2. REGIONAL OVERVIEWS

2.1 Bay-Delta Systems Regional Overview

Suisun Marsh/North San Francisco Bay Description

The Bay Region, or the Suisun Marsh/North San Francisco Bay Ecological Management Zone, includes the San Francisco Bay area (excluding Central and South bays), Suisun Bay and Marsh, San Pablo Bay, and the Napa River, Petaluma River and Sonoma Creek watersheds. This region is the westernmost zone of the Ecosystem Restoration Program. The eastern boundary is near Collinsville and the western boundary is the northwestern end of San Pablo Bay. The northern boundary follows the ridge tops of the Coast Ranges and the southern boundary is the San Rafael/Richmond Bridge.

The definition of the ERP Management Zone excludes Central and South bays. However, these areas are in the CALFED solution area and must be considered if CALFED goals are to be accomplished. South and Central Bay are interconnected with the original management zone by migration of anadromous fish (both into small streams throughout the watershed and through Central Bay as they move into the larger watershed). Overlapping territories of brackish water organisms, transport of sediments and circulation of waters also connect all the sub-systems in the Bay-Delta. For example, ecological disturbances in South or Central Bay could counter progress made in restoration efforts in the original Management Zone. Water quality and availability decisions in the Delta affect South Bay water supplies and demand in South Bay could affect supplies for other localities. The disturbance of tidal marshes and baylands, typical of the original Management Zone, also apply to Central and South Bay.

The important habitat types in this region are tidal perennial aquatic habitat, tidal brackish and salt marshes, seasonal wetland, perennial grassland, riparian habitat and agricultural land. This region supports a host of native and non-native species of fish, waterfowl, shorebirds and other wildlife, including many native plant communities housing rare or endangered plants that are dependent on wetland processes. Additionally, all Central Valley anadromous fish migrate through the Bay Region and depend on its open water and marshes for some critical part of their life cycle. Many Pacific Flyway waterfowl and shorebirds pass through or winter in the Bay Region and feed in this highly productive estuary. The Bay Region and its adjacent marshes are important nursery grounds for many marine, estuarine and anadromous fish species. Some of the species of concern include Chinook salmon, delta smelt, splitttail, salt marsh harvest mouse, California clapper rail, and numerous sensitive plant species.

Ecological factors having the greatest influence on this region include: freshwater inflow from rivers and creeks; tidal action and climate (precipitation, evaporation, wind and barometric pressure); wetland distribution, abundance and quality; structure and

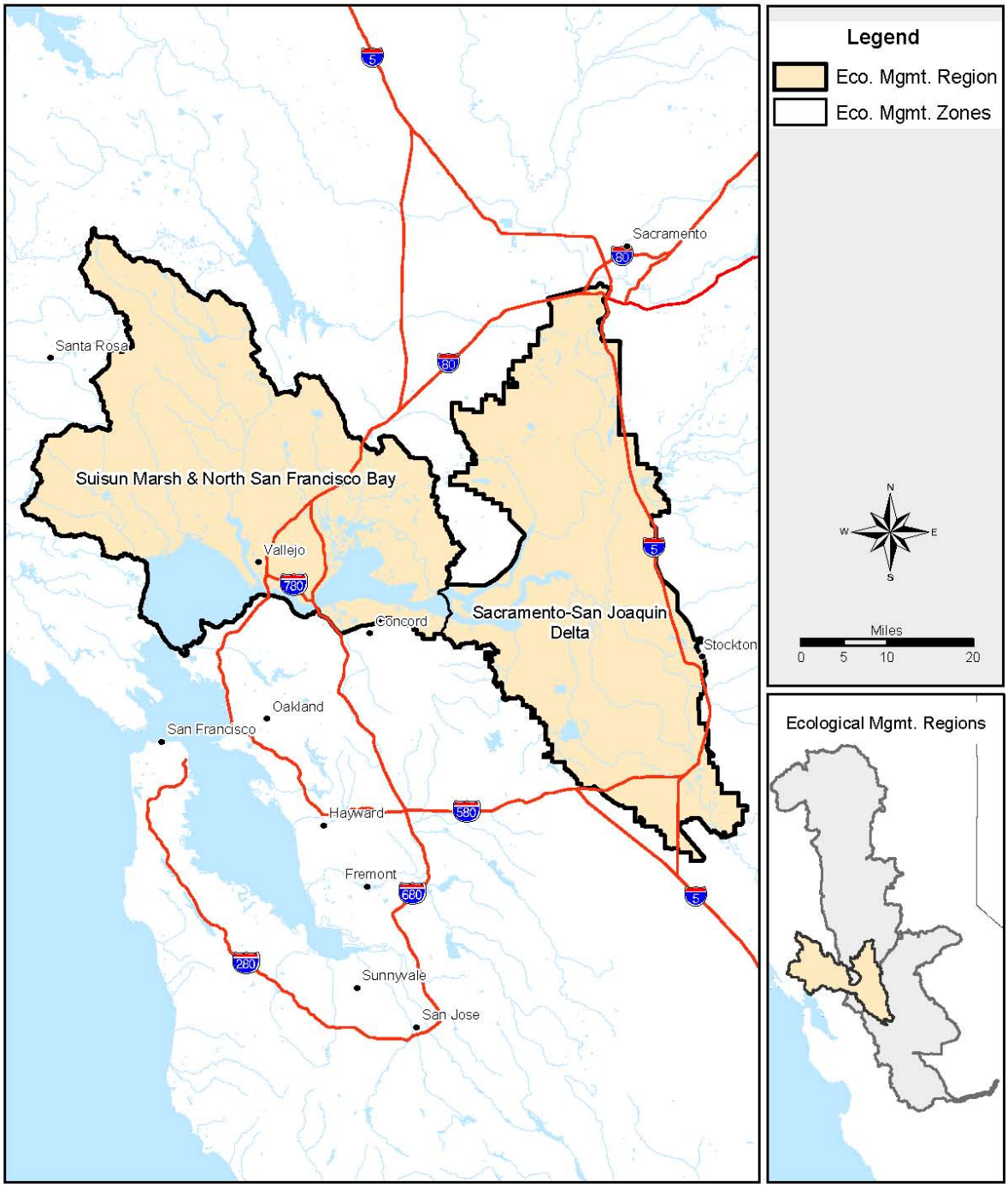

Figure 1. Bay Delta Ecological Management Region

CALFED BAY-DELTA PROGRAM

California Department of Fish and Game
Ecosystem Restoration Program

Figure 2.1.1. Map of the Bay Delta Region

distribution of riparian vegetation and the pattern or diversity of shallow aquatic habitats. Stressors include water diversions, poor water quality, legal and illegal harvest, wave and wake erosion, urbanization, and invasive non-native plant and animal species. Stressors to Bay Region tidal marshes also include alterations of tidal inundation regimes and seasonal salinity patterns, cattle grazing, and replacement of gradual ecological gradients with steep levee slopes. More in-depth descriptions and highlights on restoration efforts are discussed throughout this report in various chapters.

Delta and Eastside Delta Tributaries Description

The Sacramento-San Joaquin River Delta (Delta) is the tidal confluence of the Sacramento and San Joaquin rivers. The CALFED Delta Ecological Management Zone is defined by the legal boundary of the Delta which includes the areas that historically were intertidal, along with supratidal portions of the floodplains of the Sacramento and San Joaquin rivers. Today's legal Delta extends between the upper extent of the tidewater (i.e., near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and Chipps Island to the west, and encompasses the lower portions of the Sacramento and San Joaquin River floodplain systems as well as those of some lesser tributaries (e.g. Mokelumne River and Calaveras River). Once a vast maze of interconnected wetlands, ponds, sloughs, channels, marshes, and extensive riparian strips it is now islands of reclaimed farmland protected from flooding by hundreds of miles of levees. Remnants of the tule marshes are found on small "channel" islands or shorelines of remaining sloughs and channels.

The Delta is a mosaic of habitats that support the system's fish, wildlife and plant resources. Instream and surrounding topographic features influence ecological processes and function and are major determinants of aquatic community potential. Currently, much of the remaining natural habitats consist of small, scattered, and degraded parcels. Other, more common wildlife habitats on agricultural lands are at risk of loss because of levee failures. Important aquatic habitats are severely limited by levees and flood control systems.

Ecological factors having the greatest influence on Delta fish and wildlife include freshwater inflow from rivers, water quality, water temperature, channel configuration and hydraulics, wetlands, riparian vegetation, and diversity of aquatic habitat. Stressors include water diversions, channelization, levee maintenance, flood protection, placement of rock for shoreline protection, poor water quality, contaminants, legal and illegal harvest, wave and wake erosion, agricultural practices, conversions of agricultural land to vineyards, urban development and habitat loss, pollution, and introductions of non-native plant and animal species.

The Delta is home to many species of native and non-native fish, waterfowl, shorebirds, and wildlife. All anadromous fish of the Central Valley migrate through the Delta or

spawn in, rear in, or are dependent on the Delta for some critical part of their life cycle. Many of the Pacific Flyway's waterfowl and shorebirds pass through or winter in the Delta. Many migratory songbirds and raptors migrate through the Delta or depend on it for nesting or wintering habitat. Despite many changes, the Delta remains a productive nursery grounds and migratory route for many species. Four runs of Chinook salmon, steelhead, white sturgeon, green sturgeon, lamprey, striped bass, and American shad migrate through the Delta on their journey between the Pacific Ocean and Central Valley spawning rivers. Native resident fish including delta smelt and splittail spend most of their lives within the Delta. Considerable areas of waterfowl and wildlife habitat occur along the channels and sloughs and within the leveed agricultural lands. The Delta also supports many plants with restricted distribution and some important plants include Mason's lilaeopsis, Rose-mallow, eel-grass pondweed, delta tule pea, and delta mudwort.

