, Lower Yuba River, and South Yuba River that have the potential to meet ERP Targets for Ecological Processes including Central Valley streamflows. Planning has been completed by the Yuba Watershed Council that will help guide restoration to meet Bear River Watershed ERP Targets for ecological processes habitats, and stressors.

In the upper American River Basin, the Auburn Ravine/Coon Creek Ecosystem Restoration Plan evaluated the Auburn Ravine, Coon Creek and Markham watersheds. If implemented, the plan is expected to contribute toward the ERP targets for streamflow, as well as coarse sediment supply, and riparian and riverine aquatic habitat. Several research and monitoring projects will assist in developing and implementing an ecologically based streamflow regulation plan for the American Basin creeks and lower American River, and assist in achieving temperature reduction targets for the lower American River below Nimbus Dam. Development of a River Corridor Management Plan (RCMP) for the Lower American River Project addressed streamflow, stream temperature, and riparian and riverine aquatic habitat.

As a result of Clear Creek Coordinated Resource Management Planning Group efforts and CVPIA directives to manage flows in the creek for the benefit of anadromous fish, increased minimum flows were achieved during the winter were largely responsible for the average four-fold increase in fall Chinook spawning escapement in Clear Creek over the baseline period. The benefit of increased summer flows for threatened spring-run Chinook and steelhead were demonstrated by rotary screw trap catches and snorkel counts of adult spawners and their redds. The current instream flow prescriptions for the creek, based on 1983 conditions, will be updated in the next few years to include temperature concerns, analysis of barriers to fish passage, recent developments in minimum flow setting methodology and changes in the stream channel that have been ongoing since Whiskeytown Dam was closed in 1963.

In the Sutter Bypass, construction has been completed on a new East-West Weir to provide fish passage and improved control of the water diversion in the East and West channels in the Sutter Bypass. In addition, Weir No. 5 has been rehabilitated to control the water level in the West Side Channel and regulate the downstream. Real-time flow monitoring projects in the lower Sutter Bypass, past and ongoing, provide data on minimum instream flows and water quality required for the recovery of at-risk fish species. These projects contribute valuable monitoring data to the vision for the Sutter Bypass which will provide a healthy streamflow pattern in the bypass and emulate the natural runoff pattern, with a late-winter/early-spring flow event and summer-fall base

flows that maintain important ecological processes, functions, habitats, and important species.

The Real-Time Flow Monitoring Project continues to support "real-time" operation and maintenance of flow monitoring stations on five Sacramento River tributaries to provide data on minimum instream flows and water quality for the recovery of spring-run Chinook salmon and Central Valley steelhead, and management of fall-run Chinook populations. Information obtained from this project has and will continue to improve the ability to identify, manage, and maintain adequate stream reach flows.

The ERP has not specifically addressed environmental water acquisition with funded projects in the Sacramento Valley. Projects are needed to: develop ecological and hydrodynamic modeling tools and conceptual models that describe ecological attributes, processes, habitats, and outflow/fish population relationships; develop ecological and biological criteria for water acquisitions; and evaluate previous water acquisition strategies and biological and ecological benefits.

In the San Joaquin Basin, salmon production continues to decline and better protection measures are needed through flow management. To help VAMP better determine the effects of providing periodic high flows, a model was developed to link salmon life history production more closely with flow magnitude and duration, and to evaluate the current flow objectives in the San Joaquin Basin Water Quality Plan. The model simulates fish production over time, under the assumption that flow is the primary factor in production. Results projected that increasing Vernalis flow magnitude, duration or frequency would all increase adult salmon production

Other modeling work on instream flows was done to assist the next phases of restoration on the Merced River. USFWS Instream Flow staff completed a PHABSIM and 2D modeling habitat study on the Robinson Reach that will be used to assess the benefits and or changes in rearing and spawning habitat as a result of the restoration project. Results of this work will be incorporated into the design of future studies.

On the Stanislaus and Tuolumne rivers, the number of smolt-sized Chinook salmon outmigrants was found to be highly correlated with flow magnitude between February and mid-June (Mesick et al. 2007). These results suggest that fry survival in the tributaries is highest during prolonged periods of flooding and that adult recruitment is highly dependent on fry survival in the tributaries. It is likely that there is better fry survival during prolonged flooding because there is increased autochthonous food resources, better refuge from predators, lower water temperatures particularly during downstream migrations in May and June, slower rate of disease infestation, dilution of contaminants, and reduced entrainment (Mesick et al. 2007). Some of these benefits, such as increased food resources and refuge from predators, could be provided by restoring highly productive floodplains that are inundated on an annual basis. However,

other benefits such as reduced water temperatures and contaminant dilution would probably depend on having high flows.

Evidence collected to date strongly suggests that elevated winter and spring flow levels in the Tuolumne River, over longer durations, improves survival of out-migrating juvenile Chinook salmon. Smolt out-migration abundance on the Tuolumne River occurs from most to least in the following patterns: 1) high winter and spring pulse flow magnitude and duration; 2) high winter flow magnitude and duration combined with low spring pulse flow magnitude and duration, or low winter pulse flow magnitude and duration combined with high spring pulse flow magnitude and duration; and 3) low winter and spring pulse flow magnitude and duration.

A rigorous research program is needed to test key hypotheses regarding flow management and restoration priorities, such as comparing effectiveness of increasing floodplain connectivity with the active channel and enhancing riparian forests, with effectiveness of ongoing mobilization of gravel to enhance spawning habitat

Planned Projects for Implementation

Future management of streamflows in the Delta will likely be significantly affected by development of the Bay-Delta Conservation Plan (BDCP). The BDCP could affect Delta-related streamflow through potential changes in water conveyance facilities and water operations; as well as the inclusion of conservation measures, such as adaptive habitat management, restoration, and enhancement. Species of initial focus of the BDCP include Central Valley steelhead, Chinook salmon, Delta smelt, green sturgeon, white sturgeon, splittail, and longfin smelt.

In the American Basin, projects should continue to be implemented to support ERP targets for streamflow, stream temperature, and restoration and enhancement of the lower American River corridor's aquatic and terrestrial ecosystems and flood-control systems. Maintaining suitable water temperatures and instream flows are the highest priority activities to improve conditions for steelhead, Chinook salmon, and possibly splittail, within the lower American River. The flow management plan being developed for the lower American River includes on-going collaborative efforts to develop flow ramping criteria, and to use these criteria during operations in order to reduce the adverse effects of flow fluctuations on lower American River fish resources. The updated flow management plan will also include a comprehensive monitoring and evaluation plan as part of the adaptive management process for both real-time and long-term management application.

With Phase 1 implementation of the Battle Creek Salmon and Steelhead Restoration Project, including enhanced instream flows, 31 miles of the total 42 miles of available habitat for anadromous fish populations will be improved and restored. Because the funding is only for Phase I of the project, additional funding will be needed to complete

Phase II of the Battle Creek Salmon and Steelhead Restoration Project. Once funding is secured for Phase II, including additional instream flows, an additional 11 miles of habitat will be available for anadromous fish populations.

In the San Joaquin River Region, projects are needed that increase streamflows, especially at critical times when juvenile salmonids are outmigrating, and include expanding floodplains along the river channel for rearing and spawning habitat. This conclusion is based on a number of factors, using the salmon population as the indicator to monitor the overall health of the entire system. Population numbers have continued to drop over the last ten years in spite of a steady influx of spawning gravel, spring VAMP flows, the filling of instream dredger mining pits, and revegetation efforts.

It is important in the San Joaquin Region to address natural and modified flow regimes to promote ecosystem functions and favorable biological responses. In particular, efforts are needed that augment or improve the scientific basis for flow-related actions and which improve our ability to effectively manipulate and supplement flows. Projects are needed to develop methods, including a combination of simulation models and physical measurements, to evaluate flow, sediment transport and other fluvial processes. Projects are also needed to conduct instream flow studies to improve our understanding of the effects of flows and flow regimes on ecological and physical processes, especially their effects on fish populations in the San Joaquin Valley. Ecologically-based stream flow and temperature management plans, including geomorphic and biological criteria for water acquisitions for the San Joaquin, Stanislaus, Merced, and Tuolumne Rivers, should be designed and implemented. The effects of managed flow fluctuations on ecosystem processes and habitat conditions, especially effects of flow fluctuations on anadromous fish habitat below dams, also need to be evaluated.

Impediments to implementation

Native habitats and species in the Bay-Delta ecosystem evolved in the context of a highly variable flow regime punctuated by extreme seasonal and inter-annual changes in flow. The construction of dams and the diversion of water from Bay-Delta tributaries and the Delta have reduced the variability of the flow regime, especially by reducing peak flows and altering Bay-Delta hydrodynamics. The decrease in the variability of the flow regime is one factor that may be contributing to the explosion of exotic and invasive species, so it is hypothesized that restoring variable flows will help create habitat conditions that favor native species. However, a completely natural flow regime for a river reach below a dam is not possible (because of human water demand) and may not even be desirable since the pre-dam sediment supply has been cut off. The desired conditions below every major dam are likely to be different, suggesting a need for experimental manipulations of flows, including moderate annual floodflows, and habitat to find the right combination of factors that will maximize ecosystem benefits or

assist endangered species in ways that are compatible with other uses of water and river corridors (CALFED 2000b).

Although the historical pattern of natural streamflows can be used as a guideline for establishing streamflow targets, the actual management of flows for each tributary or river segment will require coordination with all agencies and stakeholders. Conflicting interests and priorities will most likely be the rule rather than the exception. Streamflow targets will be developed within the existing multipurpose water resource management framework for each watershed.

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3. ECOSYSTEM PROCESSES

3.1. Hydrology and Hydrodynamics

3.1.2. Bay Delta Hydrodynamics

Introduction

Bay-Delta hydrodynamics refers to the direction and velocity of flows in the Bay-Delta channels on a temporal, tidal, and seasonal basis for a given hydrological condition. The direction and velocity of flows and their distribution in time and location help define the extent to which the Bay-Delta can support important ecological functions such as sustaining a productive food web, providing spawning, rearing, and feeding habitat for estuarine and anadromous fish, and supporting migration of adult and juvenile fish. Human activities such as reduced Delta inflow, exports from the Delta, and conversion of tidal wetlands have had a large influence on the natural hydrological regime of the Bay-Delta. There are opportunities to restore or simulate, where and when appropriate, a more natural hydrological regime that sustains ecological functions and meets the life requirements of the fish and wildlife in or dependent on the Bay-Delta.

The Delta of today is greatly altered from its historical condition. Historically, a complex, dendritic array of channels drained extensive marsh plains. Now, these channels have been replaced by a greatly simplified network of uniform channels. The Delta waterways generally contain fresh water, with brief incursions of slightly brackish water into the northern and western Delta. This incursion is more pronounced during the spring and early summers of very dry years when the highly regulated discharge from the Sacramento and San Joaquin rivers are low. This differs from the natural pattern in which brackish water intrusion naturally occurred in late summer and early fall.

Beginning in the mid 1800s the Delta has been subject to the effects of alteration of the natural seasonal patterns of river discharge, Delta morphology, and tidal prism. These factors interact to determine water movement patterns and salinity distribution in the Delta. Salinity levels in Delta waters are primarily a result of tidal prism and stage, and net Delta outflow. It is also influenced by prevailing wind direction and velocity. Daily tidal cycles result in flows in the lower San Joaquin River of up to 300,000 to 400,000 cfs, and the spring-neap cycle alters water surface elevations and salinity levels on a monthly basis.

Other factors that now contribute to alteration or moderation of historic flow patterns in Delta waterways and channels include operation of the CVP/SWP pumping plants in the south Delta, the Suisun Marsh Salinity Control Structure, the Delta Cross Channel

(DCC), and a temporary flow barrier on the San Joaquin River at the head of Old River. The DCC and Old River Barrier affect flow rates, direction, and water surface elevations. At times, these factors contribute to the creation of unnatural flow patterns which are particularly evident in the channels of the southern and central Delta.

Hydrodynamic processes are an extremely important aspect of the Bay-Delta system and refer to the seasonal and daily direction and velocity of flows in Bay-Delta channels. The direction and velocity of flow and their distribution in time and location are important factors in habitat preferences of Bay-Delta organisms, erosion and sedimentation processes, migratory cues for organisms, and many other ecological processes and functions in the Bay-Delta.

Flow conditions in Delta channels affect foodweb production, transport of organisms through the Delta, and vulnerability to entrainment in south Delta pumping plant diversions. The Bay-Delta estuary provides important fish spawning, rearing, and migrating habitats. The Bay-Delta also serves as an important link in nutrient cycling and provides for high levels of primary (plant) productivity that supplies the aquatic foodweb.

Hydrodynamic patterns in the Delta are important to the survival of delta smelt, longfin smelt, striped bass, Chinook salmon, and other fish dependent on the Sacramento-San Joaquin Delta. Unfavorable hydrodynamic conditions, such as net flow moving south to Delta export facilities instead of moving west toward Suisun Bay, reduce fish survival. Improved hydrodynamic patterns will increase residence times of Delta water; provide more natural downstream flows; and improve rearing and spawning habitat, nutrient cycling, and foodweb integrity.

Applicable ERP Vision

The vision for hydrological processes in the Sacramento-San Joaquin Delta is to restore channel hydrodynamics to conditions more like those that occurred during the mid-1960s to provide migratory cues for aquatic species; transport flows for eggs, larvae, and juvenile fish; and transport of sediments and nutrients.

Stage 1 Expectations

Stage 1 expectations included implementation of actions to restore or simulate a more natural hydrodynamic regime in the February through June period. Actions were to include modifications to Delta inflow patterns and export operations during that period as well as restoration of tidal action to areas within the Bay-Delta. Studies on the factors affecting the abundance of key organisms were to have been ongoing, and a basic understanding of how effective the water operations measures have been for the

at-risk species with continued exports from the south Delta were to be developed and used to assess the need for a dual conveyance facility and to implement other strategies for their recovery.

Changes Attributable to ERP

A final report for *Juvenile Salmon Migratory Behavior Study in the North Central and South Delta* (**ERP-01-N48**) was developed in electronic format, including detailed data compiled and summarized during the study. The study demonstrated how radio-tagged salmon respond to flood and ebb tides, where fish migrated within the Delta channels, the degree of variability in migratory behavior of individual tagged fish, and predation on radio-tagged salmon. Schooling or shoaling behavior was not observed among radio-tagged fish during the three separate experiments. There were some regions in the Delta where predation appears to be higher than other regions. It was evident most of the fish utilized the middle portion of the channels for their migratory pathway. It could not be determined how some fish ultimately migrated downstream overtime, given that they moved such large distances back and forth with the ebb and flood tides in the lower Sacramento and San Joaquin River. It was clear that radio-tagged salmon did not specifically "hold in position" on flood tides and migrate on ebb tides; fish moved back and forth large distances (miles) on both ebb and flood tides. Because fish were commonly found migrating with the prevailing tidal flow direction in mid channel, there were no obvious "micro-habitat" characteristics to indicate how the fish migrated in a net downstream direction within three to four days. These experiments could not explain why some fish moved off the mainstem San Joaquin River into south Delta channels. Due to the wide variation in hydrological conditions during the two central Delta studies, it was difficult to determine the principal factors affecting fish migration. Based on limited data from the study, it may be that a combination of a neap tide, reduced exports, and increased San Joaquin River flows is beneficial for outmigrating smolts, but more research is necessary. The final report for the project provided numerous recommendations for additional research to build on findings from this field study. Of particular interest is an evaluation of how fish are diverted at key Delta channels and flow splits through concurrent measurements of fish movements and flow structure using recently-developed equipment and analytical techniques.

Several studies relating flow to dissolved oxygen have been conducted (**ERP-01-N61-06**, **ERP-01-C61-1-D**, **ERP-01-N61-01**, **ERP-01-N61-02**, **ERP-01-N61-03**, **ERP-01-N61-04**, **ERP-01-N61-05**, **ERP-02-C04-D**, **ERP-02D-P50**, **ERP-02D-P51**). For a synthesis of these projects refer to section 5.8.1 (Dissolved Oxygen) of this report.

Abundance or survival of several estuarine biological populations in the San Francisco Estuary is positively related to freshwater flow. The relationships have been described in terms of 'X2', the location of the 2 psu (practical salinity units) isohaline. X2 forms

an important basis for management of the estuary using a salinity standard. Meeting the standard can at times require releasing substantial quantities of water stored in reservoirs. Also the realized benefits of the salinity standard are not always clear. *Determining the Mechanisms Relating Freshwater Flow and Abundance of Estuarine Biota (the "Fish-X2" relationships) Phase I* (**ERP-02-P19**) is phase I of a research program to elucidate the mechanisms underlying the fish-X2 relationships. This project is in the process of developing a plan for the research, modeling, and monitoring, identifying responsible parties, timing dependencies, funding, and additional requirements or opportunities. The ultimate purpose is to contribute to the understanding of the factors that control the distribution and abundance of estuarine species, how these factors vary with X2, and how the factors might change in the future.

Effects of Climate Variability and Change on the Vegetation and Hydrology of the Bay-Delta Watershed (**ERP-02-P38**) is assessing the role of vegetation in shaping the watershed's hydrological response to climate variability and global climate change. Application of model and satellite data is ongoing. Output from the hydrology-vegetation model will be analyzed as per the project proposal (examining drought and wet spells, as well as future climate variability). The results will be used to portray the response of the combined vegetation hydrology system to climate variability and change.

The overall objectives of *Transport, Transformation and Effects of Selenium and Carbon in the Delta of the Sacramento-San Joaquin Rivers: Implications for Ecosystem Restoration* (**ERP-01-C07**) were to use newly developed approaches to determine, under a variety of conditions, how the Delta system transports and distributes conservative materials delivered from the rivers; evaluate transformations of Se and C in the Delta - within a transport context - and their consequent distributions; and determine how transport and transformation of Se will affect critical food webs in the Delta and the Bay. The outcome of the project has many applications to the Delta, including long-contentious Se issues. Delta-scale, and local-scale physical, geochemical and ecological models will be produced to help evaluate solutions to these issues.

Two-Dimensional Detailed Hydraulic Model for Determining Flood Conveyance Impacts of Ecosystem Restoration Projects in the Yolo Bypass (**ERP-02-C04-D**), proposed by the Department of Water Resources, created a hydrological model that can be used to evaluate the impact of habitat restoration projects and other alterations of the Yolo Bypass.

The objective of *Shallow Open Water Habitats: Hydrodynamics and Benthic Grazing* (**ERP-02-P22**) was to develop a detailed view of how tides and wind-generated waves determine the physical structure and hydrodynamics of shallow estuarine waters, and how these physical processes can act to constrain net primary production through their effects on grazing and light. Field experiments were carried out in the shallows of

Grizzly Bay and in Franks Tract. Measurements were made of turbulence, flows, salinities, temperatures, sediment concentration, and chlorophyll concentrations for a series of intensive sampling periods. The aims of these experiments are to quantify the rate of benthic grazing as a function of bivalve density and physical conditions, and to quantify the effects of waves on shallow water flows, mixing and sediments. Synthesis of these observations will provide information to estuarine scientists and managers for assessing the effects of grazers, like Portamocorbula and Corbicula, on the estuarine foodweb, and for the evaluating the effects of restoration activities on shallow water habitat.

The research project, *Hydroclimatic Reconstruction and Ancient Blue Oak Mapping over the Drainage Basin of San Francisco Bay* (**ERP-02-P30**) will develop 500 year hydroclimatic models based upon ancient blue oak tree-ring chronologies and the blue oak's present distribution. Understanding effects of future climate change is dependent upon understanding effects of past climate change. The purpose of this project is to develop 50 moisture-sensitive tree-ring chronologies from ancient oaks, to reconstruct a suite of precipitation and hydrological variables, and to map ancient blue oak forests in the drainage basin of San Francisco Bay. This research is mutli-regional and will provide accurate long-term data on the natural hydrodynamics of the Sacramento, San Joaquin, Delta/Eastside Tributaries, and Bay regions of CALFED. This project will provide data on the inter-annual to decadal variability of precipitation and streamflow across the entire CALFED region. Empirical data on extreme low-flow conditions in various streams over the past several centuries will be produced that will assist in the development of conceptual models of community dynamics for salmonids and other at-risk species.