The Eastside Delta Tributaries include the three major tributaries entering the Sacramento-San Joaquin Delta on its east side: the Cosumnes, Mokelumne, and Calaveras rivers. Important ecological processes within the Eastside Delta Tributaries include stream-flow, stream meander, gravel recruitment and cleansing, sediment transport, flood and floodplain process, and water temperature. Disturbance from historic mining practices is a consideration. Important habitats include seasonal wetlands, floodplain, and riparian and shaded riverine aquatic (SRA) habitat.

Fish and wildlife resources in the basin include fall-run Chinook salmon, steelhead, splittail, other native resident fish, and waterfowl. Fall-run Chinook salmon and steelhead populations are generally unhealthy due to poor habitat conditions. Achieving healthy status for these salmonid populations, as well as for splittail, will depend on actions implemented in this region and on complementary restoration actions in the Sacramento-San Joaquin Delta. The confluence of the Mokelumne, Cosumnes, and Calaveras rivers, as they enter the Delta, are important backwater floodplain areas that support excellent riparian habitats. These areas provide important habitat for juvenile Chinook salmon, delta smelt, splittail, giant garter snake, and sandhill crane. A more complete description of the East Side Delta Tributaries and the vision for this area can be found in the ERPP Volume II pages 328 - 352.

Summary of ERP Investments and Regional Highlights

Since 1995, the Ecosystem Restoration Program (ERP) has funded 149 projects within the Bay and Delta Regions totaling approximately $183 million (Table 1).

Table 1. ERP Investment in the Bay and Delta Regions

Program Region	# of Projects[1/]	Sum Of Total Amount[1/]	Fund Source
Delta	0		Clean Water Act, Section 104(b)(3)
	7	$3,456,375.00	CUWA: Category III
	0		CVPIA: Anadromous Fish Restoration Program
	0		CVPIA: Habitat Restoration Program
	20.6	$34,038,953.17	Federal Bay-Delta Act Funds - (Water and related resources)
	0.5	$17,555,436.00	Proposition 13: Flood Protection Corridor Program
	24.5	$20,086,480.97	Proposition 204: Category III
	41.4	$78,726,819.22	Proposition 204: Chapter 7
	1	$600,000.00	Proposition 50
	0		Proposition 84
	95	**$154,464,064.36**	**All Funding Sources**
Suisun Marsh / North San Francisco Bay	1	$250,000.00	Clean Water Act, Section 104(b)(3)
	1	$450,000.00	CUWA: Category III
	1	$100,490.00	CVPIA: Anadromous Fish Restoration Program
	0		CVPIA: Habitat Restoration Program
	14	$6,588,205.33	Federal Bay-Delta Act Funds - (Water and related resources)
	0		Proposition 13: Flood Protection Corridor Program
	12	$3,588,005.00	Proposition 204: Category III
	14	$14,367,699.00	Proposition 204: Chapter 7
	7	$3,449,396.32	Proposition 50
	1	$300,000.00	Proposition 84
	50	**$28,793,795.65**	**All Funding Sources**
Total	**145**	**$183,257,860.01**	**All Funding Sources**

[1/] Does not include projects that are approved for funding but have not been executed.

Bay-Delta Region ERP Stage 1 Accomplishments towards Regional Priorities

The ERP Strategic Plan (CALFED 2000a) included Draft Stage 1 actions for the Bay and Delta Regions (including their tributaries). The actions describe the critical processes, habitats and species that would be addressed for key tributary watersheds; the rationale for the selection of actions to be implemented during Stage 1; actions already being implemented as part of CALFED Restoration Coordination Program, Central Valley Project Improvement Act (CVPIA), or other restoration programs; and uncertainties about ecosystem structure and function that can be answered by designing restoration actions to maximize their information value.

Following the Strategic Plan, the ERP developed a Stage 1 Implementation Plan in August 2001 (CALFED 2001). The plan incorporated: 1) public involvement in setting

restoration priorities; 2) local involvement in accomplishing restoration actions; 3) emphasis on adaptive management and information richness in the design of restoration actions; 4) coordination with other CALFED Program elements; and 5) coordination with non-CALFED Program restoration efforts, both public and private. The plan included restoration and science priorities from a regional perspective, consistent with the CALFED Program's regional approach.

Strategic Goals in the Plan were as follows: 1) Goal 1 - At Risk Species; 2) Goal 2 - Channel Dynamics and Sediment Transport; 3) Goal 3 - Harvestable Species; 4) Goal 4 - Habitats; 5) Goal 5 - Non-native Invasive Species; and, 6) Goal 6 - Water and Sediment Quality.

Consistent with the overall Stage 1 Vision, implementation priorities for the Bay and Delta Regions focused on improving, restoring, or maintaining the health and integrity of the estuary ecosystems to sustain or support important fishery, wildlife, and plant communities. The majority of regional investments supported protection and restoration of tidal wetland, shallow water, riparian, and upland habitats; fish screen evaluations; evaluations of water quality and nonnative invasive species impacts on Delta resources; and environmental education (Table 2). Additional focused research projects have been designed to provide information that will improve future restoration efforts.

Table 2. Bay and Delta Regions, ERP Restoration Investment By Topic Area.

Topic Area	Number of Projects[1/]	Expenditures[1/]	Percent of Total Expenditures[1/]
Administrative or Program Support	1	$281,602.00	0.15%
At-Risk Species Assessment	6	$1,915,883.33	1.05%
Ecosystem Water and Sediment Quality	28	$26,391,779.61	14.40%
Environmental Education	5	$592,198.00	0.32%
Estuary Foodweb Productivity	1	$576,422.00	0.31%
Fish Passage	3	$2,328,455.00	1.27%
Fish Screens	6	$3,162,269.17	1.73%
Harvestable Species Assessment	1	$24,500.00	0.01%
Hydrodynamics, Sediment Transport, and Flow Regimes	6	$5,794,420.61	3.16%
Local Watershed Stewardship	14	$3,103,595.00	1.69%
Lowland Floodplains and Bypasses	12	$14,936,485.00	8.15%
Non-Native Invasive Species	7	$4,273,981.32	2.33%
Riparian Habitat	7	$8,350,265.00	4.56%
River Channel Restoration	1	$1,100,000.00	0.60%
Shallow Water and Marsh Habitat	40	$64,572,224.97	35.24%
Upland Habitat and Wildlife Friendly Agriculture	7	$45,853,779.00	25.02%
Totals	**145**	**$183,257,860.01**	

[1/] Does not include projects that are approved for funding but have not been executed.

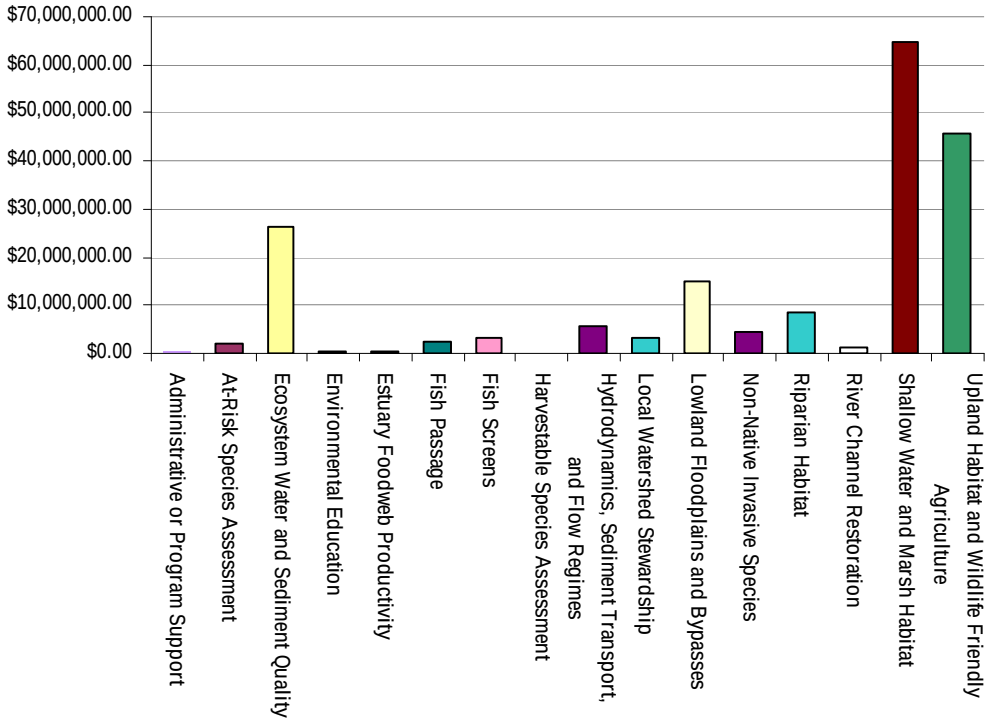

Figure 2.1.2 Bay and Delta Regions ERP Restoration Investment By Topic Area

Bay-Specific Restoration Priorities

Consistent with the CALFED ERP's regional approach; the Draft Stage 1 Implementation Plan for ERP outlined the priorities, potential projects or programs, the science needs, and priorities for regional issues and opportunities. Restoration Priorities (BR's) are as follows:

Priority 1. Restore wetlands in critical areas throughout the Bay, either via new projects or improvements that add to or help sustain existing projects.

Tidal marsh restoration is a key strategy in the Suisun Marsh and North San Francisco Bay area.