Habitat Restoration/Flood Control Bypasses System (**ERP-98-A02**) evaluated restoration needs and opportunities to improve habitat, reduce stranding and improve connectivity with the Sacramento River and the north Delta. Elements evaluated include: improving existing habitats and stream flows within the bypasses and their associated sloughs; improve wetland, riparian, slough, agricultural, and SRA habitats; eliminating fish barriers; reducing fish entrainment and stranding; developing wildlife and fisheries friendly levee maintenance programs; developing consensus based plans by implementing pilot projects; developing information on compatibility with ecology; and developing information on bypass characteristics for improvement plans.

Steelhead and Chinook Salmon Fish Passage Barrier Remediation on the Guadalupe River (**ERP-98-B23**) helped improve fish passage for steelhead and Chinook salmon on the Guadalupe River allowing enhanced access to the upper river region. Remediation of fish passage barriers occurred at the Hillsdale Avenue Weir and the San Jose Water Company's low-flow crossing. These two structures have been identified as impediments to the upstream migration of salmon and steelhead, restricting access to suitable spawning and juvenile-rearing areas located further upstream within the

Guadalupe River and its tributaries. The proposed scope of work for this project will be completed in four phases: project planning, permitting, construction, and monitoring.

Lastly, several acquisition projects (**ERP-00-F06, ERP-01-C04, ERP-97-B03, ERP-02D-P54, ERP-98-F23**) were funded that will indirectly affect hydrology.

Project Summary Table

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
CVPIA-01-F01	**Narrows 2 Hydro Power Plant Flow Bypass System Design** Engineering Final Design produced for a synchronous full flow bypass at the existing Narrows II Power House. Environmental Documentation appropriate for this project was also conducted.	9/30/2002	$299,606	Complete.
CVPIA-01-F07	**Merced River Water Temperature Management Feasibility Study** Feasibility study and Phase I effort to compile existing information as a first step in development of a potential comprehensive water temperature management plan for the lower Merced River.	12/31/2003	$45,000	Complete.
CVPIA-01-F14	**Tuolumne River Mining Reach Restoration No 3 - Warner-Deardorff Segment** Completed the design engineering started under the MJ Ruddy Project, engineering for the ROW acquisition, and the pre-project monitoring for the Warner-Deardorff segment of the Tuolumne River Mining Reach project.	12/31/2005	$518,670	Complete.
ERP-00-B04	**Focused Action to Develop Ecologically-based Hydrologic Models and Water Management Strategies in the San Joaquin Basin** Identified flow regimes that have a widespread effect on the entire length of the San Joaquin River tributaries, Delta and San Francisco Bay through analysis and modeling of hydro-biologic issues and water management.	3/30/2003	$295,925	Complete.
ERP-00-B05	**Adaptive Real-Time Water Quality Management of Seasonal Wetlands in the Grassland Water District** Provided monitoring, modeling and adaptive management of field operations, in cooperation with the currently funded CALFED San Joaquin River Real-Time Water Quality Management Project, to coordinate seasonal wetland drainage with the assimilative capacity of the San Joaquin River for salinity.	6/30/2004	$697,330	Complete.
ERP-00-F04	**A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin** Identified the physical and biological mechanisms affecting establishment of riparian vegetation, in particular Fremont cottonwood and willow communities in the San Joaquin Basin, in order to identify the most cost-effective strategies and sites for riparian protection and restoration.	3/31/2006	$293,532	Complete.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-00-F06	**Liberty Island Acquisition** Acquired fee title interest in the remaining two privately-owned properties on Liberty Island, estimated at 449 acres; and to conduct restoration of tidal shallow water habitat, tidal emergent wetlands, and seasonal wetlands for aquatic and terrestrial species.	9/30/2007	$2,625,153	The remaining inholdings have not been acquired and there is no plan for restoration. The long term ownership and management is still under negotiation.
ERP-00-F08	**McCormack-Williamson Tract Restoration Planning, Design and Monitoring Program I** Performed baseline studies necessary for project planning and design, and the development of long-term monitoring programs of the McCormack-Williamson Tract (M-W), which is a 1,600-acre Delta island.	8/1/2003	$556,200	Hydrologic, sediment and planning documents lacking at this point. Hard to analyze progress without these.
ERP-01-C02	**Real-Time Flow Monitoring.** Continued operation and maintenance of flow monitoring stations on five Sacramento River tributaries to provide data on minimum instream flows and water quality for the recovery of at-risk fish species in the creeks.	9/30/2005	$518,200	Complete
ERP-01-C03	**Revised Phase II - Merced River Salmon Habitat Enhancement River Miles 42 to 44 (Robinson Reach and Permit #307 sites)** Restored a reach of the Merced river: channel reconfiguration, creation of a large floodplain with native vegetation, and berm reconstruction to reduce predation of non-native fish on native species.	6/30/2004	$1,699,101	Complete. Scaled and reshaped channel, and replanted floodplain, over entire 2 mile reach.
ERP-01-C04	**Suisun Marsh Property Acquisition & Habitat Restoration** Acquired property in the Suisun Marsh, along Hill Slough, currently managed as seasonal wetland and restore the area to a fully functioning self-sustaining tidal wetland ecosystem which includes low-marsh, high-marsh, and upland transition zones, increasing the area and contiguity of saline emergent wetlands thereby assisting in the recovery of at-risk species.	6/30/2006	$536,750	Acquired Blacklock parcel; 69 acres in northeastern marsh.
ERP-01-C05	**Feasibility Study of the Ecosystem and Water Quality Benefits Associated with the Restoration of Franks Tract, Big Break, and Lower Sherman Lake** Feasibility study which evaluated the potential to create ecosystem, water quality/supply, recreational, and other benefits at Lower Sherman Lake, Big Break, and Franks Tract, by modifying remnant levees to inhibit salt trapping and restoring tidal marsh habitat.	6/30/2005	$1,218,105	Complete.
ERP-01-C06	**Sedimentation in the Delta and Suisun Bay** Described the movement of sediment affecting habitats in the Sacramento-San Joaquin Delta and described the availability of sediment needed for habitat restoration.	6/14/2005	$1,630,391	Complete

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-C07	**Transport, Transformation and Effects of Selenium and Carbon in the Delta of the Sacramento-San Joaquin Rivers: Implications for Ecosystem Restoration** Evaluated transformation of selenium and carbon in the Delta and determine how transport and transformation of selenium will affect critical food webs in the Delta. Phase 1 of this project is ERP-97-B06.	6/14/2005	$2,862,707	Research complete and final report available.
ERP-01-C07-D	**Cache Creek Settling Basin Feasibility Study** Investigated the feasibility of enhancing a flood control basin on Cache Creek to trap mercury laden sediments from the Cache Creek watershed (including abandoned mercury mines) and prevent the movement of mercury into the Yolo Bypass and Delta.	12/31/2006	$97,620	Ongoing. Most of the tasks are complete. The Feasibility Study Report is a draft.
ERP-01-C08-D	**Technical and Scientific Services for the Upper Yuba River Studies Program** USGS investigated water quality and sediment transport and yield in the Yuba River watershed. The overall objective was to improve understanding of sediment supply, transport, and storage of sediment in the Yuba River watershed, and to improve understanding of the current level of mercury contamination of Englebright Lake sediments and biota. An assessment of the transport of the existing sediment in the reservoir to the downstream reaches was performed following several potential management scenarios.	6/14/2005	$534,000	Complete.
ERP-01-C10	**Technical / Scientific Review of Upper Yuba River Studies Program: Ecotoxicology Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program.	6/30/2006	$44,000	Complete.
ERP-01-C11	**Technical / Scientific Review of Upper Yuba River Studies Program: Hydrotechnical Engineering Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program.	6/30/2006	$28,000	Complete.
ERP-01-C12	**Technical / Scientific Review of Upper Yuba River Studies Program: Environmental Economics Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program.	6/30/2006	$28,000	Complete.
ERP-01-C13	**Technical / Scientific Review of Upper Yuba River Studies Program: Geomorphology Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program.	6/30/2006	$28,000	Complete.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-C14	**Technical / Scientific Review of Upper Yuba River Studies Program: Zoology Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program.	6/30/2006	$28,000	Complete.
ERP-01-C15	**Technical/Scientific Review of Upper Yuba River Studies Program: Hydropower Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program.	6/30/2006	$26,000	Complete.
ERP-01-C16	**Technical / Scientific Review of Upper Yuba River Studies Program: Marine Fisheries and Economics Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program.	6/30/2006	$26,000	Complete.
ERP-01-C61-1-D	**Directed Action for Dissolved Oxygen** Investigated the effects of increasing the flow in San Joaquin River, by adding auxiliary pumps over the Grant Line Canal Barrier, and their effects on dissolved oxygen levels in the San Joaquin River Deep Water Ship Channel. This project will also develop a stand alone version of the Delta Simulation Model for the upper San Joaquin River.	1/31/2003	$120,000	A number of technical reports can be found at www.sjrdotmdl.org
ERP-01-N01	**The Influence of Flood Regimes, Vegetative and Geomorphic Structures on the Links between Aquatic & Terrestrial Systems** Examined the floodplain dynamics in the Cosumnes watershed by assessing levee breaches and other flow restoration efforts under which ecological succession is effective in restoring the structure and foodweb dynamics characteristic of functioning native ecosystems.	6/30/2006	$2,652,750	Complete.
ERP-01-N03	**Tuolumne River Restoration: Special Run Pool 10** Improved salmon spawning and rearing habitats and reduced predator habitat (bass) by filling the in-channel mining pits; preventing future connections between the River and the off-channel mining pit and restoring native riparian habitats.	6/30/2006	$652,030	Complete.
ERP-01-N09	**Tuolumne River Fine Sediment Management (Gasburg Creek)** Reduced the supply of fine sediment to increased substrate permeability for Chinook salmon.	12/31/2007	$995,119	Project has yet to complete closeout. Deliverables are still outstanding.
ERP-01-N13	**Phase II: Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands (Construction & Monitoring)** Pilot project which demonstrated biotechnical methods which can be used in lieu of riprap or other hard surfaces to protect valuable tidal wetlands associated with in-channel islands in the Delta.	9/30/2006	$1,145,400	Complete. Installed various biotechnical methods to control erosion and attenuate wave energy adjacent to 3 eroding ICI'S (in-channel islands) in the Delta. 2,159 linear feet of shoreline was treated, protecting a total of 6.24 acres of ICI habitat.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N27	**Sonoma Creek Watershed Conservancy** Expanded on the Conservancy's existing efforts to inform and engage the public in watershed issues while providing critical data for adaptive management.	10/30/2005	$545,170	Project implemented 7 vineyard bmp demonstration projects. Also Improved fish passage on Carriger Creek. Watershed planning and implementation capacity enhanced through various efforts.
ERP-01-N32	**Marsh Creek Watershed Stewardship** A watershed stewardship project that will lead to the protection and restoration of Marsh Creek. The goal of the Watershed Science Program is to organize and implement a community-based watershed analysis to improve scientific understanding of ecological trends and processes shaping Marsh Creek, thus building a knowledgeable local constituency.	6/30/2003	$126,000	Complete.
ERP-01-N41	**Bay-Delta Learning Initiative** Produced and distributed educational posters, directed at boaters and anglers, to teach them about plant and pest non-native invasive species; and will provide the media with an overview of current topics and provide workshops and teaching materials for teachers for greater awareness of and appreciation for the Bay-Delta ecosystem.	03/31/2004	$126,668	Project complete.
ERP-01-N48	**Juvenile Salmon Migratory Behavior Study in the North Central and South Delta** This research project was conducted to improve the understanding of juvenile anadromous salmonid migratory behavior in the Delta to enhance ongoing and future Delta ecosystem restoration efforts.	1/15/2004	$210,000	The final report provided numerous recommendations for additional research.
ERP-01-N61-01	**San Joaquin River Dissolved Oxygen Depletion Control Project: Coordination, Integration, and Technical Administration** Updated the August 2000 "Issues" report, incorporating new information that evolves from the Directed Action-supported projects, continue assistance with the 'Strawman development', conduct peer review of the results of the directed action project and its component projects, and provide technical administration.	02/28/2003	$276,000	Synthesis report can be found at www.sjrdotmdl.org
ERP-01-N61-02	**San Joaquin River Dissolved Oxygen Depletion Control Project: San Joaquin River Diversion Data Assimilation, Drainage Estimation, and Installation of Diversion Monitoring Stations** The objective of this specific component project is to provide data on the flow volume of agricultural and non-agricultural diversions and return flows in the lower San Joaquin River between Lander Avenue and the DWSC that will assist in the assessment of watershed nutrient loading to the DWSC.	08/31/2002	$192,672	Final report can be found at www.sjrdotmdl.org

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N61-03	**San Joaquin River Dissolved Oxygen Depletion Control Project: City of Stockton Water Quality Sampling** This project provided a framework of weekly samples to characterize the water quality patterns within the Stockton Deep Water Ship Channel and evaluated the potential relationships between regional wastewater control facility effluent loads and San Joaquin River loads.	05/31/2002	$75,000	Final report can be found at www.sjrdotmdl.org
ERP-01-N61-04	**San Joaquin River Dissolved Oxygen Depletion Control Project: Sediment Deposition Rates and Associated Oxygen Demand** Studied water and suspended sediments in the San Joaquin River and Stockton Deep Water Ship Channel to elucidate settling and resuspension mechanisms that influence DO concentrations. The information derived from these studies is necessary in determining the impact on DO from algae and other particulate matter and assessing its significance relative to the impacts from all oxygen demand sources.	08/31/2002	$112,000	Final report can be found at www.sjrdotmdl.org
ERP-01-N61-05	**San Joaquin River Dissolved Oxygen Depletion Control Project: Aeration Technology** Provided an engineering evaluation of the potential to use aeration to eliminate the Dissolved Oxygen deficit that occurs in the Deep Water Shipping Channel below water quality objectives.	12/31/2002	$165,000	Final report can be found at www.sjrdotmdl.org
ERP-01-N61-06	**San Joaquin River Dissolved Oxygen Depletion Control Project: Downstream Tidal Exchange and Residence Time in the Deep Water Ship Channel** Investigated and quantified hydraulic residence time and net San Joaquin River flow as it is influenced by tidal action in the Deep Water Ship Channel, Delta export pumping flows through Turner Cut and the Head of Old River as a means of accurately evaluating the significance of various flow regimes and related or expected Dissolved Oxygen depletion episodes.	8/31/2002	$74,000	Final report resulted in a summary of tidal hydraulics in the DWSC that will improve analyses on water quality processes that influence dissolved oxygen concentrations.
ERP-02-C01-D	**Upper Yuba River Studies Program - Sediment Studies and Water Quality** Improved the understanding of the current level of mercury contamination in Englebright reservoir sediments and biota. Sediment studies improved the understanding of sediment supply, transport, and storage of sediment in the Yuba River watershed. An assessment of the transport of the existing sediment in the reservoir to its downstream reaches was performed following several potential management scenarios. Determined if the introduction of wild Chinook salmon and steelhead trout to the upper Yuba River is feasible in the long term.	6/30/2006	$4,794,966	Complete.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02-C04-D	**Two-Dimensional Detailed Hydraulic Model for Determining Flood Conveyance Impacts of Ecosystem Restoration Projects in the Yolo Bypass** The objective of this project is the topographic update and improvement of the existing Yolo Bypass RMA-2 2-D hydraulic model. The model's geometry would be updated and refined, calibrated, validated, and tested.	06/01/2006	$500,257	Final report submitted.
ERP-02-C05-D	**Hamilton City Flood Damage Reduction and Ecosystem Restoration** Completed the Hamilton City feasibility study to restore connection to the floodplain and restore 2,600 acres of riparian habitat in the Hamilton city area, while simultaneously reducing the flood risk to local residents.	6/30/2006	$483,500	Complete.
ERP-02D-P50	**San Joaquin River Dissolved Oxygen Depletion Modeling** Developed a technically defensible modeling framework of the Deep Water Ship Channel (DWSC) and the San Joaquin River (SJR) that realistically represents the Dissolved Oxygen (DO) dynamics in the system. A major component of the project will be the development of a 3D, time variable model of the DWSC tidal hydrodynamic transport and DO dynamics coupled with a new water quality model of the SJR.	06/30/2006	$500,000	The web based viewer for the 3D DWSC Tidal Modeling is available at the HydroQual website www.hydroqual.com
ERP-02D-P51	**Hydrodynamics and Oxygen Modeling of the Stockton Deep Water Ship Channel** The primary objective for this project is to understand how hydrodynamic and biogeochemical processes interact to produce reductions in dissolved oxygen concentrations along the San Joaquin River within the Stockton Deep Water Ship Channel.	08/31/2007	$914,446	Project expired, some deliverables outstanding but will be submitted
ERP-02D-P53	**Lower Deer Creek Restoration and Flood Management: Feasibility Study and Conceptual Design** Will evaluate the feasibility of setting back levees on Deer Creek and investigate the feasibility of allowing flood flows to access the natural floodplain in a controlled manner to improve habitat and flood control.	10/31/2008	$1,519,200	Ongoing.
ERP-02D-P54	**Restoring Ecosystem Integrity in the Northwest Delta: Phase II** This project will acquire conservation easements within the Cache Slough complex, along the Barker, Lindsey and Calhoun Sloughs, north Delta tidal channels located west of the Yolo Bypass.	08/31/2008	$1,781,658	Project ongoing.
ERP-02D-P55	**Physical Modeling Experiments to Guide River Restoration Projects** Supports construction of a flume at the UC Richmond's Field Station. This flume will be used in experiments about the potential effects of river restoration projects, especially spawning gravel augmentation projects, dam removals, and channel reconstruction projects. Data from these experiments can be used to test river restoration designs and evaluate their potential effects. Was ERP-02-P13-D.	9/30/2007	$2,498,453	Ongoing.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02D-P61	**Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River** Quantified key aspects of a "naturalized' flow regime that are compatible with flood damage reduction, agriculture, diversions, storage and conveyance (was ERP-02-P15-D).	9/9/2007	$1,571,438	Complete.
ERP-02-P08	**Staten Island Wildlife-Friendly Farming Demonstration** The goal of the project is to improve wildlife-friendly agriculture to foster recovery of at-risk species and to investigate effects of agriculture on water quality.	06/30/2007	$1,757,459	Final report submitted.
ERP-02-P08-D	**M & T/Llano Seco Fish Screen Facility Short-Term/Long-Term Protection Project** Protects the existing M&T/Llano Seco fish-screen facility and its beneficiaries while investigating and identifying a technically and economically feasible long-term solution to adapt the fish-friendly pumping facility to the lateral migration of the Sacramento River.	6/30/2008	$4,390,087	Ongoing
ERP-02-P12	**Sustainable Restoration Technologies for Bay/Delta Tidal Marsh and Riparian Habitat** Protected natural embankment and reconstruction through passive recruitment of new sediment to create new riparian and shaded riverine aquatic habitat in aquatic channels.	12/30/2006	$1,800,000	Complete. Restored 3.72 river miles (1.99 miles in East Delta, 0.5 miles in North Delta, 0.81 miles in Central and West Delta, 0.42 miles in the Suisun Marsh and Bay) of riverbank, levee and shoreline tidal environments to riparian and marsh habitats.
ERP-02-P12-D	**Merced River Corridor Restoration Plan Phase IV: Dredger Tailings Reach (Merced River Ranch)** Designed pilot floodplain and channel restoration experiments, in their watershed context, intended to initiate the restoration of natural ecosystem function to the Dredger Tailing Reach of the Merced River and to set in place monitoring and evaluation schemes designed to contribute transferable scientific understanding that assists in reducing uncertainty in restoration design.	3/21/2007	$2,497,877	Complete
ERP-02-P13	**INFORM - Integrated Forecast and Reservoir Management Demonstration for Northern California Water Resources** Built on past work to establish a pilot demonstration site in Northern CA for assessing the utility of climate information for the operational management of regional water resources.	11/21/2006	$600,000	Project complete.
ERP-02-P19	**Determining the Mechanisms Relating Freshwater Flow and Abundance of Estuarine Biota (the "Fish-X2" relationships) Phase I** This project is phase I of a research program. The ultimate purpose of this project is to contribute to the understanding of the factors that control the distribution and abundance of estuarine species, how these factors vary with X2, and how they might change in the future.	3/31/2008	$509,222	Contract has expired and status is unknown. Latest deliverable states that A paper submitted to the online journal San Francisco Estuarine and Watershed Science has been accepted for publication.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02-P22	**Shallow Open Water Habitats: Hydrodynamics and Benthic Grazing** Developed, via field observation and modeling, a detailed view of how tides and wind-generated waves determine the physical structure and hydrodynamics of shallow estuarine waters, and how these physical processes can act to constrain net primary production through their effects on grazing and light. Field experiments were carried out in the shallows of Grizzly Bay and in Franks Tract.	05/31/2007	$616,605	The results of this study combined with the IEP POD report synthesis and the EET project (ERP 02-P19) will be pivotal for evaluating the outcomes of studies on POD related work funded by ERP.
ERP-02-P23	**Update Individual Ownership Adaptive Management Habitat Plans** Updated 140 "Individual Ownership Management Plans for Private Properties" within the Suisun Marsh and to provide wetland management educational information for private landowners.	10/31/2007	$214,943	Final report has yet to be submitted.
ERP-02-P28	**Stanislaus - Lower San Joaquin River Water Temperature Modeling and Analysis** Performed modeling and analysis of various alternatives for water management in the Stanislaus River.	10/31/2006	$878,827	Complete. Extended in another ERP project (ERP-06D-S20) to include the Tuolumne, Merced, and Lower San Joaquin Rivers.
ERP-02-P29	**Tuolumne River Sediment Acquisition and Spawning Ground Transfusion Project** Proposed to secure a long-term source of sediment necessary to implement present and future restoration projects, and add a large enough quantity of clean spawning gravel into the river to restore the supply that has been lost during the past century of sediment regulation. Proposed an amended Scope of Work; Approval still pending as of August 2005. The amended project entails placement of 300,000 cubic yards of spawning-sized gravel in 2006 and 2007 to increase spawning habitat for Chinook salmon and steelhead in the lower Tuolumne River.	12/31/2008	$4,350,000	Ongoing. Originally proposed to acquire and mine gravel on site along the Tuolumne River near Basso Bridge in addition to adding gravel along the entire section between the La Grange Dam and Basso. Negative public and private landowners made acquisition of the property impossible. The project maybe downgraded to a smaller, gravel purchase/spawning habitat enhancement.
ERP-02-P30	**Hydroclimatic Reconstruction and Ancient Blue Oak Mapping over the Drainage Basin of San Francisco Bay** This research project will develop high quality climate and hydrologic reconstructions up to 500 years using an unparalleled network of 50 tree-ring chronologies from moisture-sensitive blue oak trees in the drainage basin of the San Francisco Bay. The purpose of this project is to develop 50 moisture-sensitive tree-ring chronologies from ancient oaks, to reconstruct a suite of precipitation and hydrological variables, and to map ancient blue oak forests in the drainage basin of San Francisco Bay.	11/30/2008	$747,741	Research is ongoing.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02-P38	**Effects of Climate Variability and Change on the Vegetation and Hydrology of the Bay-Delta Watershed** The broad goal of this project is to assess the role of vegetation in shaping the watershed's hydrologic response to climate variability and global climate change.	2/29/2008	$562,924	Project nearing completion
ERP-02-P43	**Tiered Public Outreach Program** This proposal is for a multi-faceted education program about the CALFED ecosystem restoration efforts. The proposal includes updating the PBS special "To Quench A Thirst"; updating the "Delta Water Map"; journalists' tours of the Bay-Delta system, and continue providing Water Education Foundation teaching material to instructors.	6/30/2006	$360,000	Produced a Public Television Documentary called *Water On The Edge*: The production of the documentary and accompanying viewer's guide was completed during the last quarter of 2005.
ERP-02-P45	**Geomorphic and Geologic Mapping for Restoration Planning** Mapped geomorphic landforms and geologic deposits along the lower Sacramento, San Joaquin, and Cosumnes rivers for input into ecosystem restoration planning and levee engineering. Detailed mapping (1:24,000) completed for portions of nine 7.5-minute quadrangles.	6/01/2005	$120,000	Complete. A series of interpretive GIS map layers that show: the distribution of historical river landforms (including natural levees, floodplains, and stream channels) for floodplain and habitat restoration; likely locations of historic hydraulic mining derived sediments stored along the river margins, and the likely composition of foundation materials underlying existing levees for evaluation of levee stability.
ERP-02-P47	**Narrows II Flow Bypass System** Constructed bypass system to eliminate flow and temperature fluctuations from emergency and maintenance shutdowns at the Narrows 2 Hydropower Plant on the Yuba River.	6/30/2008	$8,535,567	Complete.
ERP-03-C04	**Technical/Scientific Review of Upper Yuba River Studies Program: Geomorphology and Hydrology Expert** Dr. Gordon Grant of the USFS provided technical expertise to the CALFED Bay-Delta Program's Upper Yuba Rivers Studies Program.	6/30/2006	$18,000	Complete.
ERP-04D-S22	**San Joaquin River Fall-Run Chinook Salmon Population Model Refinement Project** The purpose of this project is to refine a fall-run Chinook salmon population prediction computer simulation model for the San Joaquin River. This project will provide review, refinement, and improvements to existing San Joaquin River Fall-run Chinook Salmon Population Prediction Model, as well as provide a User Guide for the refined model.	6/30/2008	$250,000	Project status unknown; ERP is lacking deliverables.
ERP-04-S05	**Lower Clear Creek Monitoring Program** Avian Monitoring, Geomorphic Monitoring, and Riparian Habitat Monitoring.	1/31/2010	$1,308,449	Ongoing

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-04-S16	**Clear Creek Anadromous Salmonid Monitoring Program** A comprehensive salmonid monitoring program that will provide feedback for the adaptive management and evaluation of restoration actions of the Clear Creek Restoration Program and B2 Water Program.	12/31/2009	$1,974,068	Ongoing.
ERP-05D-S18	**Lower Clear Creek Floodway Rehabilitation Project (Phase 3B)** Will reconstruct the bankfull channel, monitor project implementation, and stabilize a headcut.	1/31/2010	$3,482,451	Ongoing.
ERP-06D-S20	**San Joaquin River Basin Water Temperature Modeling and Analysis** Expands the Stanislaus River temperature model developed under ERP-02-P28 to the Merced, Tuolumne & San Joaquin above Stanislaus R. confluence.	12/31/2008	$716,052	Project is in progress and assisted by DFG by a directed action that collects water temperatures (ERP-05D-S02)
ERP-95-M04	**Sacramento River Spawning Gravel Restoration Project (below Keswick Dam)** Restored several miles below the Keswick Dam on the Sacramento River by introducing spawning-sized gravel for natural redistribution and use by salmon as spawning habitat.	11/1/1995	$39,400	Complete.
ERP-95-M07	**Suisun Marsh Fish Screen Project** Phase 1 (diversion evaluation and selection) of a larger program to construct fish screens on 5 diversions in the Suisun Marsh to reduce downstream migrant salmonid mortality and mortality of delta smelt and splittail.	11/31/1996	$450,000	Complete.
ERP-96-M10	**Applied Research to Predict Ecological Functions of Evolution of Restored Diked Wetlands** Analyzed historically-breached dike wetlands in Delta as a means to predict the feasibility, patterns and rates of restoration to natural function that would be expected from breached-dike restoration strategies.	12/31/1999	$475,000	Final report submitted.
ERP-96-M12	**Battle Creek Chinook Salmon and Steelhead Restoration Plan** Collected data to create a watershed plan as part of the overall watershed strategy used for implementing the Battle Creek Salmon and Steelhead Restoration Project.	10/1/1999	$306,000	Complete.
ERP-96-M13	**Yolo Bypass Fish Habitat** Examined the relationship between the Yolo Bypass and the rest of the Estuary and to develop recommendations for restoration actions that would improve Bypass habitat for fisheries and other aquatic organisms.	11/3/2000	$226,000	Project complete
ERP-97-B02	**Monitor and Describe the Movement of Sediment Needed for Habitat Restoration in the Delta and Suisun Bay** Described the movement and availability of sediment in the Delta, as needed for habitat restoration.	6/30/2001	$1,047,010	Complete
ERP-97-B03	**Liberty Island Acquisition** Protected and restored tidally influenced wetlands, riparian corridors, and upland habitats on Liberty Island in the Yolo Bypass.	9/30/2003	$8,926,000	Acquisition of 4,760 on Liberty Island for future restoration projects.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-97-C11	**Spawning Gravel Introduction, Tuolumne River, La Grange** Added 11,000 tons of gravel between the Old La Grange Bridge and Basso Bridge in the lower Tuolumne River in 1999 to increase and improve Chinook salmon spawning habitat.	12/31/2001	$250,975	Complete.
ERP-97-M08	**Tuolumne River Channel Restoration (Pool 9)** Filled mining pits and constructed setback levees in the Tuolumne River at river mile 25.9 to remove predator habitat and enhance riverine processes and salmonid habitats.	2/28/1999	$2,253,100	Complete. Channel restored to 400 to 500-foot wide riparian flood plain. Rebuilt 1,200 foot long section of Tuolumne River.
ERP-97-N06	**Butte Creek Riparian Protection and Restoration Project** Provides funds for the acquisition of the McAmis Property, development of a management plan for the Ecological Preserve, and incorporation of the site into the Butte Creek Education Project.	12/31/2001	$187,128	Complete. Acquired 93.40 acres of riparian.
ERP-97-N07	**Cottonwood Creek Channel Restoration Planning/Geomorphic Analysis** Geomorphic and hydrologic analyses and re-surveys of historic data to document geomorphic trends along lower Cottonwood Creek. Funded the initial phases for research, planning and design development for restoration of streambank habitat on lower Cottonwood Creek.	11/1/2002	$61,000	Complete.
ERP-97-N11	**Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands** Demonstrated effective biotechnical methods to reduce erosion of in-channel islands and adjacent delta island banks.	5/29/2000	$270,270	Complete.
ERP-97-N18	**Cullinan Ranch Restoration** This project, part I of a larger effort, aims at restoring tidal salt marsh habitat and ecosystem function in Cullinan Ranch. The project will prepare environmental permits and design engineering plans to restore 1,495 acres of saline emergent wetland habitat by supplying the necessary sediments through accretion to restore proper tidal elevation gradients at the project site.	6/17/2004	$368,500	Due to unexpected analysis, coordination and design of the Cullinan Ranch Tidal Restoration Project, construction activities could not be initiated during the grant period.
ERP-97-N21	**Knights Ferry Gravel Replenishment** Evaluated the effects of adding different sizes and sources of gravel on the utilization of spawning habitat by fall-run Chinook salmon and the quality of incubation habitat at 18 project sites in the Lower Stanislaus River.	3/15/2002	$561,407	Complete. Restored spawning habitat for fall-run Chinook salmon, by adding 13,000 tons of gravel to the streambed, distributed among 18 sites between Goodwin Dam and Oakdale (RM 40).
ERP-98-A02	**Habitat Restoration/Flood Control Bypasses System** Project evaluated restoration needs and opportunities to improve habitat, reduce stranding and improve connectivity with the Sacramento River and the north Delta.	12/31/2002	$947,226	Project complete.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-98-B23	**Steelhead and Chinook Salmon Fish Passage Barrier Remediation on the Guadalupe River** Increased upstream passage of returning steelhead and Chinook salmon adults on the Guadalupe River by constructing fish passage structures past two diversion facilities.	12/31/2001	$178,200	Produced the Guadalupe River Low Flow Barrier Modification Monitoring Report
ERP-98-B39	**Water Challenge 2010 Exhibit** Funded a traveling environmental exhibit titled "Water Challenge 2010", which will increase public awareness, knowledge and appreciation of Bay-Delta natural resources.	12/31/2001	$64,500	Project complete.
ERP-98-C04/C05	**Basso Bridge Ecological Reserve and Merced River Ranch Land Acquisitions** Protected spawning riffles, and protected and enhance riparian species. This project was to acquire 318 acres along the Merced River near Snelling, and 39 acres along the Tuolumne River near La Grange, for the protection of riparian, wetland and riverine habitats.	12/31/2000	$830,500	Project was able to acquire 318 acres at the Merced River Ranch and three of the four Basso Bridge sites. The remaining parcel owner was unwilling to sell.
ERP-98-C10	**Comprehensive Monitoring Assessment and Research Program - CMARP** Implementation of monitoring and applied research that provides data and information necessary to evaluate the performance of completed CALFED program actions and ongoing programs.	12/31/1999	$800,000	Science Program conducted CMARP workshops (2000) and developed the Terrestrial and Amphibious Monitoring Plan (TAMP) and partially developed the Aquatic Monitoring Plan (AMP). Other monitoring planning followed, but little monitoring has been done.
ERP-98-E01	**Napa River Watershed Stewardship** Built upon work in the Napa River watershed by continuing to address a broad range of ecological and biological issues relating to habitat restoration for anadromous fish and other priority species by promoting collaborative watershed stewardship.	12/31/2000	$250,000	This project increased stakeholder capacity in the watershed and also resulted in restoration on two Napa river Tributaries.
ERP-98-E03	**San Francisco Bay Area Wetlands Ecosystem Goals Project** Enabled the collection of data to be use in the creation of habitat goals to be used by private, local, state, and federal entities seeking to protect and improve the San Francisco Bay Area's wetlands.	3/31/1998	$76,000	Complete.
ERP-98-E04	**Petaluma River Watershed Restoration Program** Provided funds to implement the restoration and monitoring projects identified in the Petaluma River Watershed Enhancement Plan with the goal of enhancing and restoring habitat and ecosystem function along the Petaluma River.	2/28/2001	$220,000	Project complete.
ERP-98-E07	**Local Watershed Stewardship: Steelhead Trout Plan, Corte Madera Creek Watershed, Marin County, California** Developed a steelhead restoration plan for the Corte Madera Creek as part of a larger watershed management plan for the Corte Madera Creek watershed.	12/31/2000	$47,500	Complete.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-98-E11	**Watershed Restoration Strategy for the Yolo Bypass** Facilitate broadbased local stakeholder group in development of watershed plan.	3/31/2002	$287,353	Final report submitted and can be found at www.yolobasin.org
ERP-98-F01	**Butte Creek Watershed Coordinator Assistant, Education Project, Road Survey Project, Geomorphology Analysis, and Restoration Implementation** Combined the tasks from four proposals submitted during the 1997 PSP year; provided funds for an assistant watershed coordinator; developed the Butte Creek Watershed Education Project; funded the Butte Creek Watershed Road Survey; and provided for a Geomorphology Analysis of Lower Butte Creek.	12/30/2001	$302,745	Complete.
ERP-98-F06	**Tuolumne River Floodway Emergency Repair and Long-Term Habitat Restoration Project (7/11)** Filled mining pits, removed dredger tailings, constructed setback levees, and restored the channel and floodplain in a 2.6-mile section of the Tuolumne River extensively mined for aggregate material.	6/30/2004	$1,358,846	Complete.
ERP-98-F11	**Merced River Salmon Habitat Enhancement - Phase III (Robinson Reach)** Eliminated predator habitat. Improved spawning and rearing habitat. Replanted riparian vegetation. Restored natural conditions to Merced River habitat at river miles 42 to 43.5. Filled/isolating deep pools, reconfigured channel and floodplain characteristics, and increased riparian habitat.	9/30/2002	$2,433,000	Complete.
ERP-98-F15	**Lower Clear Creek Floodway Restoration Project (Phase II)** Improved salmon spawning and rearing habitat by implementing the Lower Clear Creek Watershed Management Plan and restoring 2.9 miles of floodplain and riverine aquatic habitat.	6/30/2006	$4,561,940	Complete. Reported 35.9 acres restored to riparian. 1997-2000 annual gravel augmentation 24,000 tons.
ERP-98-F23	**South Napa River Tidal Slough and Floodplain Restoration Project** First phase in restoring over 460 acres of wetlands in the South Napa River Tidal Slough by funding acquisition of the property, preliminary design work, an environmental feasibility study, and environmental compliance documentation and permitting.	6/30/2001	$1,480,000	Acquisition is complete
ERP-98-N02	**Expanding California Salmon Habitat through Non-Governmental and Non-Regulatory Mechanisms to Alter Dams and Diversions** Inventoried dams and diversions in the Central Valley and developed a mechanism to purchase dams and diversions from willing sellers to improve fish passage.	3/15/2000	$49,000	Complete.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-99-B01	**Battle Creek Salmon and Steelhead Restoration Project** Will restore 42 miles of habitat for anadromous fish and improve water quality for the Coleman National Fish Hatchery in the Battle Creek Watershed by decommissioning several PG&E diversion dams, providing fish ladders and screens for those that remain, and increasing instream flows for fish.	Unknown	$27,200,000	Ongoing.
ERP-99-B04	**Preliminary Design and Engineering of Lower Western Stone Site, Merced River Salmon Habitat Enhancement Project (Phase IV)** Reduced entrainment of outmigrating fish. Improved river and floodplain dynamics and enhanced the riparian corridor.	4/30/2003	$125,000	Complete.
ERP-99-B05	**Merced River Salmon Habitat Enhancement Project Phase II- Ratzlaff Reach Construction)** Reduced entrainment and predation of out migrating fish. Isolated 45 acres of unnatural predator habitat from the river channel. Improved river and floodplains dynamics and enhanced the riparian corridor. Increased the quantity and quality of in stream spawning.	3/30/2000	$1,584,002	Complete. Reconstructed berms to isolate 45 acres of ponds from river. 3,000 ft (0.6 miles) of channel modified, 7,000 sq ft of spawning habitat will be created.
ERP-99-B11	**South Napa River Tidal Slough and Floodplain Restoration Project** Phase 2 of the South Napa River Tidal Slough and Floodplain Restoration Project, which involved the restoration of tidal flow to 2.3 miles of historic slough habitat, and the restoration of nearly 483 acres of wetlands and uplands.	9/30/2005	$1,520,000	Successfully restored 453 acres of wetlands adjacent to North Slough and the Napa River.
ERP-99-B15	**Duncan/Long Canyon Paired - Watershed Project** Conducted a paired-watershed evaluation of watershed process and function in the very important high elevation headwater areas of the Sierra Nevada with the goal of improving the health of the upper American River.	2/28/2003	$83,600	Complete
ERP-99-B16	**Determination of the Causes of Dissolved Oxygen Depletion in the San Joaquin River** Produced a management action plan to eliminate the oxygen depletion in the San Joaquin River during the fall.	6/30/2003	$866,408	Final report submitted.
ERP-99-B22	**Water Challenge 2010 Exhibit** An interactive, hands-on environmental education exhibit.	6/30/2002	$81,068	Project complete.
ERP-99-F01	**Tuolumne River Special Run Pool 10 (levee repair and monitoring)** Repaired a dike at an off-channel mine pit in the lower Tuolumne River to reduce predation on juvenile Chinook salmon.	3/31/2006	$164,800	Complete.
ERP-99-F02	**Tuolumne River Mining Reach Restoration (MJ Ruddy)** Reconstructed 1.1 miles of the lower Tuolumne River channel and floodplain that was previously diked for gravel mining and then destroyed by the January 1997 floods for the primary benefit of San Joaquin fall-run Chinook salmon.	3/31/2006	$168,813	Complete. Restored a 1.1 mi reach of river to a more natural channel by creating a 500 ft wide floodplain and repaired 100 ft of berm breached in 1997 flood.