- *Protect existing tidal marsh*. ERP made significant progress toward protecting and restoring tidal marsh in diked baylands and shoreline along San Pablo Bay and the Napa and Petaluma Rivers and Sonoma Creek, especially in the Napa-Sonoma Marsh and Petaluma River marshes. Working with San Francisco Bay Joint Ventures, a consortium of state entities and other non-profits active in the San Francisco Bay area, ERP has aided in the acquisition of over 40,000 acres of diked baylands from the San Pablo Bay to the North Bay. Many of these

acquisitions contained existing tidal marsh and other wetland habitats. The efforts in the Bay Area have been so successful that the ERP acreage targets can be fulfilled, and exceeded, after fully restoring all of the land that has been acquired for that purpose.

- *Restore marshes*. In Suisun Marsh, restore a continuous band from the confluence of Montezuma Slough and the Sacramento/San Joaquin Rivers to the Marsh's western edge. During Stage 1, ERP has been working with State agencies, local and Federal partners on a plan to restore the marsh along the northern and southern sides of Suisun Bay, Grizzly Bay and Honker Bay. A public draft of the Suisun Marsh Plan (SMP), functionally equivalent to the PEIR, is scheduled for release in October of 2010. The target for restoration acreage is being developed for consistency with the ERP stage 1 goals. The latest draft SMP indicates a target of 6,000-9,000 acres of tidal marsh restoration. Grant funds for acquisition have been dedicated and the State is actively seeking land to purchase from willing sellers in the marsh.

  Approximately 300 acres of existing and former tidal marsh have been restored or preserved, in the vicinity of Little Honker Bay, with ERP funding during stage 1.

  One difficulty with meeting the acquisition and restoration goals in the marsh is that much of the land is subsided below the optimum elevations needed for establishment of tidal marsh vegetation. Much of the land upon which restoration is feasible is in private hands. ERP has funded facilitation of stakeholder participation groups in order to increase collaborative capacity and bring forward a plan that is agreeable to private landowners.

  On the southeast of Suisun Bay, the acquisition of roughly 1,166 acres of diked baylands on Dutch Slough has been achieved. ERP, in conjunctions with DWR and the Natural heritage Institute and local partners, is in the process of completing the restoration plans.

- *Tidally muted marsh and seasonal wetland habitat*. ERP has made a long-term commitment to producing the SMP. The plan, in draft, provides for management practice improvements on 32,000 acres of privately managed wetland. The scale of tidal restoration well be dependent upon the elevation and hydraulic character of individual parcels.

  The restoration of 1,500 acres at Cullinan Ranch on the northern shore of San Pablo Bay has been studied by ERP funded projects. Complications such as subsidence and the barrier to the bay posed by State Highway 37 require that full-scale restoration be delayed for careful study. Because of the state highway

issue, funding the restoration may be delayed as well. In the meantime the area is being managed for freshwater seasonal wetland habitat benefits.

- *Enhance managed waterfowl wetlands.* The Tolay Creek and Cullinan Ranch in the North Bay have been the site of ERP studies to measure avian use by guild and management regime. ERP Studies on the Petaluma have also measured species use of habitats.

  ERP has made a long-term commitment to producing the SMP. The plan will provide for management practice improvements on 32,000 acres of privately managed wetland. The scale of tidal restoration will be dependent upon the elevation and hydraulic character of individual parcels. The goal of management plan improvement is to increase waterfowl Hunter success on managed wetlands in Suisun Marsh.

- *Retrofit historic dikes to more natural configuration.* The ERP funded Napa Salt Pond restoration effort, currently in the planning stage, has the potential to restore 9,850 acres of muted or fully tidal marsh west of the Napa River and north of Highway 37. Other projects, such as Sonoma Baylands, Muzzi Marsh, and the Sonoma Land Trust Marsh, are completed efforts that have helped inform current restoration efforts. Miles of levee have been resloped to favor habitat development. Levees associated with restoration projects in the northeastern Suisun Marsh have been, or are planned to be, retrofitted to a profile that will create more diverse marsh plant assemblages.

- *Riparian and riverine aquatic habitat restoration.* Among the North Bay watersheds, ERP riparian conservation and restoration has been most concentrated along the Napa River and tributaries. Regulatory incentive, provided by the pathogen and sediment Total Maximum Daily Loads (TMDLs) for the Napa, and landowner initiatives make the Napa River a prime choice for leveraging local interest. The Petaluma River also has received ERP funding to study the use of restored habitats by target species. Restorations on Sonoma Creek have been initiated with ERP assistance but not on the scale achieved on the Napa River.

  Riparian conservation and restoration in Suisun is ongoing on levees that have been restored as part of the tidal restoration funded by ERP. The plant communities on sloughs in the marsh are primarily grasses and forbs. Some shrubs such as coyote bush and wild rose also occur and are considered an extension of the riparian community into the brackish Suisun Marsh. Freshwater riparian corridors stretch into the Suisun Marsh from the North as well, but these streams are regulated and maintained for flood conveyance. Abundant freshwater flows and frequent overtopping increase the potential for a diverse

riparian plant community on three streams that drain Solano County into the northwestern portion of the Suisun Marsh.

- *Update existing outdated Individual Ownership Management Plans* to provide landowners with multiple management strategies to protect, conserve, and sustain brackish marsh diversity, waterfowl, and wildlife values within the managed wetlands. ERP has made a long-term commitment to producing the SMP. The plan, in draft, provides for management practice improvements on 32,000 acres of privately managed wetland. ERP has also funded work that documents the steps managed wetland operators in Suisun may take to increase the diversity of species, including game birds, that inhabit the Suisun Marsh.

Priority 2. Restore Uplands in key areas of Suisun Marsh and San Pablo Bay

- *Acquire, protect, and restore vernal pool habitats and perennial grasslands.* ERP has supported the acquisition, study and management of Vernal pools and grasslands in the area North and East of Suisun Marsh. Much of this habitat is already protected by easements and preserves. The pre-settlement vernal pools and grasslands of the North Bay watersheds have been largely supplanted by vineyard development.

Priority 3. Implement actions to prevent, control and reduce impacts of non-native invasive species.

The majority of work by ERP in regards to invasive riparian marsh plants focused on five weeds *Arundo donax*, tamarisk (*Tamarix spp.*), perennial pepperweed (*Lepidium latifolium*), cordgrass (*Spartina spp*. [introduced and hybrid species]), and purple loosestrife (*Lythrum salicaria*).

The invasive plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly cause reductions in the populations of desired fish, wildlife and native plant populations. This is particularly true if populations of rare native species are reduced as a result of invasive plant infestations.

- *Develop pilot projects*. ERP has developed pilot projects in marsh habitats to develop successful approaches to understanding invasion rates, ecological impacts and control strategies of *Lepidium latifolium* (perennial pepperweed), *Salsola soda* and other Non-native Invasive Species (NIS) plants. Research done under ERP grants has revealed the major interactions affecting perennial pepperweed colonization and should help define nuanced programs of control that may minimize perennial pepperweed without destroying the native vegetation. Results showed that perennial pepperweed density was significantly reduced by increased levels of salinity and soil moisture. ERP has an opportunity

to work with ERP implementing agency DFG on perennial pepperweed control in Suisun Marsh.

- *Research* the relationships between inundation, salinity and NIS needs in tidal wetlands to identify the hydrologic regimes less favorable to the non-natives. Researchers funded by ERP studied the effects of introduced species of zooplankton and clams in the foodweb of the Bay-Delta, with emphasis on the effects to fish species of concern. Researchers have concluded that salinity levels that fluctuate in historic natural patterns may be an effective control of non native overbite clams.

- *Consequences of Non-native Invasive Species.* In 2001, marsh slumping and pillaring in South Bay and in upstream marshes due to Chinese mitten crab and isopod burrowing (combined with erosion) had become quite serious. Since 2001 Mitten crabs are associated with: tidally influenced portions of Bay tributaries as young juveniles; with freshwater streams as older, migrating juveniles; and with the open waters of the Bay as reproductive adults after migrating from freshwater to reproduce between late fall and early spring. Mitten crab population has declined since 1998 and winter 2006-07 surveys of the Bay and Suisun Marsh did not detect adult Chinese mitten crabs. Although the factors that control the estuary's mitten crab population are not well understood, winter temperatures and outflow are hypothesized to affect larval survival and settlement time.

- *Improve knowledge base and eradication strategies for controlling non-native species with potential for major ecological impacts.* The non-native cordgrass *Spartina alterniflora* (and its hybrids) invasion in San Pablo Bay and the Bay-Delta has been characterized, monitored, and controlled with ERP funding during Stage 1. Efficacy of different methods and determined the size of the invasion to be 791 acres as of 2005. In phase II of the Introduced Spartina Eradication Project, saw the switch to a more effective herbicide. Monitoring of the invasion has continued to identify new infestations in previously uninfested areas, but overall the invasions appear to have been contained. Treatments appear to be effective and are repeated as necessary according to the monitoring input.

  ERP has funded multiple research approaches to determine the effects and reasons for the invasion of the overbite clam. The study found that:

  1. The overbite clam continues to have a significant effect on the estuarine ecosystem, particularly on the lower trophic levels at low salinity, in Suisun Bay and the western Delta, particularly in summer.
  2. Clam effects cannot be understood except in the context of variable freshwater flow.
  3. The effects of the clams in the lower estuary are somewhat less.
  4. Clam grazing has caused such a decrease in phytoplankton in the northern

estuary that distributions of silica, an essential nutrient for diatom growth, have been drastically altered. It is possible to infer the loss of diatom production by the change in silica depletion in the northern estuary.

Priority 4. Understand performance of wetlands restoration efforts on a local and regional scale.