Table 1. Bay-Delta Hydrodynamics Project Summary

Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-99-N06	**Linked Hydrogeomorphic-Ecosystem Models to Support Adaptive Management - Cosumnes-Mokelumne Paired Basin Project** Collected long-term multidisciplinary, monitoring data to be used to develop ecologically based models to predict the combination of factors that will maximize ecosystem benefits in ways that are compatible with other water uses.	6/30/2003	$1,546,016	Complete.
ERP-99-N18	**Geomorphic Model for Demonstration and Feasibility Assessment of Setback Levees: Bay-Delta River Systems** Developed a geomorphic model that allows simulation and demonstration of the response of riverine systems to levee removal and setback. Developed levee and infrastructure-placements component of this migration model; applied the model to simulate levee setback scenarios; developed interactive computer visualization of model output; and prepared model simulations, report and recommendations.	6/11/2004	$104,458	Complete.
ERP-99-N20	**Napa River Watershed Stewardship Year 2** Built upon work in the Napa River watershed by continuing to address a broad range of ecological and biological issues relating to habitat restoration for anadromous fish and other priority species by promoting collaborative watershed stewardship.	12/30/2001	$191,100	Complete. Hydrologic modeling. Multiple habitats enhanced. Eroding bank stabilization, Himalayan blackberry eradication, riparian enhancement and revegetation, spawning habitat improvement (0.05 stream miles, 0.25 acres).

Other Programs Contributing to ERP Vision

There are several environmental water management programs affecting Delta hydrology, protecting species, and restoring ecosystems. Each program complements the others, while having differing goals and priorities due to specific authorization, purpose, and funding source. Refer to the chapter on Central Valley Streamflows within this report (section 3.1.1) for a discussion on the Environmental Water Account (EWA), Central Valley Project Improvement Act (CVPIA), and Vernalis Adaptive Management Program (VAMP) contributions.

Interagency Ecological Program (IEP) has contributed significant resources into research opportunities relating to pelagic organism decline (POD). IEP has focused most of its efforts in the past on monitoring necessary to detect trends in target species, particularly as they are affected by freshwater flow. This has resulted in one of the world's most valuable data sets on estuarine biology, in terms of the length and continuity of the collection.

USGS Real-Time Water Data for the Nation provides up-to-date data that is typically recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, including streamflow conditions as a percentile, which is computed from the period of record for the current day of the year.

In 2007, Science Program contracted for a monitoring and assessment strategy, which will provide guidelines and framework for designing integrated monitoring programs and linking them with performance evaluation and adaptive management. Individual programs and projects will still need to develop their own monitoring plans, analyses, and performance measures, but within the context of the overall strategy. Draft strategy should be completed by January 2009.

Status of Topic Today

Our understanding of Bay-Delta hydrology has improved greatly during Stage 1; however, there still remains much more work to be done. Water project operations models, including CALSIM2 and DSM2, have been greatly improved during the last seven years and are continually being refined. Particle tracking modeling based on the one-dimensional DSM2 is used to simulate the transport of neutrally-buoyant particles which may translate to some fish larval stages with no or very limited swimming behavior. Other models representing Delta hydrodynamics in more than one dimension also exist, but we lack similar advancements in models that comprehensively evaluate ecosystem and species responses to changes in flows and hydrodynamics.

Planned Projects for Implementation

Synthesis of historical and new information on fluvial and hydrodynamic processes will help inform the development of strategic approaches to restoration of Bay-Delta ecosystems. Hydrodynamic models based on fundamental physics of the Delta that accurately simulates tidal flows and transport and dispersion will be critical for assessing effects, both positive and negative, of habitat restoration projects.

Impediments to Implementation

The greatest impediments to implementation involve the limited time and resources available to develop this information and complexity of these models. Some parties suggest that the only way to make progress is to proceed with implementing pilot projects that will eliminate some of the aspects of Delta channel hydrodynamics that appear to be adverse to biological resources and evaluate the outcome.

References

CALFED Bay-Delta Program. 2000. Ecosystem Restoration Program Plan - Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed. Final Programmatic EIS/EIRTechnical Appendix. Sacramento, CA.

3. ECOSYSTEM PROCESSES

3.2. Channel Forming Processes

3.2.1. Coarse Sediment Supply, Stream Meander, and Natural Floodplains and Flood Processes

Introduction

Natural sediments of streams, rivers, and estuaries may include mineral and organic silts, sands, gravel, cobble, and woody and organic debris. These materials are transported through the Bay-Delta and its watershed by hydraulic or wind-driven processes where they may be deposited in low flow areas, broken down further by physical, biological, or chemical cycles; and help to maintain other important ecological processes or functions. Sediment, like water, is one of the natural building blocks of channel forming processes. Certain habitats and species require specific types and amounts of sediment. Properly sized gravels, for example, are important to maintain spawning habitat for salmon, steelhead, and other fish species. Finer sediments are important for the natural development of riparian corridors and wetland habitats. Major factors that negatively influence the sediment supply in the Bay-Delta and its watersheds include human activities such as dam and levee construction, sand and gravel mining, diverting flows, and channelization.

The size, volume, and seasonal timing of sediments entering the riverine and estuarine systems should be compatible with both natural and altered flow regimes. Sediment transport should match channel and floodplain characteristics of individual rivers, streams, and tidal sloughs. An appropriate volume, transport rate, and particle size of sediment should be redistributed to match specific habitat requirements and ecological functions.

Stream meander or channel forming is a dynamic natural process, and is also a term used to describe the shape of the river; a sinuous or winding stream channel with specific geometric dimensions describing the degree of curvature. Rivers with active stream channel meander zones generally support a high diversity of aquatic and terrestrial habitats and compatible biotic communities.

Many fish and wildlife species rely on floodplains and flood processes to provide important seasonal habitat. Floods contribute nutrients to the aquatic foodweb when flood waters collect, transport, and process organic matter from the floodplain back into the stream channels, and eventually into the Bay-Delta estuary. In addition, these processes contribute to species diversity by creating the landforms that support different plant and animal communities. Floodplains of the Bay-Delta provide a matrix

for the interaction of secondary channel shorelines with tule marsh, riparian scrub, grassland, and intertidal habitats.

Floodplains are essential to a balanced sediment budget by providing an area with a lower velocity than the main channel, thereby capturing fine sediment and organic debris and providing a more stable substrate for many vegetation types to flourish. By providing wide areas for overflows to inundate which, floodplains act to reduce flow velocities and thereby moderate the effects of channel incision and scour. In addition, the low-velocity water provides refuge for fish and other aquatic organisms during floods and provides spawning habitat for fish species dependent on the Bay-Delta.

Conserving existing river meander zones, expanding floodplain corridors, conserving or augmenting upstream and bank sediment supplies, and incorporating simulated flood peaks into water release schedules from upstream dams during wet years, are all approaches that can restore more natural stream channels and functions on impaired rivers and streams.

Major human factors that limit natural stream channel meander include channel-confining levees, armoring of banks with riprap, dredging or channelization, loss of upstream sediment supply due to dams and diversions, gravel mining, vegetation removal, and altered flow regimes controlled by the State Water Project, Central Valley Project, and other water development projects within the Central Valley.

Before reclamation, the natural habitats that surrounded the Bay-Delta and rivers feeding into it were primarily tidal and riverine floodplains in the form of vast tule islands, perennial grasslands, and riparian fringe corridors intersected by permanent open water channels and secondary sloughs. Today only the primary open water channels remain, bordered by narrow steep-sided floodplains which form between the active channel and the levee.

Applicable ERP Vision

The vision for coarse sediment supply is to provide a sustained supply of alluvial sediments that are transported by rivers and streams and distributed to riverine bed deposits, floodplains, channel bars, riffles, shallow shoals, and mudflats, throughout the Sacramento-San Joaquin Valley, Delta, and Bay regions to contribute to habitat structure, function, and foodweb production throughout the ecosystem (CALFED 2000a).

The vision for stream meander is to conserve and reestablish areas of active stream meander, where feasible and geomorphically appropriate, by implementing stream conservation programs, constructing setback levees, and reestablishing natural

sediment supply to restore riverine and floodplain habitats for fish, wildlife, and plant communities (CALFED 2000a).

The vision for natural floodplains and flood processes is to conserve existing intact floodplains and modify or remove barriers to overbank flooding in order to reestablish aquatic, wetland, and riparian floodplain habitats (CALFED 2000a).

Stage 1 Expectations

The expectations for Stage 1 included: first, identification of sediment-starved channels in the Bay Delta system; then development of strategies to mitigate sediment starvation, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams. Demonstration projects were to be implemented (and monitored) to mitigate sediment starvation in at least six rivers (CALFED 2000b).

Studies to determine the effects of high flow releases were to be conducted on five to 10 regulated rivers in the Central Valley. Natural floodplains were to be identified that can be inundated with minimal disruption of human activity. Where feasible, flow recommendations were to developed and instituted where positive benefits can be shown (CALFED 2000b).

Plans for meander belts were to be developed for all major river corridors, including establishing priorities for land acquisition and easements established. Development of a meander belt was to be initiated on at least one river (CALFED 2000b).

All existing unurbanized floodplains in the Central Valley were to be identified and a priority list for floodplain restoration projects developed. Strategies for the restoration of natural channel and floodplain dynamics were to be developed and implemented in at least two large demonstration projects. Results of initial floodplain reactivation projects were to be used to increase understanding of channel floodplain interactions and the potential for restoration of processes (CALFED 2000b).

Changes Attributable to ERP

Note: Also see chapters on Contaminants, Mercury, Dredging and Sediment Disposal, Gravel Mining, and regional sections for detailed discussion on projects reconnecting rivers to their floodplain.

Sediment supply to rivers and channels in the Bay Delta system has been investigated in all CALFED Regions:

- *Monitor and Describe the Movement of Sediment Needed for Habitat Restoration in the Delta and Suisun Bay* (**ERP-97-B02**)
- *Sedimentation in the Delta and Suisun Bay* (**ERP-01-C06**)
- *Upper Yuba River Studies Program - Sediment Studies and Water Quality* (**ERP-02-C01-D**)
- *Physical Modeling Experiments to Guide River Restoration Projects* (**ERP-02D-P55**)
- *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**)

Strategies to mitigate sediment starved systems were addressed, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams (e.g. *Physical Modeling Experiments to Guide River Restoration Projects* (**ERP-02D-P55**) and *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**).

Demonstration projects have been implemented and monitored to mitigate sediment starvation on Butte Creek, Merced, Sacramento, San Joaquin, Stanislaus, and Tuolumne Rivers:

- *San Joaquin River National Wildlife Refuge Riparian Habitat Protection and Floodplain Restoration Project - Phase I* (**ERP-97-B04**)
- *Tuolumne River Channel Restoration (Pool 9)* (**ERP-97-M08**)
- *Sacramento River Floodplain Acquisition and Riparian Forest Restoration* (**ERP-97-N02**)
- *Knights Ferry Gravel Replenishment* (**ERP-97-N21**)
- *Butte Creek Acquisition and Riparian Restoration* (**ERP-98-F03**)
- *Merced River Salmon Habitat Enhancement - Phase III (Robinson Reach)* (**ERP-98-F11**)
- *Revised Phase II - Merced River Salmon Habitat Enhancement River Miles 42 to 44 (Robinson Reach and Permit #307 sites)* (**ERP-01-C03**)
- *Merced River Corridor Restoration Plan Phase IV: Dredger Tailings Reach (Merced River Ranch)* (**ERP-02-P12-D**)

Merced River Corridor Restoration Plan Phase IV: Dredger Tailings Reach (Merced River Ranch) (**ERP-02-P12-D**) collected baseline scientific data on the Merced River Dredger Tailings Reach. Results indicate that 1) the contemporary floodplain is largely inaccessible to flood flows; 2) the channel sediment is frequently too coarse for spawning habitat; 3) very little sediment transport occurs other than re-distribution of gravels at augmentation sites; 4) the coarse floodplain sediment has little stratigraphic differentiation above the water table; and 5) levels of mercury are mostly very low (Downs and Diggory 2006).

Physical Modeling Experiments to Guide River Restoration Projects (**ERP-02D-P55**) supported the physical modeling experiments conducted by U.C. Berkeley, S.F.S.U., and Stillwater Sciences at the U.C.'s Richmond Field Station. The project supported the construction of a flume that is being used in experiments examining the potential effects of river restoration projects, especially spawning gravel augmentation projects, dam removal, and channel reconstruction projects. Data from these experiments will be used to test river restoration designs and evaluate their potential effects.

The suspended-sediment transport in the Sacramento–San Joaquin River Delta was examined in the USGS project titled *Sedimentation in the Delta and Suisun Bay* (**ERP-01-C06**). During the 4-year period from 1999-2002 6.6 million metric tons of sediment entered the Delta and 2.2 million metric tons exited the Delta, resulting in 4.4 million metric tons of deposition (Wright and Schoellhamer 2006). This mass of deposited sediment corresponds to approximately 2 cm of deposition averaged over the entire open-water and wetland area from 1999-2002 (or 0.5 cm/yr) (Wright and Schoellhamer 2006). Eighty-five percent of the suspended-sediment came from the Sacramento River, 13% came from the San Joaquin River, and 2% came from other sources (Wright and Schoellhamer 2006). The wet season lasted about 4 months per year but accounted for 82% of the sediment supply and 85% of the total deposition (Wright and Schoellhamer 2006).

Trends of the sediment yield in the Sacramento River were analyzed by USGS via a project titled *Sedimentation in the Delta and Suisun Bay* (**ERP-01-C06**). This research showed that the delivery of suspended-sediment from the Sacramento River to San Francisco Bay has decreased by about one-half during the period 1957 to 2001 (Wright and Schoellhamer 2004). Many factors may be contributing to this trend, including the depletion of erodible sediment from hydraulic mining in the late 1800s, trapping of sediment in reservoirs, riverbank protection, levees, and altered land-uses such as agriculture, grazing, urbanization, and logging. Three large reservoirs in the watershed have accumulated a mass of sediment of the same order of magnitude as the decrease in suspended-sediment yield over the time period of study. The decrease in sediment yield may be due to reservoir sedimentation and the associated adjustment of channels downstream from the dams. Along with reservoir sedimentation, bank protection measures and the gradual depletion of stored hydraulic mining derived sediments have the potential to decrease sediment yield. This finding has implications for planned tidal wetland restoration activities around San Francisco Bay, as an adequate sediment supply will be needed to build subsided areas to elevations typical of tidal wetlands as well as to keep pace with projected sea-level rise. In a broader context, the study underscores the need to address anthropogenic impacts on watershed sediment yield when considering actions such as restoration within downstream depositional areas.

One extensive study, *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**), seeks to quantify key aspects of a "naturalized" flow regime of the Sacramento River that is compatible with

flood damage reduction, agriculture, diversions, storage and conveyance. Stillwater Sciences (2007) infer that the cumulative deficit of coarse sediment since dam construction (i.e. past > 60 years) has been on the order of 3 million yd^3 for the reaches downstream of Shasta Dam. The deficit of coarse sediment from the upper watersheds was exacerbated by the nearly 7 million yd^3 of sediment that was mined from the river and floodplains for dam building, and the 1.8 million yd^3 of aggregate that was mined to support urbanization of Redding (Stillwater Sciences 2007). As part of the ongoing gravel study, Stillwater Sciences is using a new sediment transport model to predict bedload transport rates under the current hydrology. In this way, the model will provide a much more reliable estimate of the overall post-dam coarse sediment deficit, and will also help us understand how it affects the extent and quantity of gravel in storage on the river bed.

Since 1978, approximately 242,000 yd^3 of spawning-sized gravel has been added to the channel of the Sacramento River between Keswick Dam and the confluence with Clear Creek via a project titled *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**). It is difficult to know if the recent gravel augmentation has had an appreciable effect on in-channel gravel storage. The added gravel amounts to a small fraction of the >10 million yd^3 of sediment that was mined from the basin and trapped by the dams. On the Sacramento River below Keswick Dam, the threshold flow for mobilization of spawning-sized gravel has been estimated to be about 50,000 cfs, based on observations of the mobilization of injected gravel during floods stages (Stillwater Sciences 2007). Whereas bankfull flow may provide a good first approximation for assessing changes in bed mobilization, it is not necessarily indicative of flows that are required to maintain the health of habitats in the alluvial system (Stillwater Sciences 2007).

The Upper Yuba River Studies Program (UYRSP) created a conceptual model of sediment processes in the Upper Yuba River, in the project titled *Implement Upper Yuba Studies Program Water Quality and Sediment Studies* (**ERP-02-C01-D**), to provide a roadmap for understanding sediment dynamics at a watershed scale (Curtisa et al. 2005). UYRSP is evaluating the feasibility of introducing anadromous fish into the Middle and South Yuba Rivers above Englebright Dam. Management scenarios under consideration include removing or lowering the structure, which could cause downstream transport of stored sediment. A 2001 survey found that the deposit occupied 25.5% of the reservoir volume. USGS sediment-transport studies provide baseline annual and event-based data used to assess sediment loads that may affect the viability of long-term fish introduction strategies.

Plans for meander belts have been developed for the Sacramento River:

- *Sacramento River and Major Tributaries Corridor Mapping Project* (**ERP-96-M16**)

- *Geomorphic Model for Demonstration and Feasibility Assessment of Setback Levees: Bay-Delta River Systems* (**ERP-99-N18**)
- *Floodplain Acquisition and Sub-reach/Site Specific Management Planning on the Sacramento River (Red Bluff to Colusa)* (**ERP-00-F03**)
- *Sacramento River Conservation Area Program* (**ERP-01-N28**),
- *Sub-Reach Planning for the Sacramento River: River Mile 144-164* (**ERP-02-P27**)
- *Geomorphic and Geologic Mapping for Restoration Planning* (**ERP-02-P45**)

In addition, priorities for land acquisition and easements were established. Development of a meander belt has begun on portions of the Sacramento:

- *Sacramento River Floodplain Acquisition and Riparian Forest Restoration* (**ERP-97-N02**)
- *Sacramento River Floodplain Acquisition and Riparian Forest Restoration* (**ERP-97-N03b**)
- *Sacramento River Meander Restoration* (**ERP-97-N04**)
- *Floodplain Acquisition, Management, and Monitoring on the Sacramento River* (**ERP-98-F18**)
- *Floodplain Acquisition and Sub-reach/Site Specific Management Planning on the Sacramento River (Red Bluff to Colusa)* (**ERP-00-F03**)

Geomorphic Model for Demonstration and Feasibility Assessment of Setback Levees: Bay-Delta River Systems (**ERP-99-N18**) used a meander migration model to examine the relationship between setback distance and habitat formation through a measure of the land reworked over one hundred years of channel migration and cutoff events under different setback levee scenarios on a 28 km reach of the Sacramento River. The study section showed complete cutoff restriction at distances less than about one channel width (300 m), and showed no cutoff restriction at distances greater than about three channel widths (700 m). Three basic patterns of rate of land reworked based on different migration and cutoff dynamics were apparent – complete restriction of cutoffs, partial restriction of cutoffs, and no restriction of cutoffs. Results suggest that management decisions concerned with land reworked could usefully identify the site-specific "restriction of cutoff" thresholds to optimize habitat benefits versus cost of acquired land.

Studies have been conducted on regulated rivers in the Central Valley to determine the effects of high flow releases:

- *Pilot Project to Benefit Riparian Vegetation Along the San Joaquin River* (**ERP-99-B29**)
- *A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin* (**ERP-00-F04**)

- *The Influence of Flood Regimes, Vegetative and Geomorphic Structures on the Links between Aquatic & Terrestrial Systems* (**ERP-01-N01**)
- *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**)

Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations have been developed and instituted when feasible:

- *Focused Action to Develop Ecologically-based Hydrologic Models and Water Management Strategies in the San Joaquin Basin* (**ERP-00-B04**)
- *A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin* (**ERP-00-F04**)
- *Lower Deer Creek Restoration and Flood Management: Feasibility Study and Conceptual Design* (**ERP-02D-P53**)
- *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**)

See Riparian and Riverine Aquatic Habitats Eco-element for *A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin* (**ERP-00-F04**) and *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**).

No one project identified all existing unurbanized floodplains in the Central Valley or prioritized floodplain restoration projects; however there are several projects that contributed to this action:

- *Merced River Corridor Restoration Plan - Phase II* (**ERP-98-E09** Merced)
- *Sacramento River Conservation Area Program* (**ERP-01-N28** Sacramento)
- *Restoring Ecosystem Integrity in the Northwest Delta: PHASE II* (**ERP-02-P21** Cache Slough)
- *Sub-Reach Planning for the Sacramento River: River Mile 144-164* (**ERP-02-P27** Sacramento)
- *Geomorphic and Geologic Mapping for Restoration Planning* (**ERP-02-P45** Delta)

Strategies for the restoration of natural channel and floodplain dynamics e.g. *East Delta Corridor Habitat Studies: Cosumnes and Mokelumne Rivers Feasibility Study* (**ERP-99-C01/C02**), *Physical Modeling Experiments to Guide River Restoration Projects* (**ERP-02D-P55**), and *Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River* (**ERP-02D-P61**) and implementation of a large demonstration project, *The Influence of Flood Regimes, Vegetative and Geomorphic Structures on the Links between Aquatic & Terrestrial Systems* (**ERP-01-N01**), have been developed.

The Lower Deer Creek Restoration and Flood Management: Feasibility Study and Conceptual Design project (**ERP-02D-P53**) created a three-dimensional hydrodynamic model to simulate a large flood event that resulted in levee failure. Simulation results provide detailed information about the capacity of floodplain pathways and will be used to help guide the planning and implementation of future flood management strategies on Lower Deer Creek.

Geomorphic and Geologic Mapping for Restoration Planning, Sacramento-San Joaquin Delta Region (**ERP-02-P45**) mapped geomorphic landforms and geologic deposits along the lower Sacramento, San Joaquin, and Cosumnes rivers for input into ecosystem restoration planning and levee engineering. This research provides a record of long-term changes along the lower Sacramento River that have shaped current conditions. Maps cover nine USGS quadrangles from Courtland to Rio Vista, and identify geomorphic landforms along the river and associated sediments, including older, denser sediments that are stable foundations for set back levees. The mapping shows the distribution of remnant sediments from historic hydraulic mining that washed downstream into river floodplains during the 19th century. These historic sediments, with potentially high mercury contents, currently are stored along the margins of, and within historic floodplains of, the Sacramento River and are separated from the current river system by the modern levee system.

Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River (**ERP-02D-P61**) has produced a comprehensive report on linking biological responses to river processes for the Sacramento River (see Riparian and Riverine Aquatic Habitats Eco-element).

Project Summary Table

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-00-B04	**Focused Action to Develop Ecologically-based Hydrologic Models and Water Management Strategies in the San Joaquin Basin** Identified flow regimes that have a widespread effect on the entire length of the San Joaquin River tributaries, Delta and San Francisco Bay through analysis and modeling of hydro-biologic issues and water management.	3/30/2003	$295,925	Complete
ERP-00-E01	**Last Chance Creek Watershed Restoration** Restored the Ferris-Meadowview reach of the Feather River through a collaborative effort to restore hydrologic function and meadow condition in the Last Creek watershed for the benefit of target species.	12/31/2004	$980,000	Complete. Natural channel restoration, using pond and plug technique to reconnect the channel/floodplain system. Stream length 9.1 miles.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-00-E02	**Panoche/Silver Creek Watershed Management and Action Plan** Building upon the completed Panoche/Silver Creek Watershed Assessment, this project evaluated recommended Best Management Practices (BMPs), implemented selected BMPs on feasible test sites throughout the upper watershed, and carefully monitored the test sites and the watershed at large to determine the effectiveness of BMPs for reducing loads of sediment, selenium, and other contaminants delivered during high flow events. Information gathered was used to develop the Action Plan component of the Panoche/Silver Creek Coordinated Resource Management Plan.	6/30/2005	$868,600	Complete
ERP-00-E03	**Cottonwood Creek Watershed Monitoring and Assessment** Continued management of the Cottonwood Creek Watershed Group to oversee the implementation of a watershed plan. This phase would assess current conditions in the watershed, both as to the land and stream conditions, and to give a baseline for future projects.	12/31/2003	$350,000	Complete
ERP-00-E05	**Merced River Corridor Restoration Project - Phase III** Developed a publicly supported, technically sound, and implementable restoration plan for the Merced River corridor from Crocker-Huffman Dam downstream to the San Joaquin River.	11/1/2002	$341,271	Complete. Plan covered the Merced River from Crocker Huffman Dam (RM52) downstream to the San Joaquin River (RM0).
ERP-00-F01	**Tuolumne River Bobcat Flat Floodplain Acquisition Project** Comprised of 3 parcels offered to Friends of the Tuolumne (FOT) by 2 willing sellers. The owners wish that the parcels be managed for friendly environmental use. FOT will hold fee title until restoration is complete. The BLM will own and maintain the property in perpetuity. A restoration plan was prepared and coordinated with the Tuolumne River Technical Advisory Committee.	11/1/2006	$1,984,320	Complete. 303 acres/1.6 miles river frontage were acquired and restored to various habitat types, specific acreage by type were not reported.
ERP-00-F03	**Floodplain Acquisition and Sub-reach/Site Specific Management Planning on the Sacramento River (Red Bluff to Colusa)** Acquisition of 9 parcels (1,733 acres) within the SB 1086 Sacramento River Conservation Area (Red Bluff to Colusa); baseline assessment/start-up stewardship for newly acquired parcels; site-specific management planning for the "Beehive Bend Subreach"; monitoring; and project management.	9/30/2003	$519,000	Complete
ERP-00-F04	**A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin** Identify the physical and biological mechanisms affecting establishment of riparian vegetation, in particular Fremont cottonwood and willow communities in the San Joaquin Basin, in order to identify the most cost-effective strategies and sites for riparian protection and restoration.	3/31/2006	$293,532	Complete

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-00-F07	**McCormack-Williamson Tract Restoration Planning, Design and Monitoring** Performed baseline studies necessary for project planning and design, and develop a long-term monitoring program for the 1,600-acre McCormack-Williamson Tract Delta island.	12/31/2007	$355,000	Complete
ERP-00-F08	**McCormack-Williamson Tract Restoration Planning, Design and Monitoring Program I** Performed baseline studies necessary for project planning and design, and the development of long-term monitoring programs of the McCormack-Williamson Tract (M-W), which is a 1,600-acre Delta island.	8/1/2003	$556,200	Complete
ERP-01-C03	**Revised Phase II - Merced River Salmon Habitat Enhancement River Miles 42 to 44 (Robinson Reach and Permit #307 sites)** Restored a reach of the Merced river: channel reconfiguration, creation of a large floodplain with native vegetation, and berm reconstruction to reduce predation of non-native fish on native species.	6/30/2004	$1,699,101	Complete. Scaled and reshaped channel, and replanted floodplain, over entire 2 mile reach.
ERP-01-C06	**Sedimentation in the Delta and Suisun Bay** Described the movement of sediment affecting habitats in the Sacramento-San Joaquin Delta and described the availability of sediment needed for habitat restoration.	6/14/2005	$1,630,391	Complete
ERP-01-C13	**Technical/Scientific Review of Upper Yuba River Studies Program: Geomorphology Expert** Provided technical expertise to the CALFED Bay-Delta Program, Upper Yuba Rivers Studies Program. As a member of the Technical Review Panel, the Contractor reviewed materials, attended workshops, participated in discussions, responded to inquiries and presented findings and advice. A three-day workshop was held during September 2001 during which the technical details of the proposed work on the UYRSP was discussed.	6/30/2006	$28,000	Complete
ERP-01-N01	**The Influence of Flood Regimes, Vegetative and Geomorphic Structures on the Links between Aquatic & Terrestrial Systems** Examined the floodplain dynamics in the Cosumnes watershed by assessing levee breaches and other flow restoration efforts under which ecological succession is effective in restoring the structure and foodweb dynamics characteristic of functioning native ecosystems.	6/30/2006	$2,652,750	Complete
ERP-01-N03	**Tuolumne River Restoration: Special Run Pool 10** Improved salmon spawning and rearing habitat and reduced predator habitat (bass) by filling the in-channel mining pits; preventing future connections between the River and the off-channel mining pit and restoring native riparian habitats.	6/30/2006	$652,030	Complete. Funding was for the assessment, planning, and design portion of the project. Actual channel restoration has not occurred due to lack of funding.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N08	**San Joaquin River NWR Riparian Habitat Protection & Floodplain Restoration Project - Phase II** Funded easement acquisition. Restored riparian and wetland habitat, reintroduced riparian brush rabbits, and monitored. Associated project (ERP-97-B04) for Phase I.	12/31/2006	$7,968,112	Complete. Acquired 361.97 acres of riparian and riverine aquatic - riparian, seasonal wetland - connected. 808 acres reported restored were riparian habitat.
ERP-01-N10	**Cosumnes/Mokelumne Corridor Floodplain Acquisitions, Management, and Restoration Planning** Planning phase, which includes acquisition. Phase I of a two-part flood management and ecosystem restoration project in Sacramento County, which will ultimately result in 600 acres of land along the Cosumnes and Mokelumne Rivers incorporated into non-structural flood management practices of the Cosumnes River Preserve. Phase 1 will identify and acquire, from willing sellers, suitable parcels and conduct start-up stewardship activities, including baseline monitoring and preliminary restoration planning.	9/30/2007	$3,044,342	Ongoing. Acquired Siverado-Valley Oak Tract 122.07 acres; wildlife friendly agriculture, seasonal wetlands, uplands, and vineyards. Acquired Giovannoni property 648.77 acres; conservation easement to prohibit planting of permanent crops like vineyards or orchards. Acquired CE on Cowell property 25 acres (Delta EMZ). Acquired Oneto, 129 acres Eastside Tributaries (EMZ).
ERP-01-N11	**Habitat Acquisition for Riparian Brush Rabbit and Riparian Woodrat** Acquire fee title or conservation easements on 400 acres of riparian habitat to provide secure sites for release of captive-bred riparian brush rabbits.	12/31/2006	$2,720,085	Complete. Acquired fee title or conservation easement on property, 371.16 acres.
ERP-01-N12	**Yolo Bypass Management Strategy, Phase II** Technical research, planning, and stakeholder development efforts for implementation of potential habitat enhancement projects of the Yolo Bypass.	12/31/2006	$284,142	Complete
ERP-01-N28	**Sacramento River Conservation Area Program** Funded efforts of the Sacramento River Conservation Area Program to act as a coordinating body between local, state, and federal agencies regarding restoration activities in the Sacramento River watershed.	6/30/2007	$1,034,249	Complete
ERP-01-N29	**Kirker Creek Coordinated Resource Management & Planning Program** Kirker Creek Watershed Coordinated Resource Management & Planning (CRMP) Program facilitated, coordinated, and supported the efforts of landowners, municipalities, community organizations, industry, and citizens of the Kirker Creek Watershed and developed a watershed management plan using the CRMP process.	7/16/2004	$220,402	Complete

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N30	**Digital Soil Survey Mapping and Digital Orthophotoquad Imagery Development** Made soils information more accessible to individuals and groups engaged in ecosystem restoration projects in the Bay-Delta Region, and in doing so, improved the responsiveness of these projects to establishing habitat and supporting sustainable populations of valuable species.	8/15/2004	$430,390	Complete
ERP-01-N40	**Discover the Flyway II** The Discover the Flyway program takes an ecosystem approach to educating teachers, students, and the public about wetland ecosystems and habitats primarily in the Yolo Basin Ecological Management Zone.	8/1/2005	$197,391	Complete
ERP-02-C01-D	**Upper Yuba River Studies Program - Sediment Studies and Water Quality** Improved the understanding of the current level of mercury contamination in Engelbright reservoir sediments and biota. Sediment studies improved the understanding of sediment supply, transport, and storage of sediment in the Yuba River watershed. An assessment of the transport of the existing sediment in the reservoir to its downstream reaches was performed following several potential management scenarios. The objective was to determine if the introduction of wild Chinook salmon and steelhead trout to the upper Yuba River is feasible in the long term.	6/30/2006	$4,794,966	Complete
ERP-02-C04-D	**Two-Dimensional Detailed Hydraulic Model for Determining Flood Conveyance Impacts of Ecosystem Restoration Projects in the Yolo Bypass** Carried out a topographic update and improvement of the existing Yolo Bypass RMA-2 2-D hydraulic model. The model's geometry was updated and refined, calibrated, validated, and tested.	6/1/2006	$500,257	Complete
ERP-02-C05-D	**Hamilton City Flood Damage Reduction and Ecosystem Restoration** Completed the Hamilton City feasibility study to restore connection to the floodplain and restore 2,600 acres of riparian habitat in the Hamilton city area, while simultaneously reducing the flood risk to local residents.	6/30/2006	$483,500	Complete
ERP-02-C07-D	**Dutch Slough Tidal Marsh Restoration Project (Phase I)** Acquired the three contiguous parcels totaling 1,166 acres that comprise the Dutch Slough site.	12/31/2006	$23,550,000	Complete
ERP-02-C08	**Restoration of Eastern Delta Floodplain Habitats on Grizzly Slough in the Cosumnes River Watershed - Phase I** Phase 1 (Planning) in an effort to restore function to an historic seasonal floodplain on Grizzly Slough in the Cosumnes River watershed.	6/30/2006	$300,000	Complete