To date, land purchases and restoration in the Bay have not been accompanied by substantial efforts to document the accomplishments of the investments.

- *Retrofit monitoring to existing restoration projects.* Several retrofit type monitoring and research projects have been completed during stage 1. Some of these are phased projects, such as BREACH and Integrated Regional Wetland Monitoring (IRWM), that are ongoing in various parts of the Bay-Delta system. The objective of these projects is to integrate multiple species and habitat types as indicators of overall benefits of restoration actions at an ecosystem level.

  Models of ecosystem response to restoration and management actions are also being developed with ERP funding. Data from monitoring and fine scale models will be used to create individual species, guild and community outcome modules. These modules will be used to calibrate and run ecosystem scale models that can assist with resource management and restoration priority decisions.

  While a formal approach to regional monitoring is still in development, the past and ongoing phases of these ERP projects are expected to contribute to the adaptive management framework upon which regional monitoring will be based.

- *Enhance interpretations of existing aquatic system monitoring information from the Bay.* A number of ERP projects have focused on water quality and use of the Bay by fish and wildlife. New information from these projects has revealed that even as species decline in the Delta is a concern, the value of Bay habitat to various fish species has increased along with water quality. Stage 1 ERP funded research has also revealed that global processes that manifest offshore locally, such as upwelling and the El Niño/La Niña cycles, also drive habitat quality changes in the Bay.

Priority 5. Restore shallow water, local stream and riparian habitats for the benefit of at-risk species while minimizing potential constraints to successful restoration efforts.

Hydrology, water/sediment quality and invasive species are major limitations to effectively restoring populations and ecosystems in the Bay and to sustaining restoration efforts. Better understanding of the relative importance of the most

important limiting factors, especially relative to some specific restoration efforts, is important.

- *Modeling and physical measurement studies that detail how freshwater and brackish water interact in Suisun Marsh.* As part of the SMP development funded by ERP, water quality standards are being developed. Consultants have assisted with one dimensional scalar transport modeling and two dimensional regional hydrodynamic modeling to determine tidal restoration configurations that minimize any adverse effects to water quality.

- *Mercury inputs from Yolo Bypass and their implications in Suisun Marsh and Grizzly Bay.* Numerous studies of mercury transformation and transport have been funded by ERP. The results of these projects have informed understanding of the mercury risks due to restoration and operation of the Yolo bypass as a flood way. The environmental sources of mercury in the region and behavior of mercury in the Yolo bypass are well known. Mass balance has been characterized as well.

  Recent ERP research project results indicate that, transport issues aside, the wetting and drying of soils is likely the main driver of mercury bioavailability. Other ERP research has indicated that vegetated wetland environments seem to lower bioavailable mercury either through sequestration or phytoremediation. These conclusions have been recently confirmed by preliminary geospatial analysis of available data. These analyses indicate that there may not be an overall correlation between wetlands and elevated methylmercury in biota.

- *Effects of hydraulic mining debris and other mercury sources on wetlands development and production of methylmercury*. ERP studies have determined that, in addition to the early gold mining practices in the Sierra Nevada foothills, mercury mine sites in the Coastal Ranges are also a significant contributor of mercury to the Bay-Delta ecosystems. Much of the mass balance, species transformation and bioavailability of the mercury has been learned from these studies.

  Mercury monitoring is usually required as a permit condition for ERP funded restorations in the Suisun Marsh and the San Pablo Bay region watersheds. ERP and its implementing agency, DFG, are involved in both the funding and conducting of such post restoration monitoring for mercury.

- *Spatial and temporal variability of structure and dynamics of tidal wetland plant communities*. Research and monitoring of both natural and restored tidal marsh habitats has received extensive funding through ERP. Both the vegetation and physical drivers for various habitat types have been and continue to be studied in an effort to determine the tidal marsh vegetation structure and dynamics.

Papers on structure and dynamics of restored wetlands, with titles such as "Productivity of the halophytic plant *Sarcocornia pacifica* along a salinity gradient in the San Francisco Bay Estuary"; "Landscape Influence on the Quality of Heron and Egret Colony Sites"; "Vegetation Colonization in a Restoring Tidal Marsh: A Remote Sensing Approach" and "Restoration Trajectories and Food Web Linkages in the San Francisco Bay's Estuarine Marshes: A Manipulative Translocation Experiment" can be accessed from the ERP deliverables library.

More recently, ERP funding will produce data for ground up modeling that will be used by restoration practitioners and resource managers to achieve specific plant community goals. These modeling efforts are based upon early phases of the work that characterized the plant communities established in various sedimentation, soil, salinity and inundation regimes.

- *Critical life stages and range of edaphic requirements of sensitive plant species*, including listed species and species recognized to be in decline, which could become further endangered by management actions, have not been well studied by ERP. ERP has funded some work in the region to determine sediment accretion and deposition in floodways and tidally influenced wetlands. ERP work with vernal pool species has included some analysis of soil properties in relation to sensitive plant species. Additional commitments to relate soil properties to the prioritization of resource and conservation actions can be made a higher priority in Stage 2.

- *Track the distribution of rare plants, listed species and species diversity in different tidal and managed environments.* Inventory of rare plants is typically performed on state owned and managed lands. Managing these lands to maintain stands of rare plants is a challenge due to the managing agency staff limitations. During stage 1, ERP has been able to fund projects to acquire lands that are favored habitat of rare plants. However, more must be done to identify additional non-public lands with the potential to host rare plants.

- *Demonstration projects to evaluate the potential use of dredge material to restore deeply subsided areas to tidal marsh*. Clean uncontaminated dredge spoils can be used for levee reconstruction, wetland restoration, reversal of subsidence, creation of shallow water habitats, rehabilitate natural processes to create and maintain channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh. ERP's objectives are to link dredging and spoil disposal with environmental restoration, to reduce adverse environmental impacts and demonstrate the beneficial reuse of dredge materials.

  A series of important ERP projects looked at ways to reduce the adverse environmental impacts from dredging. These projects addressed the reuse of

materials, dredged from Delta channels during maintenance operations, to maintain levees and as fill material in habitat restoration projects.

In addition, ERP funded planning and environmental documentation tasks for the restoration of 2,500 acres of subsided, from diked baylands to a mix of seasonal and tidal wetlands. Nearly 33 million cubic yards of material dredged from San Francisco Bay were used to restore the former site of Hamilton AFB to tidal wetlands.

ERP also funded the Delta Dredge Reuse Strategy (DDRS) planning effort and created the DDRS document, which analyzed technical and regulatory issues related to Delta dredging projects and includes recommendations for additional studies and pilot projects to fill data gaps. These recommendations will be applicable to dredging and restoration planned for the Suisun Marsh as part of the ERP funded SMP.

- *Fine sediment loadings.* ERP has not undertaken actions to assess the level of, determine the ecological impacts of, and reduce fine sediment loading to streams, especially in the Napa and Petaluma Rivers and Sonoma Creek.

- *Understand implications of contamination problems for local restoration projects and regional restoration strategies.*

  The San Francisco Bay Regional Water Quality Control Board includes sediment TMDLs on the Sonoma Creek and Napa River in its Basin Plan. Salmonids are the key beneficial use that these TMDLs are intended to preserve. ERP has supported projects in the watersheds to monitor water quality and characterize salmonid habitat. Stage 1 ERP actions also include other projects to improve salmonid habitat Napa River through riparian restoration, gravel augmentation and other activities.

  During Stage 1, ERP-funded studies looked at sources of selenium and impact of selenium on critical prey/indicator species, and measured levels and kinetics in species of concern. White Sturgeon were studied for tissue selenium burden and to help determine selenium bioaccumulation and effects on reproduction. The study also demonstrated significant increases in mortality rates and defects in larvae containing more than 15 µg/g selenium, which is similar to concentrations associated with developmental toxicity in other fish species. In addition to research on the effects of selenium on wildlife, during stage 1, ERP also funded work to determine possible methods of reducing the loading of selenium to agricultural drainwater, a primary source of selenium to the Bay-Delta Ecosystem.

Identification of previously uncharacterized contaminants has been funded in previous CALFED work, but the focus has been on the pesticides and on a certain class of pesticides, the pyrethroids. Pharmaceutical and other compounds in the waters of the Bay-Delta is the subject of a number of studies conducted by ERP's partner in science, San Francisco Estuary Institute.

Many disciplines outside the biology specialty must be engaged in order to identify unknown organic compounds suspected of having toxic effects on wildlife. The CALFED science program recently (2008) presented the results of a pioneering East Coast study that found numerous pharmaceutical and other contaminants of human origin in waters downstream of POTWs. Not all of the organics suspected of toxicity were estrogen analogs. In addition, the biochemical pathways through which endocrinologically active toxins inadvertently act in the ecosystem are not as well characterized as compounds designed to have neuro- and respiro- toxicity but which inadvertently leak into the ecosystem. The desired effect of presenting this material to a statewide audience of scientists is promote new ways of looking at the problem of toxic effects and compounds.

Priority 6. Protect at-risk species in the Bay using water management and regulatory approaches.

Availability of organic carbon could be an important limitation to restoration of critical fish populations in the Bay. Restoration actions in the watershed might influence estuarine food web productivity by affecting the carbon and nutrient loads delivered to the estuary through bypasses and rivers. Internal production of organic material may also be affected if restoration projects result in increased production of bioavailable organic material. Exotic species may also play a role in redistributing the flow of carbon. Finally, many food webs in the Bay are poorly understood, as are the factors that control their structure, function and productivity.

- *Better understand primary and secondary productivity* within Suisun Bay, North Bay, and South Bay and linkages among internal and external inputs. ERP, as a CALFED partner in the IEP, has advanced the collective understanding of Pelagic Organism Decline (POD) stressors by funding research related to primary productivity, benthic grazing rates of invasive clams, primary productivity, contaminants, and other studies. Funded research studied the distribution and abundance of shrimp, plankton and benthos in Suisun Marsh, as well as the context of Bay energetics.

  Other work studied productivity with respect to X2, salinity stratification and mixing, and stage dependent habitat volumes. These studies also produced models that may be used by IEP teams to study ecosystem scale effects and single species of interest such as the delta Smelt.

- *Better understand linkages between North and South Bay* that might affect restoration or productivity in either; and understand implications of engineering projects for such linkages.
- *Understand linkages* between tidal marshes and adjacent habitat, in creation and transfer of bioavailable organic material. The local and regional impacts of restorations of the magnitude completed and planned in the North and South Bay, over a long period, are unknown. It is hypothesized that primary productivity will increase. Regional patterns of salinity and tidal exchange may also respond to the increased tidal prism in the western end of the Bay-Delta estuary. Scalar transport models indicate the possibility that X2, the location of the 2 psu (practical salinity units) isohaline, may migrate westward as a result of the tidal marsh restorations in the North Bay. (This effect is dependent on the extent that global warming may alter tidal prisms). Mercury mobilization and transformation may also occur.

  The extent to which these changes may alter the food web, hydrodynamics, and salinity regimes in the Delta and South Bay, where restoration of an additional 15,000 acres is underway, is also unknown. The year of 2007 will be the first year that the 1,000-2,000 acre target has been met for the Napa River EMU. Combined with the expanded tidal prism resulting from the other North Bay restoration sites, at least 4,000 acres of tidal restoration was implemented in 2006. It will be most cost effective to monitor these DFG owned sites for hypothesized productivity changes.

- *Understand poorly known aspects of the food webs* of Grizzly Bay, San Pablo Bay and South Bay. ERP funded projects that examined food web research to look at the specific problems posed by heavy benthic grazing by overbite calms and local productivity. Other work on this subject sought to determine whether the Suisun Region was a net importer or exporter of productivity. Conclusions to date suggest that Suisun is a net exporter of productivity under certain conditions and that it has a higher potential in this regard that the eastern end of the system.

Priority 7. Improve scientific understanding of the linkages between populations of at-risk species and inflows, especially relative to regulatory measures like "X2".

Flow and physical structure are important determinants of the positioning of the freshwater/seawater interface in the Bay; which in turn seems to be related to success of some species. The mechanistic basis for these relationships are not well known, however. Better understanding of physical, biogeochemical and ecological processes related to X2 and this zone is needed. Investigation of the benefits of tidal wetlands restoration in proximity to X2, in comparison with other sites, is also needed.

- *Hydrologic/sediment transport models as restoration tools*;
- *Improve understanding of how physical processes* affect ecological processes in the sloughs, bays, tidal flats and associated marsh plains;
- *Understand short-term to long-term sediment deposition patterns* throughout the Bay, especially as they relate to sustainability of sediment deposition at restoration sites. Numerous studies on sediment transport, channel dynamics and X2 have been funded by ERP and other entities during Stage 1. United States Geological Survey (USGS) Integrated Science Place-Based studies are studying linkages between physical processes, sediments and ecosystems in Suisun Bay and Napa Marsh; the San Francisco Estuary Institute's Regional Monitoring Program monitors contaminants throughout the Bay system, including numerous sites in Suisun. The paucity of sediment available in the eastern end of the system and the abundance in the western end, in the Petaluma River, has been well characterized. Observations of restoration trajectories in the Petaluma River Estuary and unintended breaches of subsided islands in the Delta have confirmed the results of these studies.

  In many respects, the best subjects for continued research will be the tidal restoration projects that ERP has already completed or initiated during stage 1. These sites are owned by state agencies, in most cases, and the continued monitoring can be conducted in a cost efficient manner.

Priority 8. Use monitoring, evaluations of existing monitoring data and new investigations to develop improved strategies for restoring Bay fish populations and at-risk species

Priorities include:

- Effects of open water and tidal marsh food web interactions on fish population dynamics.
- Examine how trends in chlorophyll a, zooplankton and pollutants impact different fish species locally (in Suisun Marsh) and across the Bay region landscape (interconnections between Bay segments); Develop pilot programs for monitoring of zooplankton from tidal marshes to open water;
- *Monitor and improve understanding of zooplankton and juvenile fish distribution and abundance* (species composition, density, size distribution, condition factor) in the Bay proper and various types of shallow water habitats, including marsh plain channels and larger order sloughs of tidal marshes and riparian floodplains in San Pablo Bay tributaries. ERP funding of IEP POD studies begun in stage 1 and continuing into stage 2 provides new information for agency deliberations on management of the system to benefit at risk species and the fishery in general. ERP's support of IEP insures that the institutional knowledge of past and present studies will not be lost. Integration and analysis of the data is also promoted by the CALFED commitment to science as demonstrated in the production of yearly

conferences and seminars on the Bay-Delta ecosystem that continue to be well attended.

ERP studies found that zooplankton are most abundant in interior sloughs and channels. Data suggest that Suisun Marsh plays a significant role in estuarine productivity, providing an abundant source of food to otherwise depleted bay and river channel habitats. With respect to regional or overall productivity, ERP research indicates hydrodynamic factors tend to outweigh biological and chemical processes.

- *Understand anadromous and estuarine fish use of North Bay and South Bay tributaries*;
- *Interpret existing region-specific monitoring data on fishes, aquatic ecosystems, wetland communities and water quality for North Bay, Central Bay and South Bay. Develop new data and monitoring approaches;*
- *Better understand the Bay waterfowl community*;
- *Determine the extent of intermarsh movements by at-risk species*. ERP has invested in monitoring remnant wildlife populations in the open space buffers that have been carved out of former industrial uses, such as salt ponds and flood ways, and watershed lands. Bird surveys in the baylands have often been conducted in advance and following ERP funded conversions of baylands back to a semblance of their former tidal regimes.

  The use of Bay Area creeks by anadromous species has been studied by numerous local interests and supported by ERP funding during stage 1. The former abundance of anadromous fishes in the North Bay drainages, habitat and the species richness has been noted by ERP funded historical research. During stage 1, a small run of salmon, periodically observed on the Napa River, has gained recognition as a possible native or naturalized Central Valley Chinook population. While the ERP has, due to funding limitations and the urgency of ecosystem decline in the Delta, limited its bayward investments in the later phases of Stage 1, restoration projects and monitoring on the Napa River are still being supported.

Delta and Eastside Tributaries-Specific Priorities

Consistent with the CALFED Program's regional approach to representing goals, strategies and progress, the Draft Stage 1 Implementation Plan outlined the priorities, potential projects or programs, the science needs, and priorities for regional issues and opportunities. Restoration Priorities (DR's) are as follows:

Priority 1. Restore habitat corridors in the North Delta, East Delta and San Joaquin River.

Delta habitat corridor restoration remains a priority. Projects restoring Delta wetland, aquatic, riparian, and associated habitats are needed that that will contribute to creating the following habitat corridors that connect the Delta with upstream areas:

- *North Delta habitat corridor*. While many investments were made in research, planning, acquisitions, and restoration in the Yolo Bypass, there continues to be a need for improved coordination and understanding when historically conflicting land uses collide on the landscape. The Yolo Bypass has proved to be a great example of mixing an engineered flood control facility with habitat conservation and agriculture but additional enhancement and restoration opportunities is often met with much conflict. More work is needed to bridge the gap between multi-disciplinary landscapes such as the Yolo Bypass where water rights, land use, and conservation collide. An example of attempts to resolve these complex issues can be found in the projects that address the restoration, conservation, agriculture, and toxics on the Yolo Wildlife Area and research, monitoring, and acquisition projects that are addressing the diverse habitat types in Prospect Island, Liberty Island, and Little Holland Tract in the Lower Yolo Bypass where water rights, land use, and conservation have come to head with natural re-colonization of marshes on the breached lands in an engineered flood control facility.

- *East Delta habitat corridor*. Many investments were made for restoration of a contiguous corridor containing a mosaic of marsh, aquatic, and associated floodplain and riparian habitat types in the area of Georgiana, Snodgrass, and other east Delta sloughs, the lower Cosumnes River, and the South Fork of the Mokelumne River. Most notably were the planning efforts for the North Delta Improvements Program that looked to address flood improvements for the rural area of Sacramento County in conjunction with restoration planning along the Cosumnes River. There were many acquisitions made along the lower Mokelumne and Cosumnes rivers by ERP such as McCormack Williamson Tract, a portion of Staten Island (funded in part by DWR's Flood Corridor Protection Programs as well), and many other easement and fee acquisitions along the Cosumnes River between Interstate 5 and Highway 99. The multi-disciplinary North Delta Improvements effort did develop a draft EIR but failed to develop a comprehensive, coordinated plan for meeting multiple objectives of flood control and restoration. There are several components that were analyzed in that effort that remain implementable but additional work on flood control benefits/impacts may be needed in order to turn some of the stranded investments into restoration and flood improvement projects on the ground.

- *San Joaquin River* - Delta habitat corridor. Achievement of a contiguous corridor containing a mosaic of aquatic, wetland, and associated riparian and floodplain habitat types in this area has been very difficult. The opportunities were extremely limited due to lack of willing sellers, the uncertainty of doing

restoration so close to the major water diverters and operators, and water quality concerns in this region of the Delta for upstream migrating adult anadromous fish species.