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02D-C11	**Recovery Implementation for Riparian Brush Rabbit and Riparian Woodrat on the Lower Stanislaus River** Will restore riparian habitats along the lower Stanislaus and San Joaquin Rivers adjacent to the Caswell State Park and the San Joaquin River National Wildlife Refuge.	11/30/2008	$5,465,944	Ongoing. Acquired 184.34 acres.
ERP-02D-P52	**Big Break and Marsh Creek Water Quality and Habitat Restoration Program** This project will develop a public outreach and education program in the Marsh Creek watershed.	10/15/2007	$402,600	Ongoing.
ERP-02D-P53	**Lower Deer Creek Restoration and Flood Management: Feasibility Study and Conceptual Design** Will evaluate the feasibility of setting back levees on Deer Creek and investigate the feasibility of allowing flood flows to access the natural floodplain in a controlled manner to improve habitat and flood control.	10/31/2008	$1,519,200	Ongoing.
ERP-02D-P54	**Restoring Ecosystem Integrity in the Northwest Delta: Phase II** Will acquire conservation easements within the Cache Slough complex, along the Barker, Lindsey, and Calhoun Sloughs, north Delta tidal channels located west of the Yolo Bypass.	8/31/2008	$1,781,658	Ongoing. Acquisition of conservation easements on 1,100 acres of existing riparian, wetland and/or agricultural lands.
ERP-02D-P55	**Physical Modeling Experiments to Guide River Restoration Projects** This project proposes to support construction of a flume at the UC Richmond's Field Station. This flume will be used in experiments about the potential effects of river restoration projects, especially spawning gravel augmentation projects, dam removals, and channel reconstruction projects. Data from these experiments can be used to test river restoration designs and evaluate their potential effects. Was ERP-02-P13-D.	9/30/2007	$2,498,453	Ongoing.
ERP-02D-P61	**Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River** This project seeks to quantify key aspects of a "naturalized' flow regime that are compatible with flood damage reduction, agriculture, diversions, storage and conveyance.	3/31/2008	$1,571,438	Ongoing. Developing a linked decision analysis tool to quantify ecosystem flow regime needs, and holding stakeholder workshops and scoping meetings.
ERP-02-P03-D	**Dutch Slough Restoration Project** Will develop a restoration plan for a 1,166-acre site adjacent to Dutch Slough and the mouth of Marsh Creek in the western Delta.	11/2/2008	$1,500,000	Ongoing.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02-P08	**Staten Island Wildlife-Friendly Farming Demonstration** The goal of the project is to improve wildlife-friendly agriculture to foster recovery of at-risk species and to investigate effects of agriculture on water quality.	6/30/2007	$1,757,459	Complete. Demonstration project for wildlife friendly agriculture practices that increase habitat availability by allowing 2,500-5,000 acres of corn to be flooded for a longer duration than is presently possible. Also, determined the effect of winter flooding strategies on target bird species, namely greater sandhill crane and northern pintail (see ERP-01-N23).
ERP-02-P12-D	**Merced River Corridor Restoration Plan Phase IV: Dredger Tailings Reach (Merced River Ranch)** Designed pilot floodplain and channel restoration experiments, in their watershed context, intended to initiate the restoration of natural ecosystem function to the Dredger Tailing Reach of the Merced River and to set in place monitoring and evaluation schemes designed to contribute transferable scientific understanding that assists in reducing uncertainty in restoration design.	3/21/2007	$2,497,877	Complete
ERP-02-P16-D	**Restoration of the Confluence Area of the Sacramento River, Big Chico and Mud Creeks** Will complete phase II of a four-phase project to protect and restore 311 acres of floodprone, ecologically significant land located within the Sacramento River Conservation Area at the confluence of the Sac. R, Big Chico, and Mud Creeks at river miles 194-195. The goal is to protect and complete restoration and management planning for three properties located in Butte County; the Nicolaus, Nock and Singh properties. Will improve the viability of at-risk species by protecting and restoring riparian habitat and rehabilitating floodplain processes, increasing the knowledge of ecosystem function, reducing flood damage to important human infrastructure by increasing floodwater storage in project area, and improving water quality.	6/30/2008	$2,603,377	Ongoing. Acquired 146.03 acres within the active meander zone of the Sacramento River, Big Chico, and Mud Creeks.
ERP-02-P21	**Restoring Ecosystem Integrity in the Northwest Delta: PHASE II** The project's goal is to manage and restore up to 1300 acres of perennial grassland/vernal pool complex in Solano County, CA, and develop a management plan for the Pembco property or other acquisition within the JPP Island Corridor.	8/31/2008	$246,370	Ongoing. Planning, outreach, experimental treatment plots, to determine restoration methods for various habitats.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02-P27	**Sub-Reach Planning for the Sacramento River: River Mile 144-164** Leading planning efforts for the Colusa-Princeton Sub-reach of the Sacramento River (RM 144-164)). Sub-reach planning is site-specific at a spatial scale of approximately 20 river miles. This is a comprehensive approach to restoration planning that includes a high level of stakeholder involvement to develop conceptual restoration plans and analyzes potential benefits to, and impacts of, restoration implementation on surrounding landowners and land uses.	4/14/2008	$1,488,009	Ongoing.
ERP-02-P29	**Tuolumne River Sediment Acquisition and Spawning Ground Transfusion Project** Proposed to secure a long-term source of sediment necessary to implement present and future restoration projects, and add a large enough quantity of clean spawning gravel into the river to restore the supply that has been lost during the past century of sediment regulation. Proposed an amended Scope of Work; Approval still pending as of August 2005. The amended project entails placement of 300,000 cubic yards of spawning-sized gravel in 2006 and 2007 to increase spawning habitat for Chinook salmon and steelhead in the lower Tuolumne River.	12/31/2008	$4,350,000	Ongoing. Originally proposed to acquire and mine gravel on site along the Tuolumne River near Basso Bridge in addition to adding gravel along the entire section between the La Grange Dam and Basso. Negative public and private landowners made acquisition of the property impossible. The project maybe downgraded to a smaller, gravel purchase/spawning habitat enhancement.
ERP-02-P39	**Riparian Restoration Planning and Feasibility Study for the Riparian Sanctuary, Llano Seco Unit** Identified feasible management options that will 1) improve habitat and ecosystem processes on 950 acres of the Riparian Sanctuary at the Sacramento River National Wildlife Refuge, Llano Seco Unit; 2) develop and evaluate ecological acceptable options that would improve pumping plant protection and, 3) increase scientific understanding of riparian restoration projects.	2/28/2006	$289,784	Complete. Planning and site data collection.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02-P45	**Geomorphic and Geologic Mapping for Restoration Planning** Mapped geomorphic landforms and geologic deposits along the lower Sacramento, San Joaquin, and Cosumnes rivers for input into ecosystem restoration planning and levee engineering. Detailed mapping (1:24,000) completed for portions of nine 7.5-minute quadrangles.	6/01/2005	$120,000	Complete. A series of interpretive GIS map layers that show: the distribution of historical river landforms (including natural levees, floodplains, and stream channels) for floodplain and habitat restoration; likely locations of historic hydraulic mining derived sediments stored along the river margins, and the likely composition of foundation materials underlying existing levees for evaluation of levee stability.
ERP-04-S11	**Sacramento River Riparian Monitoring and Assessment Consolidated Projects** Will address Sacramento River corridor riparian vegetation restoration effectiveness and biological response as a function of time, location, restoration technique, river channel migration, and other natural processes. This project will quantitatively assess the extent to which past ERP funded restoration projects have achieved their stated goals, and through a scorecard approach will provide a means to track ERP project changes over time.	6/30/2009	$1,261,057	Ongoing.
ERP-05D-C01	**Hamilton City Flood Damage Reduction and Ecosystem Restoration Project** Preconstruction, engineering, and design phase to prepare final design, plans, and specifications for construction.	11/30/2008	$1,020,100	Ongoing.
ERP-05D-S29	**Riparian Sanctuary (Phase II) – Bringing Agricultural and Ecological Interests Together for Pumping Plant Protection and Riparian Restoration (Sacramento River Mile 178) - Design Development and Environmental Compliance** Planning and design efforts to develop second phase of multi-phase process to protect PCGID-PID's pumping plant and fish screen facility and to meet Sacramento River National Wildlife Refuge habitat goals for the Riparian Sanctuary.	6/30/2010	$660,665	Ongoing.
ERP-06D-S15	**Sacramento River Conservation Area Forum (SRCAF)** Will provide funding to continue the efforts of the Sacramento River Conservation Area Forum to act as a coordinating body between local, state, and federal agencies regarding restoration activities in the Sacramento River watershed.	3/31/2010	$656,277	Ongoing.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-95-M04	**Sacramento River - Gravel Restoration Project Below Keswick Dam** Restored several miles below the Keswick Dam on the Sacramento River by introducing spawning-sized gravel for natural redistribution and use by salmon as spawning habitat.	11/1/1995	$39,400	Complete. Gravel augmentation.
ERP-96-M06	**Cosumnes River Watershed Project - Valensin Ranch Acquisition** Acquired the Valensin ranch and included it in the Cosumnes River Preserve.	12/31/1996	$1,500,000	Complete. Protected 500 acres of seasonal and permanent wetlands, 270 acres of mature, closed canopy valley oak forest and 60 acres of vernal pools. Contract to acquire 4,300 acres.
ERP-96-M13	**Yolo Bypass Fish Habitat** Examined the relationship between the Yolo Bypass and the rest of the Estuary and to develop recommendations for restoration actions that would improve Bypass habitat for fisheries and other aquatic organisms.	11/3/2000	$226,000	Complete
ERP-96-M16	**Sacramento River and Major Tributaries Corridor Mapping Project** The California State University, Chico Geographic Information Center will create a GIS package detailing riparian corridors along the Sacramento River and its major tributaries in portions of Glenn, Sutter, Colusa, Yuba, Yolo, and Sacramento Counties. Tasks included: 1) obtain infrared and enlargement aerial photographs; 2) develop base-maps; 3) interpret vegetation and ground-truth; 4) digitize photo/vegetation information; 5) develop GIS files; and 6) complete the USVSCPP coverages.	12/31/1999	$145,200	Complete
ERP-96-M24	**Butte Creek Watershed Management Strategy** Created Butte Creek Watershed Management Strategy, which provides specific implementation actions aimed at maintaining a sustainable river ecosystem while addressing the concerns of local stakeholders.	12/31/1998	$83,100	Complete. Mapping and environmental investigation for a Watershed Management Strategy.
ERP-97-B02	**Monitor and Describe the Movement of Sediment Needed for Habitat Restoration in the Delta and Suisun Bay** Described the movement and availability of sediment in the Delta, as needed for habitat restoration.	6/30/2001	$1,047,010	Complete
ERP-97-B04	**San Joaquin River National Wildlife Refuge Riparian Habitat Protection and Floodplain Restoration Project - Phase I** Acquire and plan restoration of additional floodplain lands for USFWS San Joaquin National Wildlife Refuge.	3/31/2002	$10,947,000	Complete. Acquired 3,112 acres (in fee title) of San Joaquin River floodplain on west side of river.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-97-B05	**Feasibility Analysis for the San Joaquin-Bear Creek Floodplain Restoration Project, San Luis National Wildlife Refuge, Merced County** Evaluated the benefits and impacts of allowing seasonal flooding onto lands adjacent to Bear Creek onto refuge lands. The purpose of this project is to restore unimpeded overflow to existing and future dedicated wetlands along the San Joaquin River system to the extent that impacts to adjacent lands and facilities can be mitigated and accepted.	9/30/2000	$334,000	Complete
ERP-97-E01	**Watershed Management Strategy for the Big Chico Watershed** Created a Watershed Management Strategy for Big Chico Creek to serve as a tool for the protection and restoration of the watershed.	12/31/1999	$422,830	Complete
ERP-97-M08	**Tuolumne River Channel Restoration (Pool 9)** Filled mining pits and constructed setback levees in the Tuolumne River at river mile 25.9 to remove predator habitat and enhance riverine processes and salmonid habitats.	2/28/1999	$2,253,100	Complete. Channel restored to 400 to 500 foot wide riparian flood plain. Rebuild 1,200 foot long section ~ 0.23 miles of Tuolumne River.
ERP-97-M09	**Tuolumne River Setback: Dikes and Channel Restoration, Mining Reach 7/11 Segment** Filled mining pits, removed dredger tailings, constructed setback levees, and restored the channel and floodplain in a 2.6 mile section of the Tuolumne River extensively mined for aggregate material. Other project funding is associated with ERP-98-F06.	12/31/2004	$2,801,000	Complete. Constructed a series of setback levees along portions of the river adjacent to gravel mining operations RM 40.2 to 37.5 (2.6 mi). Revegetated 21.8 acres of riparian habitat.
ERP-97-N02	**Sacramento River Floodplain Acquisition and Riparian Forest Restoration** Increased extent of channel meander and flood zones. Mapped aquatic and terrestrial habitats. Increased native riparian growth and reduced exotic distribution adjacent to the river.	12/31/2002	$9,905,438	Complete. Acquired 1,880 acres, Sacramento River Conservation Area - between Keswick and Verona in Shasta, Tehama, Butte, Glenn, Colusa, Sutter and Yolo Counties
ERP-97-N03b	**Sacramento River Floodplain Acquisition and Riparian Forest Restoration** The Wildlife Conservation Board/Dept. of Fish and Game (DFG) actively restored 93 acres of flood-prone agriculture lands to native riparian forest along the Sacramento River between Keswick and Verona. This project increased shaded riverine aquatic habitat and improved degraded instream aquatic conditions. In addition, bird monitoring indicated the restored areas have dramatically improved existing riparian areas for bird usage.	11/1/2002	$512,500	Complete. Beehive Bend (River mi 169.5), 65.5 acres restored/converted from agricultural land to riparian. Thomas Unit (River mile 166.5) 27.2 acres restored/converted from agricultural land to riparian.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-97-N04	**Sacramento River Meander Restoration** Project acquired 94.55 acres of agricultural land and restored natural floodplain and river meander to the site. Goals include: Increase extent of channel meander and flood zones, mapping of aquatic and terrestrial habitats, increasing native riparian growth and reducing exotic distribution adjacent to the river.	2/25/2001	$898,700	Complete. Acquired 94.55 acres of flood-prone agricultural land, and restored a 10 acre portion of it to riparian habitat. The remaining acres can still be farmed at owner's risk (Prune Orchard).
ERP-97-N05	**Auburn River/Coon Creek Restoration Plan** Developed Coordinated Resource Management Plans addressing the protection of habitat and improvement in water quality on the North and Middle Forks of the American River and the Auburn Ravine-Coon Creek watershed.	4/30/2002	$222,530	Complete
ERP-97-N06	**Butte Creek Riparian Protection and Restoration Project** Provided a portion of the funds for the acquisition of the McAmis Property, developed a management plan for the Ecological Preserve, and incorporated the site into the Butte Creek Education Project.	12/31/2001	$187,128	Complete. Acquired 93.40 acres of riparian land.
ERP-97-N07	**Cottonwood Creek Channel Restoration Planning/Geomorphic Analysis** Involved geomorphic and hydrologic analyses and re-surveys of historic data to document geomorphic trends along Lower Cottonwood Creek. Funded the initial phases for research, planning, and design development for restoration of streambank habitat on lower Cottonwood Creek. Project implementation is not part of this project.	11/1/2002	$61,000	Complete
ERP-97-N16	**Bay Point Shoreline Restoration Plan** Developed a restoration plan for the Bay Point Regional Shoreline aimed a restoring tidal salt marsh habitat and ecosystem function.	10/31/2001	$185,000	Complete. Phase I, hired a consultant to develop a restoration plan for the shoreline.
ERP-97-N21	**Knights Ferry Gravel Replenishment** Evaluated the effects of adding different sizes and sources of gravel on the utilization of spawning habitat by fall-run Chinook salmon and the quality of incubation habitat at 18 project sites in the Lower Stanislaus River.	3/15/2002	$561,407	Complete. Restored spawning habitat for fall-run Chinook salmon, by adding 13,000 tons of gravel to the streambed, distributed among 18 sites between Goodwin Dam and Oakdale (RM 40).
ERP-98-A02	**Habitat Restoration/Flood Control Bypasses System** Evaluated restoration needs and opportunities to improve habitat, reduce stranding, and improve connectivity with the Sacramento River and the north Delta.	12/31/2002	$947,226	Complete

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-98-B13	**South Napa River Wetlands Acquisition** The inter-disciplinary team involved in this project will address considerable uncertainty in predicting the outcome and ecological benefit of restoring shallow-water tidal habitat in three different regions of the Bay Delta: the Delta, Suisun Bay, and San Pablo/North Bay.	9/30/2000	$1,073,513	Complete. Acquired and restored 68 acres. Habitats: seasonal connected wetland, riparian and riverine aquatic - riparian & instream, saline emergent wetlands.
ERP-98-B35	**The Butte Creek Watershed Educational Workshops and Field Tours Series** Supported the efforts of the Butte Creek Watershed Project (BCWP) to create education workshops and outreach materials focused on watershed issues. Includes 13 workshops/field tours to be held over the course of eighteen months.	12/31/2002	$32,276	Complete
ERP-98-C04/C05	**Basso Bridge Ecological Reserve and Merced River Ranch Land Acquisitions** Protected spawning riffles, protected, and enhanced riparian species. Acquired more than 318 acres along the Merced River near Snelling, for the protection of riparian, wetland and riverine habitats.	12/31/2000	$830,500	Complete. Acquired 359.6 acres, 1.5 miles along the Merced River.
ERP-98-C10	**Comprehensive Monitoring Assessment and Research Program - CMARP** Implementation of monitoring and applied research that provides data and information necessary to evaluate the performance of completed CALFED program actions and ongoing programs.	12/31/1999	$800,000	Complete
ERP-98-E01	**Napa River Watershed Stewardship** Built upon work in the Napa River watershed by continuing to address a broad range of ecological and biological issues relating to habitat restoration for anadromous fish and other priority species by promoting collaborative watershed stewardship.	12/31/2000	$250,000	Complete. Developed a computer modeling and monitoring program.
ERP-98-E04	**Petaluma River Watershed Restoration Program** Provided funds to implement the restoration and monitoring projects identified in the Petaluma River Watershed Enhancement Plan with the goal of enhancing and restoring habitat and ecosystem function along the Petaluma River.	2/28/2001	$220,000	Complete. Willowbrook/Lichau Creek reduced habitat fragmentation by reestablishing riparian vegetation along 3000 ft of stream. San Antonio Creek stabilized 1000 ft of streambank and plant native vegetation along 2000 ft of streambank. Habitat restored: saline emergent wetlands, riparian and riverine aquatic - instream. (0.76 miles total).
ERP-98-E05	**Cottonwood Creek Watershed Group Formation** Provided funds to develop a comprehensive, community-based organization that will be able to develop and implement watershed stewardship strategies for the Cottonwood Creek watershed.	12/31/2001	$161,000	Complete

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-98-E06	**Battle Creek Watershed Stewardship** This project provided funds to facilitate the activities of the Battle Creek Watershed Conservancy in development and implementation of watershed restoration activities in the Battle Creek watershed.	9/15/2002	$145,000	Complete
ERP-98-E07	**Local Watershed Stewardship: Steelhead Trout Plan, Corte Madera Creek Watershed, Marin County, California** Developed a steelhead restoration plan for the Corte Madera Creek as part of a larger watershed management plan for the Corte Madera Creek watershed.	12/31/2000	$47,500	Complete
ERP-98-E09	**Merced River Corridor Restoration Plan - Phase II** Analyzed and quantified current in-channel, riparian, and floodplain conditions in the Merced River Corridor.	5/23/2001	$345,443	Complete
ERP-98-E11	**Watershed Restoration Strategy for the Yolo Bypass** Facilitated broadbased local stakeholder group in development of watershed plan.	3/31/2002	$287,353	Complete
ERP-98-E13	**Union School Slough Watershed Improvement Program** The Yolo RCD together with Audubon-California enacted portions of the 1996 Willow Slough Integrated Resources Management Plan, which Union School Slough is a part. This project developed California's first "service" to assist landowners with conservation practices and formed a landowner stewardship group for information sharing, problem-solving, and "neighbor-convincing." Conservation activities included: 1) restoring upper watershed riparian areas and rangelands; 2) revegetating canals and drainage ditches; 3) constructing wildlife and tailwater ponds; and 4) restoring natural riparian function to the highly altered lower portion of the slough.	7/10/2002	$636,000	Complete. Multiple habitats (including agricultural land - grazing; riparian and riverine aquatic - riparian) protective fencing, revegetation, controlled burns, seeding and pond construction. 1,190.7 acres.
ERP-98-F01	**Butte Creek Watershed Coordinator Assistant, Education Project, Road Survey Project, Geomorphology Analysis, and Restoration Implementation** 1) Provided funds for an assistant watershed coordinator, 2) developed the Butte Creek Watershed Education Project, 3) funded the Butte Creek Watershed Road Survey, and 4) provided for a Geomorphology Analysis of Lower Butte Creek.	12/30/2001	$302,745	Complete

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-98-F03	**Butte Creek Acquisition and Riparian Restoration** Acquired and restored riverine habitat adjacent to spawning and holding pools in Butte Creek to provide an opportunity to develop and demonstrate methods of channel and floodplain management that would help stabilize the sediment from the remains of the gravel mining operations.	Unknown	$186,128	Complete. Acquired and conducted planning for stream length 93 acres/0.75 miles (Butte Creek Ecological Preserve, Honey Run Unit). Habitats: riparian, wet meadow, annual grassland, gray pine, SRA, oak woodlands.
ERP-98-F06	**Tuolumne River Floodway Emergency Repair and Long-Term Habitat Restoration Project (7/11)** Filled mining pits, removed dredger tailings, constructed setback levees, and restored the channel and floodplain in a 2.6 mile section of the Tuolumne River extensively mined for aggregate material.	6/30/2004	$1,358,846	Complete
ERP-98-F07	**Grayson River Ranch Perpetual Conservation Easement and Restoration** Provided a perpetual conservation easement on 140 acres, returning historic floodplain to the river, restoring critical riparian habitat, and providing greater flexibility with flood management.	10/31/2007	$582,000	Complete. Acquired 140 acres of which 26.5 acres were restored to riparian and riverine aquatic - riparian.
ERP-98-F11	**Merced River Salmon Habitat Enhancement - Phase III (Robinson Reach)** Eliminated predator habitat. Improved spawning and rearing habitat. Replanted riparian vegetation. This project will restore natural conditions to Merced River habitat at river miles 42 to 43.5. Restoration included filling/isolating deep pools, reconfiguring channel and floodplain characteristics, and increased riparian habitat.	9/30/2002	$2,433,000	Complete
ERP-98-F14	**South Napa River Wetlands Acquisition and Restoration Program** Attempted to acquire and restore over 600 acres of historical wetlands adjacent to the Napa River from four different private property owners.	3/30/2002	$688,500	Cancelled. This project is related to additional restoration activities taking place in the area under ERP-98-B13. Project was unable to purchase properties and remaining funds ($430,088.28) were deobligated on 11/12/02.
ERP-98-F15	**Lower Clear Creek Floodway Restoration Project (Phase II)** Improved salmon spawning and rearing habitat by implementing the Lower Clear Creek Watershed Management Plan and restoring 2.9 miles of floodplain and riverine aquatic habitat.	6/30/2006	$4,561,940	Complete. Reported 35.9 acres restored to riparian and from 1997-2000, annual gravel augmentation 24,000 tons was conducted.
ERP-98-F17	**Benicia Waterfront Marsh Restoration Project** This objective is to restore 8 acres of degraded salt marsh habitat along the Benicia waterfront in downtown Benicia for the benefit of several important plant and animal species.	2/28/2001	$59,000	Complete. Phase 1, which only involves final planning and permitting.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-98-F18	**Floodplain Acquisition, Management, and Monitoring on the Sacramento River** Funded the acquisition (via title or easement) of flood-prone lands adjacent to the Sacramento River between Keswick and Verona with the purpose of protecting and improving essential spawning, rearing, and migratory habitat for Chinook salmon and other riparian species, as well as supporting the river's natural ecological processes.	9/30/2002	$1,000,000	Complete. Acquired flood prone agricultural land (~106 acres) for riparian restoration.
ERP-98-F19	**Cosumnes River Floodplain Acquisition, Restoration Planning, and Demonstration** Supplemental funding for the acquisition of Denier property that was purchased in project ERP-97-N14.	9/30/2001	$750,000	Complete. Acquired 475 acres of agricultural land with ERP-97-N14.
ERP-98-F20	**Deer and Mill Creeks Acquisition and Enhancement** Project planned to acquire and restore almost 2,500 acres of critical riparian and floodplain habitat along the lower and middle reaches of Deer and Mill Creeks in the upper Sacramento River watershed for the benefit of wildlife.	12/31/2003	$1,000,000	Complete. Reported only 12 acres acquired.
ERP-98-F21	**Lower San Joaquin River Floodplain Protection and Restoration Project** Protect floodplain habitats. Implemented the acquisition of the Arambel and Rose property. Acquired 223.54 acres of wildlife habitat. This project is associated with an acquisition for the San Joaquin National Wildlife Refuge.	9/30/2002	$1,100,000	Complete
ERP-98-F23	**South Napa River Tidal Slough and Floodplain Restoration Project** This project represents the first phase in restoring over 460 acres of wetlands in the South Napa River Tidal Slough by funding acquisition of the property, preliminary design work, an environmental feasibility study, and environmental compliance documentation and permitting.	6/30/2001	$1,480,000	Complete. Acquired 453.24 acres. Habitats include: tidal perennial aquatic, saline emergent wetland, sloughs, seasonal wetlands, and perennial grasses.
ERP-99-B05	**Merced River Salmon Habitat Enhancement Project Phase II- Ratzlaff Reach Construction)** Reduced entrainment and predation of out migrating fish. Isolate 45 acres of unnatural predator habitat from the river channel. Improved river and floodplains dynamics and enhanced the riparian corridor. Increased the quantity and quality of in-stream spawning habitat. Funding covered costs for part of the construction.	3/30/2000	$1,584,002	Complete. Reconstructed berms to isolate approx. 45 acres of ponds from river. 3,000 ft (0.6 miles) of channel modified, 7,000 sq ft of spawning habitat will be created.
ERP-99-B11	**South Napa River Tidal Slough and Floodplain Restoration Project** Phase 2 of the South Napa River Tidal Slough and Floodplain Restoration Project, which involved the restoration of tidal flow to 2.3 miles of historic slough habitat, and the restoration of nearly 483 acres of wetlands and uplands.	9/30/2005	$1,520,000	Complete. Original and new habitats: perennial grasslands, saline emergent wetland, tidal perennial aquatic, tidal sloughs, and seasonal wetlands.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-99-B29	**Pilot Project to Benefit Riparian Vegetation Along the San Joaquin River** Monitored the downstream effects of the augmented flows at ten recommended cross sections, including the response of riparian seedlings and saplings on the San Joaquin River. This pilot project released 35,000 acre-feet of water during the period of June through October 1999, for the purpose to promote dispersal and germination of seed from native riparian plant species.	12/31/2001	$2,500,000	Complete. Released 25,052 acre-feet of water from Friant Dam during June-October 1999, to promote dispersal and germination of seeds from native riparian trees.
ERP-99-C01/C02	**East Delta Corridor Habitat Studies: Cosumnes and Mokelumne Rivers Feasibility Study** Feasibility Study of Ecosystem Restoration opportunities on the lower Cosumnes and Mokelumne Rivers.	12/31/2007	$1,007,800	Ongoing.
ERP-99-F02	**Tuolumne River Mining Reach Restoration (MJ Ruddy)** Reconstructed 1.1 miles of the lower Tuolumne River channel and floodplain that was previously diked for gravel mining and then destroyed by the January 1997 floods for the primary benefit of San Joaquin fall-run Chinook salmon.	3/31/2006	$168,813	Complete. Created a 500 ft wide floodplain and repaired 100 ft of berm breached in 1997 flood.
ERP-99-F03	**Part B: The McCormack-Williamson Tract's Wildlife-Friendly Levee Management Project** On the purchased McCormack-Williamson Tract (99-F04), The Nature Conservancy initiated startup stewardship, coordinated with agencies for restoration planning, and implemented a wildlife-friendly levee program.	12/31/2004	$860,778	Compete
ERP-99-N03	**East Delta Habitat Corridor, Tidal Marsh and Riparian Habitat Restoration** This tidal marsh and riparian restoration project improved habitat conditions along 14 miles of Georgiana Slough.	9/30/2003	$1,100,000	Complete. Enhanced 0.57 stream miles of tidal perennial aquatic (by ballast bucket planting method), and 7 stream miles of riparian (by planting propagated riparian trees along berm; removal of NIS species), and finally protected an addition 1.5 stream miles of riparian.
ERP-99-N15	**Lower Mokelumne River Watershed Stewardship Plan Program (Phase II/III)** This project was a continuation of a previously funded project by completing preparation of the Lower Mokelumne River Watershed Stewardship Plan/Watershed Owner's Manual, Action Plan, and Monitoring and Evaluation Program and implemented the Initial Watershed Stewardship Actions.	6/30/2002	$227,000	Complete. Produced watershed stewardship plan.