Actions that restore natural and managed seasonal or permanent wetlands are also a priority; including actions that contribute to connectivity between aquatic, wetland and riparian habitats. The goal was to protect or restore lands already under government ownership, ultimately resulting in mosaics of seasonal and permanent tidal wetlands, riparian zones, and associated upland habitats. Such actions should include monitoring programs and be designed as adaptive management experiments to better contribute (or evaluate if and how they contribute) to recovery and restoration of native species and biotic communities. Additional priorities are:

- Restore tidal marsh and mid-channel island littoral zone (shoreline marsh and shallow water) habitats in the central and west Delta. Although efforts were made to restore and protect shoreline marsh and shallow water habitats around midchannel islands little progress was made. The opportunities were limited because of the interior land elevations on Delta islands within this region. There were advances however through collaborative projects with the Levee System Integrity Program (LSIP) that implemented the Twitchell Island setback levee. While monitoring has not yielded the ecosystem response we hoped for, it did expand the levee designs available for Delta islands. In other regions of the Delta, additional techniques were implemented through the ERP and LSIP that provided alternative techniques for sediment accretion and bank stabilization. Monitoring has not been accomplished at this time to address ecosystem benefits or response but techniques that move us away from the traditional rock and steep slopes are encouraging nonetheless.

- *Acquire, protect, and restore habitat.* There were several projects that were aimed to benefit giant garter snake, greater sandhill cranes, Swainson's hawk and waterfowl. Studies to improve our understanding of sandhill cranes were funded in coordination with the acquisition of Staten Island and resulted in a greater understanding of the distribution, habitat preferences, forage preferences, and potential limiting factors in the Delta. Collaborative projects to survey for giant garter snakes were conducted in the Yolo Bypass and resulted in new populations associated with the management and restoration on the State Wildlife Area. Because of the decline of the pelagic organisms, however, much of the focus was on water quality and native fish species such as the delta smelt. As the Interagency Ecological Program continued its long term monitoring and identified areas of uncertainties, funds were provided to monitor and research potential stressors to improve our understanding of the pelagic organism decline.

Restore inland dune scrub habitat. There was little or no work done to restore habitat that would benefit the Antioch Dunes evening primrose, Contra Costa wallflower, Lange's metalmark butterfly. The FWS has been working on a recovery plan with some of the local planning districts for enhancements of the existing conservation area and a recovery plan.

Priority 2. Restore and rehabilitate floodplain habitat in eastside tributaries and the lower Sacramento and San Joaquin Rivers

Many species native to the Delta and the Eastside tributaries are adapted to the large floodplains that were frequently flooded in the original system. Rehabilitating and restoring this functional habitat and the species that reproduce on or otherwise use floodplains (Sacramento splittail, delta smelt and Chinook salmon) remain important goals. Projects are continually requested to improve floodplain habitat, complete or sustain existing restoration projects, or restore new areas of such habitat.

- *Improve floodplain habitat*. Restoration projects that improve slough and creek channels, or develop networks of channels to effectively drain flooded lands and provide connections with the Delta or Eastside tributaries continues to be an ERP priority. The collaborative planning, lead by the Nature Conservancy, along the Cosumnes River has resulted in some of the most significant restoration of a river and its floodplain in the State. Through the partnerships and a variety of funding sources, acquisitions, planning, monitoring, and research have lead to extensive floodplain restoration and natural processes that contribute to improvements downstream in the Delta.

  Along the lower Sacramento River, work was focused primarily on the Yolo Bypass. The Sacramento River enters the Yolo Bypass in the Yolo Basin of the Sacramento Region. Research continues in the bypass to improve our understanding of fish passage, food web production and transport, spawning and rearing, mercury methylization, and invasive species to improve management of the bypass.

  In the lower San Joaquin River, the opportunities were limited in the Delta Region. The focus for Stage 1 has been on improving water quality conditions for upstream migrating adult anadromous fish species. Future opportunities for floodplain restoration are still a priority and will continue to be sought.

- *Floodplain management plans and actions.* ERP evaluate setback levees, and/or restored areas where rivers inundate their floodplain on a seasonal basis on the Cosumnes and Mokelumne Rivers as well as the lower San Joaquin and the lower Sacramento Rivers. Through the implementation of the Cosumnes River project, breaches were implemented to connect the river to restored areas of its seasonal floodplain. Other opportunities for the Region were limited but the North Delta

Improvements Project and the Levee System Integrity Program did include evaluations and alternatives for setback levees but none were ever implemented.

- *Yolo Bypass*. Completed and on going studies continue assess the values of restoring large seasonally flooded areas like the Yolo Bypass including projects that provide hydraulic impact information that allows for restoration projects to take place without jeopardizing conveyance. Monitoring, planning, and restoration has always been supported by the locally-led efforts in the Yolo Bypass. The Yolo Working Group and the Yolo Basin Foundation continued their education and outreach program to protect and restore at-risk species dependent on the Yolo Bypass and balance the needs of local agricultural communities and local governments. Collaborative projects were funded with the Army Corps of Engineers (USACE) to conduct hydrologic modeling that improved the ability of land managers and resource professionals to increase restoration opportunities without jeopardizing conveyance capacity.

Priority 3. Restore upland wildlife habitat and support wildlife-friendly agriculture.

Encouraging farming practices that improve agricultural lands' value as habitat for at-risk wildlife and other species dependent on the Delta and Eastside Tributaries Region and that minimize polluted run-off into nearby waterways remains an important goal. In addition to specific habitat improvements, efforts are encouraged that:

- *Develop agricultural incentive programs*. Research on sandhill crane distribution and habitat requirements has lead to improved understanding of foraging needs that describe crops, farming methods, and marketing programs that favor wildlife.

- *Comparative analysis.* During Stage 1, several projects were implemented in the Yolo Bypass that compared different wetland and crop management practices for mercury and mosquito abatement. These projects are still underway but once completed, should improve our decision making for land use in the bypass and crop management. As part of that project, they also intend to compare existing projects and/or use new projects to compare, the effectiveness of the different crop management approaches to maximize benefits for wildlife-friendly agriculture.

Priority 4. Restore habitat that would specifically benefit one or more at-risk species; improve knowledge of optimal restoration strategies for these species.

- *Adaptive experimentation with species-specific restoration approaches.* In the lower bypass at Liberty Island, an opportunity for adaptive management on the natural restoration of tidal wetlands lead to experiments that test the effectiveness of breached islands as an alternative restoration strategy for one or more at-risk fish, bird, or riparian species (or communities that include these species) in the Delta. Adaptive management approaches and strategies in the Delta Region remain a priority. Investigations and monitoring efforts are also a priority to better understand existing Delta restoration environments or newly designed restoration experiments.

  The early phase of monitoring for Liberty Island was completed with a grant made available for Prospect Island. When Prospect Island lost momentum, the levee failures on Liberty provided a new opportunity. Additional phases of monitoring are underway on Liberty to address food web production and transport into the Delta, floodwater conveyance, wave and wind erosion, habitat restoration and species response.

  On the Cosumnes River, many partners have been working on riparian and floodplain restoration to benefit splittail, salmon, neotropical migrants, and special plant species and communities. Most notably has been the research done by UC Davis and other partners on floodplain processes.

- *Restoration of Sacramento splittail and delta smelt.* Several studies have been implemented or are underway to improve our understanding of the life history of these species, factors controlling its migrations through and distribution (space and time) in the Delta, and development of population. The Delta Regional Ecosystem Restoration Implementation Plan's effort to develop quantitative life cycle models for many aquatic species in the Delta has just completed. These models have incorporated and compiled the current state of knowledge and understanding of the species and are specifically designed to identify the limiting factors or stressors to species and populations. In another effort, the Interagency Ecological Program (IEP) has been working on population models for delta smelt and striped bass.

- *Life histories and restoration or habitat requirements of at-risk species.* Workshops, white papers, or pilot scale monitoring and survey programs that summarize or better the state of knowledge about poorly known riparian or wetland species or groups of species that inhabit the Delta, especially where such studies can lead to population models have been completed or are underway. DFG staff wrote a recent white paper on the importance of tidal

wetlands in the Delta and Suisun Marsh for pelagic organisms and ecosystem function in the Delta.

ERP funded the IEP to conduct some focused research on POD stressors to improve our understanding and the relationship of primary productivity, benthic grazing rates of invasive clams, contaminants, and other studies on at-risk species such as delta smelt. The results have resulted in the POD Synthesis Report and should assist us in restoring habitats and processes to benefit POD species.

- *Changes in species abundances on a landscape basis.* Little progress has been made on understanding gains and losses of specific species and communities on a landscape basis as a cumulative result of establishing corridors of restored habitat however it remains a priority. There are efforts underway to develop performance measures and a comprehensive monitoring and research plan that was originally the responsibility of the Science Program but staffing and funding have been limited. In the mean time, the IEP has been the primary monitoring program for aquatic resources in the Delta. Plans are underway to evaluate expansion of IEP components and increase the resources being monitored to get at a landscape based approach.

  In response to science panel review recommendations for the IEP from earlier work, ERP also funded a project to develop monitoring responses of POD species to restoration actions that have been implemented. The project methodology will combine information from the histopathology of fish tissues, gut analysis, and otolith characterization. This work has just begun but promises to shed more light on smelt natal origins related to condition, feeding success, metabolic stressors, and other fish survival factors that are not completely understood.

Priority 5. Implement actions to prevent, control and reduce impacts of non-native invasive species.

Non-native invasive species are especially problematic in the Delta and improving our understanding and their implications on native species and natural processes remains a priority. Actions that improve our knowledge of the distributions of these unwanted species are needed as well as actions to begin control or eradication.