Table 1. Channel Forming Processes Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-99-N16	**Clear Creek Prescription** Created an ecosystem-based watershed management prescription for the Clear Creek watershed to 1) help achieve CBDA's vision of restoring important fishery, wildlife, and plant communities to a healthy condition, and 2) serve as a model for other watersheds in the state.	3/31/2003	$256,260	Complete. Treated 3 fuel break sites and 2 erosion sites, 3 culverts were replaced, and 200 ft of road out sloped to address erosion, sediment sources, and fire protection in upper watershed (36 acres enhanced total).
ERP-99-N18	**Geomorphic Model for Demonstration and Feasibility Assessment of Setback Levees: Bay-Delta River Systems** Developed a geomorphic model that allows simulation and demonstration of the response of riverine systems to levee removal and setback. Developed levee and infrastructure-placements component of this migration model; applied the model to simulate levee setback scenarios; developed interactive computer visualization of model output; and prepared model simulations, report and recommendations.	6/11/2004	$104,458	Complete
ERP-99-N20	**Napa River Watershed Stewardship Year 2** This project builds upon work in the Napa River watershed by continuing to address a broad range of ecological and biological issues relating to habitat restoration for anadromous fish and other priority species by promoting collaborative watershed stewardship.	12/30/2001	$191,100	Complete. Hydrologic modeling. Multiple habitats enhanced. Eroding bank stabilization, Himalayan blackberry eradication, riparian enhancement and revegetation, spawning habitat improvement (0.05 stream miles, 0.25 acres).
ERP-99-N21	**Development of a River Corridor Management Plan for the Lower American River** Developed a River Corridor Management Plan (RCMP) for the lower American River between the Sacramento River and the Nimbus Dam in Sacramento County to serve as a planning framework and consensus-building process for pursuing CALFED's vision and objective for ecosystem restoration along the American River.	4/1/2002	$250,000	Complete

Other Programs Contributing to ERP Vision

The CALFED Science program funded research that measured meander migration rates in the Sacramento River between Red Bluff and Colusa Constantine et al. (2006). Results show two temporally persistent patterns in migration rates: a previously recognized downstream alternation of active and stable reaches, and a mid-basin peak in migration rates. Stable reaches form where the river contacts resistant bank

material, and these reaches follow a distinctive temporal evolution. Among active reaches, migration rates increase through a zone of declining bed shear stress and stream power and peak where sinuosity and bankfull discharge are greatest (Constantine et al. 2006). Bankfull discharge and migration rates decline where frequent overbank flooding occurs. Increasing interaction of the channel with levees may contribute to the decline of migration rates (Constantine et al. 2006). These results suggest that both point bar growth, and curvature, drive migration in active portions of the river and that discharge plays a role in controlling migration rates by limiting the river's ability to erode and transport bank material (Constantine et al. 2006).

Status of Topic Today

Several organizations have purchased thousands of acres of land in the Sacramento River corridor for habitat conservation and restoration, aligning their conservation efforts with the goals and objectives of the Sacramento River Conservation Area Forum (SRCAF). For example, the Sacramento National Wildlife Refuge Complex has protected over 65,000 ac of riparian, upland, and wetland habitat in the northern Central Valley by obtaining fee title and conservation easements (Stillwater Sciences 2007). Meanwhile, agencies and non-profit organizations, like The Nature Conservancy, have purchased approximately 15,000 ac along the Sacramento River in the past decade. In the process, nearly 3,600 ac have been restored to native riparian forest (Stillwater Sciences 2007). Land acquisition for conservation and restoration are a significant step toward attaining the shared vision of promoting a healthy, contiguous riparian zone bordering a meandering Sacramento River between Red Bluff and Colusa (Stillwater Sciences 2007).

DWR funded restoration of 238 acres of former agricultural fields along the Lower Tuolumne River was initiated by notching surrounding berms to restore hydrologic connectivity, and planting 60 acres with native riparian trees and shrubs (Hayden et al. 2007). Results imply that restoration of floodplain hydrogeomorphic function at this site is modest under regulated flow conditions without lowering floodplain surfaces. However, it does provide periodic benefits to aquatic ecosystems during wet years and will continue to improve riparian conditions for terrestrial species as planted and naturally recruited vegetation matures (Hayden et al. 2007).

U.S. Geological Survey (USGS) created a GIS tool to assist environmental managers in addressing concerns regarding the remobilization of buried and sometimes contaminated sediments in the San Francisco Bay (Higgins et al. 2006). Approximately 400 million cubic meters of mining debris associated with elevated mercury levels were deposited in North San Francisco Bay during the 1800s, and the model reveals that about half of this deposition remains on the bay floor (Higgins et al. 2006). San Francisco Bay Conservation and Development Commission developed a Long Term

Management Strategy (LTMS) for the placement of dredged material in the San Francisco Bay region was developed and implemented (Goldbeck and Ross 2007). Today the LTMS agencies are halfway through the transition to low in-Bay disposal volumes and significant beneficial reuse. The Sonoma Baylands project was constructed using dredged material, the Montezuma Wetlands project is accepting material, the Hamilton Wetlands project is coming online, and dredged sand is being used to directly nourish Ocean Beach (Goldbeck and Ross 2007). There is a comprehensive testing program for dredged material, and an interagency Dredged Material Management Office coordinates permit applications.

USGS studied the channel response to the Saeltzer Dam removal on Clear Creek (Miller and Kondolf 2006). The dam removal has allowed over 3000 m^3 of sediment to erode from the former dam site. About 10% of the total volume has redeposited in a downstream riffle. High flows caused lateral bank erosion to occur which led to the desiccation and mortality of riparian trees near the site.

Delta Protection Commission developed a comprehensive map of urbanization risk in the Delta (Westhoff et al. 2007). They determined that at least 75,000 acres of land was at very high risk of urbanization within or adjacent to the Delta. In many cases these developments were on deep floodplain and below sea level by up to ten feet (Westhoff et al. 2007).

Climate change will have a potentially large, but yet unknown, effect on sediment availability in the future. Sea level rise has accelerated and the landward movement of the marshes has been restricted by the bayfront levees. The marshes have been 'squeezed' between the rising water and the levees, resulting in erosion of the mudflats and loss of marsh. In turn, the loss of marsh in front of the levees has allowed larger waves to reach and erode the levees. Most restoration projects in San Francisco Bay are subsided sites separated from the Bay or slough by levees. With each passing year, subsided land in the Bay and Delta will require additional material to be restored.

Planned Projects for Implementation

There are approximately 77 projects that have provided either planning or acquisition of property for restoration of floodplain in various locations throughout the CALFED Regions. One project that needs to move forward is the Yolo Bypass Management Strategy Project which provides guidance for the 59,000 acre Yolo Bypass. The purpose of the project is to foster stakeholder stewardship in order to encourage practices that protect and enhance fish and wildlife habitat, while respecting and maintaining economic viability of the land and water users, and maintaining flood management functions. Another project which will help ERP reach its goals to restore floodplain is the Restoring Ecosystem Integrity in the Northwest Delta project. It is developing plans for fee acquisition or conservation easement acquisition within the

Jepson Prairie-Prospect Island Corridor. Planning for various sub-reaches of the Sacramento River have been or are nearly complete (e.g. Colusa Subreach Planning on the Sacramento River between River Miles 143.5 and 164.5). Implementation of these plans should be start soon.

Impediments to Implementation

Impediments to making further gains come primarily from conflicts or concern posed by adjacent landowners with different land use goals. Tension between agricultural landowners and restorationists along the Sacramento River is due to the conversion of farmland into riparian forest and valley oak savanna. There is a perception that restoration will cause negative biological and physical impacts on farming and the local environment, such as more frequent flooding and additional wildlife issues (Singh 2007). Some local agricultural landowners have created political opposition to increasing the riparian habitat corridor within the Sacramento River Conservation Area.

The Glenn County Resource Conservation District looked at an environmental conflict management process to reduce tensions between stakeholders along the Sacramento River. They researched the environmental history of the river and interviewed stakeholders to describe the evolution of, and reasons for, the conflicts between stakeholders (Singh 2007). The study constructed a theoretical model of an ecological commons to describe the political and environmental interactions that contribute to the conflict as well as the difficulty in managing conflict along the Sacramento River (Singh 2007).

The issue of riparian areas harboring agricultural pests was examined by Golet et al. (2007). Farmers are concerned that riparian areas harbor agricultural pests in numbers at least as high as would be found in the absence of adjacent riparian vegetation. However, the relative abundance of small mammal pests was found to be typically lower in older restoration sites and remnant habitats than in agricultural sites (Golet et al. 2007).

Other impediments to protecting or increasing riparian habitat are issues with flood control and bank armoring (riprap) projects. There are levee, bridge, and bank-protection structures are present along more than 2,600 miles of rivers in the Central Valley and in the Delta (DWR 2005). These projects work against the natural meander process of the rivers and isolate riparian habitat from the rivers which they are associated. Plans for new bank protection projects continue to be developed and, if implemented, would further reduce available habitat.

Gaining and maintaining public support is important to the future of ecosystem restoration of riparian systems. In addition to the values of biodiversity and healthy natural systems, large segments of the public look for specific benefits that affect their

everyday lifestyle, such as recreation opportunities (Werner et al. 2007). TNC in partnership with EDAW developed two public recreation plans that were tied to the conservation of riparian habitat in Colusa County (Werner et al. 2007). Through an intensive public engagement process, local consensus on these plans was achieved in an area which has not traditionally supported ecosystem restoration efforts (Werner et al. 2007).

Finally, the very high risk of urbanization within or adjacent to the Delta continues to be a major impediment to floodplain restoration in and around the Delta.

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3. ECOSYSTEM PROCESSES

3.3. Cycling and Transport of Nutrients, Detritus and Organisms

3.3.1. Bay-Delta Aquatic Foodweb

Introduction

The Bay-Delta aquatic foodweb is the system where energy flows through the different trophic levels from primary producers (e.g. phytoplankton and plants) up to top predators such as fish, birds and mammals in the Bay-Delta system. Each trophic level receives energy from lower levels, with the primary producers obtaining energy via photosynthesis (CALFED 2000a). The second level in aquatic foodwebs (primary consumers) generally consists of algae-eating zooplankton and bacteria that feed on a variety of plant products.

Phytoplankton and benthic algae are the main contributors to primary productivity in the aquatic foodweb. Chlorophyll *a* concentrations (a measure of phytoplankton production) have declined in the past 40 years. This decline has been especially dramatic since the mid-1980s, when *Corbula amurensis* (previously *Potamocorbula amurensis*) was introduced to the estuary from ship ballast water.

There has been a restructuring of the zooplankton community in the Delta over the last 40 years. Relative abundance of native species has changed and numerous non-native species have been introduced. There has been an overall decline in zooplankton during this time period, coinciding with a decline in phytoplankton, a main food source for zooplankton. This may be a serious problem because many fish species depend on zooplankton as a food source during at least early life stages.

Many Delta species appear to be food-limited. This may be due to a variety of factors including: low phytoplankton production in open water habitats due to light limitation from high turbidity; a shortage of productive shallow-water regions such as marshes; consumption and sequestering of primary and secondary production by the non-native overbite clam (*Corbula amurensis*) and the Asian clam (*Corbicula fluminea*); shifts in the primary consumer community toward non-native species; toxic substances; and other factors.

Applicable ERP Vision

The vision for the Bay-Delta aquatic foodweb is to increase estuarine productivity and rehabilitate estuarine foodweb processes to support the recovery and restoration of native estuarine species and biotic communities. The associated goal is to restore primary and secondary production to levels comparable to those found in the 1960s and early 1970s by enhancing productivity and reducing the adverse effects of introduced aquatic species (CALFED 2000a).

This will be accomplished by actions such as increasing the residence time of water in the Delta; restoring tidal action to diked wetlands; and reducing concentrations and loadings of trace metals, herbicides, and other toxic substances in sediments and waters of the Central Valley. In addition, information about nonnative species impacts to the foodweb must be developed.

Stage 1 Expectations

Specific Stage 1 expectations for this topic were not called out in the ERPP documents. However, the visions listed above give a clear direction as to what ERP is expected to achieve regarding the aquatic foodweb.

Changes Attributable to ERP

Sustained biological monitoring in the Sacramento-San Joaquin Delta has shown that some biological populations are smaller now than they were only two or three decades ago. The causes of these population declines, and the degree to which they are linked to impairment of ecosystem functions that support fish production, are not well understood.

Delta foodwebs are influenced by a complex interaction of factors such as nutrients, hydrodynamics, toxic contaminants, and invasive species. The ERP funded nine projects to increase understanding of these factors and their interactions within Delta foodwebs.

DOC is a key component at the base of the foodweb, and understanding its sources and fates is critical to understanding more complex elements of the Delta foodweb. *Dissolved Organic Carbon Release from Delta Wetlands, Part 1* (**ERP-99-B17**) and *Dissolved Organic Carbon Release From Delta Wetlands, Part II - Fluxes and Loads from Tidal and Non-tidal Wetlands and from Agricultural Operations* (**ERP-00-G01**) examined the complex interactions of soil, vegetation, hydrologic and biogeochemical processes, land and water management, and other factors that determine the amount and timing of dissolved organic carbon (DOC) input to the Delta.

These studies found that seasonal variability in DOC is common, with concentrations in peat island agricultural drainage waters ranging from 10 to 70 mg/L throughout the year. DOC in Delta peat island drains may result largely from groundwater flow through oxidized peat soil layers. Wetland plants and soils may also be a significant source of DOC in surface water, particularly where tides may carry DOC from wetlands into the major channels. However, wetlands are not always important sources of DOC; a particular wetland may release insignificant amounts of DOC, depending on its configuration.

Rivers supply the bulk of DOC to the Delta, with DOC loads the greatest in the winter. However, the winter was also found to be the time of greatest in-Delta contributions. In late summer and fall there is little contribution from in-Delta sources and river DOC accounts for greater than 80% of the DOC arriving at the Banks Pumping Plant (Banks) in the south Delta.

Overall, the studies found that the composition of DOC at Banks is best explained as a mixture of river-, wetland-, and island-derived material, with larger contributions from wetlands from early spring, through fall, and larger contributions of island drains in early winter. These and other studies demonstrate that there are a number of sources of DOC within the Delta, with substantial variability in their relative contribution during the year. The notion that the island drains are the sole significant in-Delta source of DOC has been replaced by the realization that other in-Delta sources, such as wetlands, flood plains and riparian areas, also appear to be significant sources.

Assessment of the Sacramento-San Joaquin River Delta as Habitat for Production of the Food Resources that Support Fish Recruitment (**ERP-97-B06**) focused on determining how different Delta habitats support secondary production which fuels many organisms in the Delta. The researchers found that Delta zooplankton appear to be food limited, with phytoplankton being a key food source, and concluded that restoration actions to augment Delta primary production may help to increase zooplankton production.

Primary Production in the Delta: Monitoring Design, Data Analysis and Forecasting (**ERP-02-P33**), focused on improving phytoplankton monitoring and modeling to help quantify processes regulating long-term change. In contrast to the results from *Assessment of the Sacramento-San Joaquin River Delta as Habitat for Production of Food Resources to Support Fish Recruitment* (**ERP-97-B06**), above, this study concluded that the trend in primary productivity was positive in the Delta and neutral in Suisun Bay. The authors postulate that therefore changes in fish populations were likely due more to competition for this food source by the invasive clam, *Corbula amurensis* than an actual decrease in primary productivity. *Corbula* feeding on phytoplankton compete for primary production with the zooplankton, and also consume zooplankton larvae. The resulting reduction in zooplankton populations is thought to contribute to reduction in fish populations.

Delta hydrodynamics strongly affect the cycling and transport of food resources in the Delta. *Shallow Open Water Habitats: Hydrodynamics and Benthic Grazing* (**ERP-02-P22**) conducted field and modeling studies to investigate the role of both wind waves and currents in determining vertical mixing in shallow water and the resulting implications for phytoplankton dynamics. This study observed that benthic grazing increased as flow increased, due to the greater flux of phytoplankton biomass, suggesting hydrodynamic rather than biological control on benthic food supply.

Contaminants are also transported by Delta hydrodynamics. *Transport, Transformation and Effects of Selenium and Carbon in the Delta of the Sacramento-San Joaquin Rivers: Implications for Ecosystem Restoration* (**ERP-01-C07**) analyzed and modeled selenium uptake in the bay and its effect on Delta foodwebs. Studies focused on bivalves in the Delta, and predatory relationships that result in bioaccumulation in the foodweb through trophic transfer. This study indicated that bacteria and phytoplankton in the Delta seem to be very different in their selenium content, that concentrations of selenium in clams have not changed since 1995, and that these concentrations are highly dependent on growth.

Many exotic species are able to flourish in the Delta because they lack both competition and predators. These species now dominate many aquatic communities, and are thought to exert major influence on the Delta foodweb. An example of this is the substantial decline in lower trophic level production that followed the introduction of the Asian clam, *Corbula amurensis* (Kimmerer and Orsi 1996).