- *Support the formation of a Delta-wide multi-county interagency coordinating council* to identify and organize implementation of non-native invasive species management in the Delta. Several projects were funded to develop outreach and educational programs as well as a coordinating body that covered the entire ERP are of interest. Most notably might be the development and funding of the Non-native Invasive Species Council that has been responsible for the

coordination and implementation of activities and projects that address the issues of NIS in the CALFED area of concern.

- *Develop pilot projects* in marsh habitats to develop successful approaches to control of *Lepidium latifolium* (pepperweed), *Salsola soda* and other non-native invasive plants. Projects to develop to control these invasive species have occurred. Programmatic approaches for invasive control measures could be handled out of the NIS Program.

- *Research* in to the relationships between inundation, salinity and non-native invasive species needs in tidal wetlands to expose the hydrologic regimes less favorable to the non-natives has not been addressed directly through ERP at this time. Through the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) efforts, qualitative conceptual models have been or are completing development that will help improve our understanding of ecosystem water quality components and habitat restoration.

- *Document the distribution and abundance* of *Corbicula fluminea, as well as the trophic impacts of their populations in fresh, shallow water habitat, which may be targeted for restoration work.* Initial investigation through the POD efforts and other research indicates that this species may be the fresh water counterpart to *Potamocorbula amurensis* and may seriously affect our attempts to restore shallow water habitat and food web processes for pelagic fish.

- *Evaluate the relationship between DO and Egeria densa*, as well as the DO impacts of implementing a control program for *Egeria densa*. The DRERIP efforts are developing and nearing the completion of qualitative conceptual models that will help improve our understanding of aquatic vegetation control as well as restoration of favorable vegetation. Restoration actions have been identified and will be evaluated using the network of models to refine approaches to restore native flora and ecological processes that favor native Delta species.

- *Evaluate the relationships/interactions between nonnative organisms and Egeria densa* in areas of possible delta smelt spawning. Research and monitoring to improve our understanding of smelt spawning continues. Some focused research on the flooded islands and *Egeria densa* was conducted and results have lead to conclusions that these areas perform more like lacustrine habitats that are more favorable to non-native fish species and could be disruptive to pelagic process because of the lack of exchange or production to the open water systems that native fish depend on.

  High priority was given to surveys, studies, eradication efforts and monitoring efforts for nonnative species in the Delta, because non-native species represent one of the greatest threats to successful restoration of native populations.

Eradication actions that are accompanied by assessments of effects on non-target species will be a priority. In particular, priorities will be given to developing better knowledge of:

- *Responses* of striped bass, centrarchid predators, zooplanktons, non-native bivalves, mitten crabs or aquatic macroflora to different restoration actions. ERP has conducted major studies of the use of shallow water habitats by native and non-native species to test the assumption that shallow water habitat is indeed the key to restoring many of the native species for expectations for stage 1 strategic objective 2. BREACH and IRWM have produced refined conceptual models for predicting the outcome and ecological benefit of restoring shallow-water tidal habitat in the Bay-Delta.

  The CALFED Science Program and the IEP have been investigating the benefits of shallow water habitat in the Delta. There is growing body of evidence that shallow habitats dominated by submerged macrophytes are generally unsuitable for the Delta's remnant native fish fauna.

- *Methods* for comprehensive mapping, system-wide surveys and/or on-going monitoring of specific invasive species actions. There are projects that monitor on going invasive species eradication efforts as well projects that have mapped or are mapping the distribution of various invasive species including *Aurndo donax*, perennial pepperweed, and purple loosestrife. Extensive monitoring has revealed that perennial pepperweed density is significantly reduced by increased levels of salinity and soil moisture. Interagency Ecological Program for the San Francisco Estuary provides status information on various species including many that are introduced.

- *Education* efforts to help the public better understand the non-native species threat actions. A great amount of progress has been made toward the five Stage 1 Expectations: Ballast Impacts monitoring, management, and treatment; outreach regarding live bait industry; public information programs regarding species introductions; assessment of the pathways, risks to reduce, and eventually eliminate, introduction of unwanted aquatic organisms from these sources into natural waters; assessment of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts.

- *Mechanistic understanding* of the life histories of key non-native species actions. ERP has examined the life history of *Egeria densa*, the ecology of alien invasive jellyfish, the effects of introduced species of zooplankton and clams on the Bay-Delta food web. and along with IEP examined the effects of striped bass, large mouth bass and other introduces species of centrarchids. The increase in largemouth bass occurred when *E. densa*, an introduced aquatic macrophyte was

expanding its range in the Delta. Beds of *E. densa* provide good habitat for largemouth bass and other species of centrarchids, introduced predators. The areal coverage of E. densa in the Delta continued to expand by more than 10% per year from 2004 to 2006, as it infested a greater portion of channels and invaded new habitat. The populations of largemouth bass and other species using submerged aquatic vegetation will likely continue to grow. The key to restoring desirable pelagic species is to recreate habitats that have a high variability in abiotic factors such as salinity, channel flows, depth, and water clarity, which would discourage the growth of the *E. densa* as well as the introduced centrarchids.

Priority 6. Restore shallow water habitats in the Delta for the benefit of at-risk species while minimizing potential adverse effects of contaminants.

Results from the CALFED Science Conference showed that the ecological outcomes of habitat restoration projects in the Delta can differ widely, but the reasons for those differences are not fully understood. Understanding the factors that shape or constrain the outcomes of different habitat restoration scenarios is needed. Better understanding is sought of the comparative outcomes of existing projects, under different conditions or where different strategies have been employed. Additional priorities include:

- *Performance measures*. A suite of modeling tools being developed by the upcoming BREACH III project which evaluates and predicts restoration thresholds' in evolving freshwater-tidal marshes. These models may be of considerable value in developing restoration planning scenarios in the saline emergent habitat types west of the Central Delta. Many portions of Cullinan Ranch and the Suisun Marsh, while already in public ownership, are not at optimal elevations for emergent wetland colonization. Modeling may be able to identify restoration opportunities that are presently not recognized.

- *Finding solutions to the constraints to restoring ecosystems of inundated islands by advancing process understanding of Delta ecosystems.* Several projects examined the effect of subsidence, sediment deposition, sediment availability and re-suspension on time to achieve or sustainability of restoration. A study of methods for reversing subsidence on Delta islands came to the following conclusions: initially high DOC loading due to wetland creation on subsided islands would diminish, within 7 years, to less than current levels; rice straw may be a practical method for enhancing accretion rates on subsided islands that are still farmed; and reliance on mineral sediments as fill materials is impractical due to compaction and depressed in situ biomass accumulation. In-channel island restoration and prevention of the loss of relict natural islands, were the subject of two projects funded in the central and west Delta. The structures used in these projects did not facilitate sediment accretion. Geomorphic and geological mapping was conducted to develop a thorough understanding of the physical

processes that historically created and destroyed floodplains and associated habitats. Another study provided fully digital data on the distribution and composition of deposits in the lower Sacramento-San Joaquin Delta region, including the extent of the pre-development river and delta system, for restoration planning and engineering construction.

An ongoing delta smelt project is striving to contribute more information to the at-risk native species. The project to implements a state-of-the-art monitoring program to link key vital parameters for delta smelt collected by existing monitoring programs with survival to adulthood. This project will make concurrent, linked measurements of population variables to help understand how environment, restoration, and management activities affect the fish.

The natural breach on Liberty Island has presented an excellent opportunity to monitor landscape evolution from known initial conditions that were essentially a blank slate. The BREACH project is developing a new and promising spatial modeling tool that incorporates a shallow-water hydrodynamic module, a soil-building component to account for elevation changes, and a vegetation module that computes above and below biomass. The tool is expected to expand the range and scope of predictive modeling and enable restoration managers and practitioners to run different restoration scenarios on a diverse array of site-specific boundary conditions in the Bay-Delta.

IRWM is examining how tidal marsh restoration projects are affecting ecological processes at different spatial scales. It is collecting intensive data at six sites covering physical processes, geomorphology, landscape ecology, vegetation, birds, fisheries, invertebrates, food web, primary production, and nutrients. IRWM is building on the BREACH potential with landscape ecology and closely linked vegetation and biota data to help understand these elements better.

The nexus of IRWM and BREACH is now providing new insights into relating tidal marsh restoration progress with their effects on ecological processes and consequently a better understanding of how regional restoration efforts will contribute to species support and recovery.

In regards to the effect of restoration has on contamination problems or effects of contaminants on restoration outcomes, reports from the Yolo Bypass indicate that the mercury from the upper bypass is not showing up in fish tissue in the naturally restored areas. Potential mercury transport is either being sequestered or is of very limited biological availability. There is speculation that vegetation and soils are mediating mercury bioavailability.

BREACH research examined the nature of native and non-native biological communities and their restoration trajectories on diked and subsided lands

breached in the Bay and Delta. Preliminary conclusions were that invasive species would predominate restorations; and more restricted specialists in the food web would not rebound until the later stages of ecosystem recovery.

- *Restoration and monitoring strategies for riparian zones.* The development of the State of System report utilized monitoring techniques for riparian communities that could be incorporated into ERP's monitoring strategies. To promote riparian vegetation recruitment and establishment the State of the System report recommended that agencies:

    1. Manage the recession limb of spring high flow events in wet water years to promote seedling establishment of cottonwoods and willows.
    2. Promote channel migration to create new seedbeds for cottonwood recruitment through scour and fine sediment deposition.
    3. Promote strategic horticultural restoration on higher floodplains surfaces where passive recruitment is infeasible.
    4. Prioritize actions to eradicate and control invasive plant species.