Effects of Introduced Clams on the Food Supply of Bay-Delta Fishes (**ERP-99-F11**) studied the effects of *C. amurensis* on higher trophic levels. It was found that these effects varied, depending on the species. Longfin smelt showed the greatest decline, possibly because they feed on mysids during the juvenile stage. Northern Anchovies shifted their abundance pattern after the clam arrived so that they were no longer very abundant in the low-salinity zone. According to the researchers, this shift is likely a behavioral response to limited food, and the studies conclude that growth and reproductive rates are severely food-limited most of the time, largely due to impacts of invasive species.

Effects of Introduced Species of Zooplankton and Clams on the Bay-Delta Food Web (**ERP-99-N09**) conducted research to determine the effects of clams on the feeding environment of fish, the competitive and predatory relationships of native and introduced fish, the production rate of food for young fish in the estuary; and to characterize how native and introduced zooplankton are used as food. Nearly all previous studies of food limitation of different animals in the San Francisco Estuary concluded that growth or reproductive rate is severely food-limited most of the time. The grazing by these invasive species has caused a dramatic decrease in the production of phytoplankton where distributions of silica (required for diatom growth) have been

severely changed. Mysid biomass is an important link between the sea floor and the open water food webs, and these studies indicated that since the invasion of these invasive exotic species, mysid biomass has been declined dramatically.

An Evaluation of the Potential Impacts of the Chinese Mitten Crab on the Benthic Communities in the Sacramento-San Joaquin Delta and Suisun Bay (**ERP-99-B18**) studied the relationship between the Chinese Mitten Crab (*Eriocheir sinensis*) and the larger benthic invertebrate community within the Sacramento-San Joaquin Delta and Suisun Bay.

Assessing Delta food webs is difficult because of the interactions of hydrodynamics, water quality, and invasive species, and trends can be identified only through long term monitoring and consistent measurement.

A possible mechanism for the decline in native and harvestable fishes is that the quantity and quality of their food resources may have become insufficient for successful recruitment. This *Food Resources for Zooplankton in the Sacramento-San Joaquin River Delta* study (**ERP-01-N50**) investigated how copepods utilize the food resources available in different Delta habitats and compare our findings to those for cladocerans; this project also compared the diets and habitat requirements of the formerly very abundance copepods, *Eurytemora affinis* and *Cyclops vernalis*, with those of the new dominant exotic species, *Pseudodiaptomus forbesi*, *Sinocalanus doerri* and *Limnoithona sinesis*; and analyzed historic zooplankton and phytoplankton compiled by IEP for relationships between phytoplankton food quality and zooplankton abundances. The project does not propose specific restoration efforts, but the data derived from this project directly benefits restoration and preservation objectives in the Delta.

Project Summary Table

Table 1. Bay-Delta Aquatic Foodweb Project Summary

ERP Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-02-P32	**Distribution and abundance of shrimp, plankton and benthos in Suisun Marsh** The project objectives are: 1) to evaluate the effect of the presence of alien species on the local community structure and 2) to investigate the influence that habitat type and environmental conditions have on the type and abundance of species present in the tidal marsh community. Tasks include selecting sampling site locations, benthos sampling, mysid sampling, zooplankton sampling and a draft and final report on methodology, data summary and analyses and conclusions.	10/31/2007	$377,549	Ongoing

Table 1. Bay-Delta Aquatic Foodweb Project Summary

ERP Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-02-P33	**Primary Production in the Delta: Monitoring Design, Data Analysis and Forecasting** Investigated mechanisms governing phytoplankton production and biomass.	3/31/2007	$315,811	Successfully completed. Project Final Report in ERP Database.
ERP-02-P22	**Shallow Open Water Habitats: Hydrodynamics and Benthic Grazing** Developed detailed view of how tides and wind-generated waves determine physical structure and hydrodynamics of shallow estuarine waters, and how physical processes can constrain net primary production through their effects on grazing and light.	5/31/2007	$616,605	Successfully completed. Project Final Report in ERP Database.
ERP-02-P40	**Trophic Transfer in the San Francisco Bay/Delta: Identifying Critical Processes for the Ecosystem Restoration Program** This research project focused on factors affecting production of methyl mercury and its bioaccumulation in the foodweb, primarily by contrasting two Delta sites- Frank's tract and the Cosumnes River.	6/30/2007	$2,684,824	Complete.
ERP-01-C07	**Transport, Transformation and Effects of Selenium and Carbon in the Delta of the Sacramento-San Joaquin Rivers: Implications for Ecosystem Restoration** Evaluated transformation of selenium and carbon and determined how transport and transformation of selenium affects critical food webs.	6/14/2005	$2,862,706	Successfully completed. Project Final Report in ERP Database.
ERP-01-N01	**The Influence of Flood Regimes, Vegetative and Geomorphic Structures on the Links between Aquatic & Terrestial Systems** This project examined the floodplain dynamics in the Cosumnes watershed by assessing levee breaches and other flow restoration efforts under which ecological succession is effective in restoring the structure and foodweb dynamics characteristic of functioning native ecosystems.	6/30/2006	$2,652,750	Complete.
ERP-01-N38	**Delta Studies Program: San Joaquin County Schools** This project increased student and teacher knowledge at sixty targeted schools in San Joaquin County. The program developed a Delta Studies Curriculum, developed and maintained a Delta Education Resource Center, and recruited, identified, trained, and supported a cadre of thirty teacher leaders each per years Two and Three called Delta Educational Leaders for Teaching and Action (DELTA).	6/30/2004	$323,198	Complete.
ERP-01-N50	**Food Resources for Zooplankton in the Sacramento-San Joaquin River Delta** Assessed the quantity and quality of food resources for copepods in various habitats of the Sacramento-San Joaquin River Delta.	3/31/2005	$576,422	Complete.

Table 1. Bay-Delta Aquatic Foodweb Project Summary

ERP Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-00-G01	**Dissolved Organic Carbon Release From Delta Wetlands, Part II - Fluxes and Loads from Tidal and Non-tidal Wetlands and from Agricultural Operations** Focused on the loads of DOC contributed to tidal and non-tidal wetlands and agricultural operations and provides a quantitative basis for estimating the relative contributions of different wetlands to Delta TOC/DOC.	12/31/2006	$3,571,121	"Final report" is submission of a series of subject-specific reports that will be published in scientific journals. Reports are in various stages of review and completion, but all should be submitted within the next few months.
ERP-99-N08	**Assessment of Pesticide Effects on Fish and their Food Resources in the Sacramento-San Joaquin Delta** An integrated laboratory and field study with the objectives of providing information on pesticide toxicity to resident species in the Sacramento-San Joaquin Delta, developing the data needed to apply laboratory-derived toxicity measures to realistic field conditions, and putting results in an ecological context focusing on juvenile Chinook salmon and their prey.	12/29/2003	$1,706,670	Complete.
ERP-99-N09	**Effects of Introduced Species of Zooplankton and Clams on the Bay-Delta Food Web** Investigated effects of introduced species on food web with emphasis on the clam *Corbula amurensis*, and other introduced zooplankton.	3/31/2004	$653,384	Successfully completed. Project Final Report in ERP Database.
ERP-99-F11	**Effects of Introduced Clams on the Food Supply of Bay-Delta Fishes** Analyzed existing data and modeled effects of introduced clam *Corbula amurensis* on food webs.	12/31/2003	$100,490	Successfully completed. Project Final Report in ERP Database.
ERP-99-B18	**An Evaluation of the Potential Impacts of the Chinese Mitten Crab on the Benthic Communities in the Sacramento-San Joaquin Delta and Suisun Bay** Investigated relationship between Chinese mitten crab (*Eriocheir sinensis*) and benthic invertebrate community.	3/31/2003	$178,764	Contract expired.
ERP-98-B07	**Evaluation of Selenium Sources, Levels, and Consequences in the Delta** This study performed an integrated evaluation of Se sources and impacts within the Bay-Delta system. The tasks included a description of the sources of and current baseline levels of Se, the effect of changing sources on concentrations in primary consumers, subsequent uptake by predators, the effects on reproduction and development in sturgeon, and models to forecast outcomes of alternative Se remediation strategies.	12/31/2001	$1,627,117	Complete.

Table 1. Bay-Delta Aquatic Foodweb Project Summary

ERP Project Number	Project Name and Purpose	End Date	Total Funding	Project Status
ERP-98-C15	**Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watersheds** This project will investigate green sturgeon's biological requirements, such as food and oxygen requirements at different water temperatures, swimming performance, larvae and fry development needs, and effects of stressors on reproductive functioning.	10/31/2001	$241,000	Complete.
ERP-99-B17	**Dissolved Organic Carbon Release from Delta Wetlands, Part 1** Evaluated the concentration, quantity, and microbial alteration of organic carbon from different sources.	12/31/2006	$1,582,669	Contract has closed, but work has been continued through ERP-00-G01 (see below).
ERP-97-B06	**Assessment of the Sacramento-San Joaquin River Delta as Habitat for Production of Food Resources to Support Fish Recruitment** Evaluated habitat influences on the production and utilization of organic matter as a food source.	9/30/2001	$923,429	Successfully completed. Project Final Report in ERP Database.

Other Programs Contributing to ERP Vision

The Interagency Ecological Program (IEP) for the San Francisco Bay-Delta is an estuary monitoring and research program conducted by three state and six federal agencies, including the Department of Fish and Game, the Department of Water Resources, the State Water Resources Control Board, the U.S. Army Corps of Engineers, the Environmental Protection Agency, NOAA Fisheries, the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey. The IEP has collected data in the Bay/Delta Estuary for more than 45 years.

In early 2005, the IEP announced their observation of a decline in pelagic organisms. While inter-annual variations are typical, the IEP believed that their observation was a long term trend. This was unexpected because the hydrologic conditions in the estuary during this period were believed to be relatively less harmful to fish species than during other periods during which a decline had not been observed. In addition, the decline in multiple species also made the changes of particular concern.

To address these concerns a new IEP working group was formed in January 2005, and more than $22 million was earmarked to support the IEP and research the causes of the pelagic organism decline (POD). More than 40 POD-related studies and monitoring programs are underway.

A variety of actions are being implemented, or are under study, to address the POD, including comprehensive ecosystem evaluations, changes to water project operations,

food web enhancement through increased flows, habitat improvements, increased control of invasive species, and delta smelt research (Resources Agency 2007).

Other state and federal efforts to restore the productivity of the Bay-Delta foodweb include:

- The Central Valley Project Improvement Act (PL 102-575) and its associated Anadromous Fish Restoration Plan, which includes provisions to reduce losses of organisms from water diversions, restore aquatic habitat, improve water quality, improve freshwater flows, and restore wetland and riparian habitats in the rivers and Bay-Delta.
- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes, which calls for improving flows, reducing diversions, and increasing habitat.
- The Recovery Plan for Winter Run Chinook Salmon, which includes recommendations for habitat and foodweb restoration in the Bay-Delta and Sacramento River.

Status of Topic Today

Solving the foodweb problem directly is difficult. However, other actions taken as part of the IEP, such as increasing the acreage of tidal or seasonally flooded marshlands, are presumably contributing to the solution. Recent studies have demonstrated that tidal marsh restoration would likely increase phytoplankton biomass in the estuary and enhance the planktonic foodweb. In a study of carbon types and bioavailability, tidal marsh sloughs had the highest levels of DOC, POC (particulate organic carbon), and phytoplankton-derived carbon (Sobczak et al. 2002). Tidal sloughs were also the highest in Chlorophyll *a* concentration, an important factor in zooplankton growth rate (Müller-Solger et al. 2002). It appears that high residence time of water, nutrient availability, and absence of alien clams contribute to high levels of primary production (Jassby et al. 1993) and empirical studies (Lopez et al. 2006) suggest that productivity from high-producing areas, such as marsh sloughs, is exported to other habitats.

Planned Projects for Implementation

Efforts should continue to evaluate large-scale restoration projects of tidal emergent, seasonal, and non-tidal perennial wetlands, and to generate hypotheses about what actions might increase productivity. Pilot studies should be conducted based on those findings and testing hypotheses.

Impediments to Implementation

A major obstacle to solving problems of estuarine productivity is our poor understanding of complex estuarine systems. Research and monitoring of the effects of various ecosystem restoration projects is essential to improving our understanding. Extensive invasion of the estuary by non-native species has substantially impacted Delta foodwebs. Non-native species directly compete with natives for food, or have so significantly altered the food web that native species are food-limited. Exotic plants and weeds have changed native aquatic habitats by altering substrate, food/light availability, and/or water quality constituents. Additional introductions of new invasive species are probably inevitable, as are their impacts on Delta foodwebs.

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3. ECOSYSTEM PROCESSES

3.4. Water Quality

3.4.1. Central Valley Stream Temperatures

Introduction

Water temperatures in Central Valley streams are determined by water source, surface and groundwater inflow, geomorphology, tides, riparian shading, water clarity, and ambient air temperature. Water temperature is a major factor in habitat suitability for aquatic organisms; and unnaturally high water temperature is a stressor for many aquatic organisms, particularly because warm water contains less dissolved oxygen. Lower water temperatures also hinder the success of non-native species, thus reducing predation and competition for food and habitat (CALFED 2000a).

Major factors that limit water temperature contributions to the health of the Bay-Delta are disruption of historical streamflow patterns, loss of riparian vegetation, stored water releases from reservoirs, and discharges from agricultural drains.

Applicable ERP Vision

The vision for Central Valley stream temperatures is to restore natural seasonal patterns of water temperature in streams, rivers, and the Delta by protecting and improving ecological processes that regulate water temperature and reducing stressors that change water temperature, in order to benefit aquatic species (CALFED 2000b).

The ERP goal for Central Valley stream temperatures is to rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats to favor native species (CALFED 2000b).

Virtually all streams in the Central Valley are regulated to at least some extent, and the regulated flow regimes frequently favor non-native fishes. The ERP objective for Central Valley stream temperatures is to create and maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species (CALFED 2000a). Associated short- and long-term objectives are to provide adequate flows, temperatures, and other conditions to double the number of miles of regulated streams that are dominated by assemblages with four or more native fish species, and to restore native fish and invertebrate assemblages to other regulated streams wherever feasible.

Stage 1 Expectations

Stage 1 expectations for Central Valley stream temperatures included the expectation that surveys to determine the status of native fishes would be completed in all regulated streams in the Central Valley. Flow recommendations would be made to restore native fishes, where feasible. During negotiations for relicensing of dams, agency personnel were to evaluate and consider flow regimes favorable for native fishes (CALFED 2000b).

Changes Attributable to ERP

Four projects were funded by the ERP to address the targets for Central Valley stream temperatures. Two of these projects, *Stanislaus-Lower San Joaquin River Water Temperature Modeling and Analysis* (**ERP-02-P28** and **ERP-06D-S20**) conducted monitoring and modeling for flow recommendations. Another project, *Data Collection for the San Joaquin Basin-wide Temperature Model* (**ERP-05D-S02**) provides the funding needed by DFG to carry out activities related to collecting, storing, and managing water temperature and meteorological data in support of developing the San Joaquin River Basin-Wide Water Temperature Model. And the fourth project, *Narrows II Flow Bypass System* (**ERP-02-P47**) was a construction project for a bypass system to eliminate flow and temperature fluctuations.

Stanislaus-Lower San-Joaquin River Water Temperature Modeling and Analysis (**ERP-02-P28**) modeled water management alternatives in the Stanislaus River Basin to determine the relationship between water operations and river temperatures, and simulated operational strategies to assess the costs and benefits of several alternatives. Actions identified for potential implementation on the Stanislaus River were: removing the Old Melones Dam; constructing a power bypass on the New Melones Dam; modifications to the operations of New Melones Dam; and retrofitting the lower outlet of the Goodwin Dam.

San Joaquin River Basin Water Temperature Modeling and Analysis (**ERP-06D-S20**) expands the completed Stanislaus-Lower San Joaquin River Water Temperature Model to include the Tuolumne and Merced Rivers, and the main-stem San Joaquin River from Stevenson to Mossdale. This will to provide a single basin-wide model intended to be more effective for evaluating the impacts of competing water demands.

The Narrows 2 Power Plant Flow Bypass System (**ERP-02-P47**) was constructed on the Yuba River about 24 miles upstream from its confluence with the Feather River, and completed in February 2007. The system was designed to eliminate or substantially reduce flow fluctuations, caused mainly by uncontrollable emergency shutdowns of the

Narrows 2 Power Plant, and their associated biological impacts on fish habitat for at-risk species in the lower Yuba River.

The Narrows 2 Power Plant Flow Bypass System provides for continuous release of cold water from Englebright Reservoir during emergency shutdowns by releasing water from the bottom of the reservoir as opposed to spilling warmer water over the top of Englebright Dam, thereby preventing potential downstream water-temperature impacts to fish habitat. U.S. Geological Survey stream gages are located downstream from Englebright Dam and Reservoir, however sufficient temperature data are not yet available to determine long-term changes to the frequency or magnitude of temperature and flow fluctuations.

Project Summary Table

Table 1. Central Valley Stream Temperature Project Summary.

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-06D-S20	**San Joaquin River Basin Water Temperature Modeling and Analysis** Expand the existing Stanislaus-Lower San Joaquin River Water Temperature Model to include the Tuolumne and Merced Rivers, and the main-stem San Joaquin River from Stevenson to Mossdale.	12/31/2008	$716,052	Ongoing.
ERP-05D-S02	**Data Collection for the San Joaquin Basin-wide Temperature Model** This directed action provides the funding needed by DFG to carry out the support activities related to collecting, storing, and managing water temperature and meteorological data in support of developing the San Joaquin River Basin-Wide Water Temperature Model.	6/30/2008	$781,000	Ongoing. Will deploy and maintain 106 thermographs throughout the project area. Transferred all temperature model input data for model calibration runs.
ERP-02-P28	**Stanislaus-Lower San Joaquin River Water Temperature Modeling and Analysis** Model water management alternatives in the Stanislaus River Basin to determine the relationship between water operations and river temperatures, and simulate operational strategies.	10/31/2006	$878,827	Complete.
ERP-02-P47	**Narrows II Flow Bypass System** Construct bypass system to eliminate flow and temperature fluctuations from emergency and maintenance shutdowns at the Narrows 2 Hydropower Plant on the Yuba River.	6/30/2008	$8,535,567	Complete.

Other Programs Contributing to ERP Vision

Numerous fish and wildlife agencies and water resource agencies have collaborated through the Federal Energy Regulatory Commission's Relicensing processes to

reevaluate flow and water temperature standards. The newer standards are typically better for aquatic resources.

Other state and federal efforts to better manage water temperatures include:

- Department of Water Resources' operation of Lake Oroville to satisfy DFG hatchery and stream temperature objectives.
- Bureau of Reclamation's operation of Central Valley Project reservoirs to achieve specific temperature criteria for salmon and steelhead.
- Federal Energy Regulatory Commission's regulation of minimum flows below hydropower projects throughout California.
- State and Regional Water Quality Control Boards' administration of water rights and water quality objectives for beneficial uses.
- USGS's measurement of streamflow and temperature to provide data necessary for adaptive management of stream temperatures.

Status of Topic Today

The water temperature requirements of aquatic species have been well documented. However, having the flexibility to provide water at the appropriate temperature and time is sometimes problematic. Through FERC relicensing, FESA and CESA consultations, and State Water Board hearings, stream temperature targets and requirements have been set for most waterways. Still, water temperature modeling is a useful tool to see if existing operations can be improved.

Other opportunities may arise in the near future to provide water at the necessary temperature for fish restoration purposes. One example is the San Joaquin River Restoration Program that is seeking to reestablish a spring-run Chinook salmon population.

Planned Projects for Implementation

The Narrows Bypass at Englebright Dam on the Yuba River has been completed. The other two studies are modeling efforts to better understand water management implications for storage, release, and water temperatures. Although more modeling is probably needed, such modeling could potentially result in operational opportunities to improve water temperatures for aquatic species.

Impediments to Implementation

A lack of funding for additional studies is an impediment.

References

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