- *Better understand net effects of multiple restoration projects on waterfowl and wildlife distribution and abundance across the landscape.* Waterfowl, like many other avian species, are highly mobile and can quickly respond to changes in distribution of preferred habitats. Habitat changes including wetland restoration and enhancement of agricultural habitats related to the implementation of the Central Valley Joint Venture Plan beginning in 1990 has increased waterfowl in the Northern Central Valley where availability of rice lands, flooded rice fields, and wetlands increased greatly from 1989 and 1999. However, in the Delta Region, the loss of crane-compatible habitats continues due to land conversion into vineyards, turf farming, and urban areas. Additionally, some areas of the Delta where compatible crops remain managed in ways not conducive to crane use.

Water and sediment quality also threaten the success of restoration, but many of these issues are not adequately understood to set priorities for regulation or elimination of problems. High priority is thus given to advancing understanding of the importance of water quality issues and bettering the regulatory basis relative to other issues. To that end, the following are the highest priorities:

- *Effects of contaminants.* Identification of previously uncharacterized contaminants has been funded in previous CALFED work, but the focus has been on the pesticides and on a certain class of pesticides, the pyrethroids. Pharmaceutical and other compounds in the waters of the Bay-Delta is the subject of a number of studies conducted by ERP's partner in science, San Francisco Estuary Institute. Many disciplines outside the biology specialty must be engaged in order to identify unknown organic compounds suspected of

having toxic effects on wildlife. The CALFED Science Program presented the results of a pioneering East Coast study that found numerous pharmaceutical and other contaminants of human origin in waters downstream of Publicly Owned Treatment Works (POTWs). Not all of the organics suspected of toxicity were estrogen analogs. In addition, the biochemical pathways through which endocrinologically active toxins inadvertently act in the ecosystem are not as well characterized as compounds designed to have neuro- and respiro- toxicity but which inadvertently leak into the ecosystem. The desired effect of presenting this material to a statewide audience of scientists is promote new ways of looking at the problem of toxic effects and compounds.

- *Sediment Contamination* and effects of dredging in contaminated areas or disposing of marginally contaminated sediment. A series of projects addressed the reuse of materials, dredged from Delta channels during maintenance operations, to maintain levees and as fill material in habitat restoration projects. ERP funded the Delta Dredge Reuse Strategy (DDRS) planning effort and created the DDRS document, which analyzed technical and regulatory issues related to Delta dredging projects and includes recommendations for additional studies and pilot projects to fill data gaps. These recommendations will be applicable to dredging and restoration planned for the Suisun Marsh as part of the ERP funded SMP.

- *Fish survival in the Central and South Delta.* The juvenile salmon migratory behavior study in the North and Central Delta used radio telemetry to improve the understanding of juvenile anadromous salmonids migratory behavior in the Delta. The project demonstrated that the fish utilized middle portions of the channels during migration. It was not, however, able to determine how the fish ultimately migrate downstream over time, because of the vast distances the fish moved upstream and downstream during both ebb and flood tides. This "distance traveled" information showed that the fish do not "hold in position" on flood tides and then only migrate on ebb tides.

  Another study in the Lower San Joaquin River and South Delta used ultrasonic transmitters to determine: the relationship between fish movements and dissolved oxygen and water temperature; identify milling and straying behaviors; and determine the rate at which salmon travel through the Sacramento–San Joaquin Delta. Most of the tagged salmon ascended the Sacramento River. The study results suggest that the salmon were not delayed in the Stockton Deep The salmon behavior was highly individualistic and their migration times and distance traveled were variable.

  A series of studies in the South Delta found that DO fluctuates in the San Joaquin River study area with both season and flow, and confirmed that DO levels at times exceed the RWQCB objectives. The study team observed that,

other than near the Port of Stockton, on most reaches the Low DO conditions are not as persistent as those on other rivers with substantial biochemical oxygen demand loadings.

- *Mercury.* Numerous studies of mercury transformation and transport have been funded. The results of these projects have informed understanding of the mercury risks due to restoration and operation of the Yolo bypass as a flood way. The environmental sources of mercury in the region and behavior of mercury in the Yolo bypass are well known. Mass balance has been characterized as well. Recent research project results indicate that, transport issues aside, the wetting and drying of soils is likely the main driver of mercury bioavailability. Other research has indicated that vegetated wetland environments seem to lower bioavailable mercury either through sequestration or phytoremediation. These conclusions have been recently confirmed by preliminary geospatial analysis of available data has indicated that there may not be an overall correlation between wetlands and elevated methylmercury in biota.

- *Selenium.* Understand transport of selenium from the San Joaquin River to and through the Delta. Advance understanding of selenium trapping in Delta shallow water/wetlands and accumulation/effects in the Delta food webs. A recent USGS study identified the most likely selenium loads that would be carried outside the San Joaquin Valley, if a drainage conveyance to Suisun were completed. A model was developed to forecast selenium concentrations and forms in the Bay-Delta from identified loads, then used those concentrations to model selenium exposures of invertebrates, like clams. Transfer from clams to predators was also estimated, and selenium effects on wildlife were then forecast. The methodology could aid comprehensive consideration of the impacts of various drainage disposal options. The authors concluded that most options that fully meet existing demand for drainage disposal by an out-of-valley conveyance system appear to pose strong risks to the reproduction and survival of sensitive birds and fish in the Bay. Threats to reproduction and survival of birds and fish are particularly severe during periods of low river flow.

- *Transport of nutrients and current-use pesticides.* Research continues in the Yolo Bypass to improve our understanding of fish passage, food web production and transport, spawning and rearing, mercury methylization, and invasive species to improve management of the bypass.

Priority 7. Protect at-risk species in the Delta using water management and regulatory approaches.

Long-term management of the water-use system to protect fish is important to accomplishing the goals of ecosystem restoration. Therefore, it is essential to improve the scientific underpinning of regulatory activities and manipulations of water

management to protect species of concern. New, creative solutions to water management dilemmas can also result from better scientific knowledge of environmental processes in the Delta, fish behavior and biology, and the influences of water management. Priority is given to studies of processes relevant to the interconnections of water management, regulation and fish protection. Studies that address processes relevant to, or that directly address the following topics continue to be a priority:

Minimize effect of diversions on fish: Projects are needed that address the following questions about diversion effects on fish:

- What is the relationship between screening water diversions and protecting individual fish, populations and ecosystems? ERP has funded few fish screen projects in the Delta. One project on the Banta-Carbona Irrigation District intake to reduce losses of juvenile salmon, steelhead and delta smelt in the South Delta EMU. The fish screen was completed in 2003 and used the standards for protection of MSCS species including juvenile salmon, steelhead and delta smelt. Monitoring of the fish screen has shown this project has succeeded in reducing out-migrating juvenile salmon and steelhead mortality rates.

- What are the full, economic or non-economic, cost-benefit implications of current water use, water management and fish protection strategies? There has not been an analysis of the full economic or non-economic, cost-benefit implications of current water use, water management and fish protection strategies.

- Can models or statistical relationships be used to improve knowledge of the relationships between management actions and their influences on fish populations? The Delta Conceptual Models (include both ecosystem element models and species life history models) are qualitative models that describe current understanding of how the system works. They are designed and intended to be used by experts to identify and evaluate potential restoration actions. They are not quantitative, numeric computer models that can be "run" to determine the effects of actions. Rather they are designed to facilitate informed discussions regarding expected outcomes resulting from restoration actions and the scientific basis for those expectations. The structure of many of the Delta Conceptual Models can serve as the basis for future development of quantitative models. Several models have been completed (e.g. delta smelt, and Chinook salmon and steelhead models), and it is believed that they improve our knowledge of the relationships between management actions and their influences on fish populations.

- What are the implications and environmental tradeoffs associated with the environmental water account? The Environmental Water Account (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 five years. It is apparent that the combination of regulatory requirements, ecosystem restoration, EWA water, and other water management actions carried out in recent years were not adequate to meet the needs of many species dependent on the Bay-Delta and its watershed.

Optimize use of Delta Cross Channel: Projects are needed that address the following question regarding Delta Cross Channel Operations.

- How do operational manipulations of the Delta Cross Channel, the export pumps or barriers, independently or in combination, affect water movement, water chemistry, transport of pollutants, fate of oxygen consuming materials, sediment deposition, or fish distributions/behavior? What is the net effect, or the cumulative effect, of such actions and changes on the Delta ecosystems or on restoration projects? Delta Cross Channel (DCC) water quality modeling indicates that the DCC could potentially provide significant reductions in salinity. Field studies show that DCC operations have a regional impact; circulation patterns at bends in rivers affect fish behavior; fish move in the water column due to day and night conditions; and reconfiguration of slough entrances may reduce fish entrainment.

Optimize regulatory strategies to protect fish and develop temporal regimes for water movement that minimize adverse effect on fisheries: Projects are needed that support temporal management regimes for water movements in the Delta.

- What are the ecological characteristics of shallow water habitat in the Delta and how should those characteristics affect the definition used for management and restoration purposes? ERP has conducted major studies of the use of shallow water habitats by native and non-native species to test the assumption that shallow water habitat is indeed the key to restoring many of the native species for expectations for stage 1 strategic objective 2. BREACH and IRWM have produced refined conceptual models for predicting the outcome and ecological benefit of restoring shallow-water tidal habitat in the Bay-Delta. The CALFED Science Program and the IEP have been investigating the benefits of shallow water habitat in the Delta. There is growing body of evidence that shallow habitats dominated by submerged macrophytes are generally unsuitable for the Delta's remnant native fish fauna.

- During what windows of time (and space) do species such as delta smelt, longfin smelt, Sacramento splittail and salmon occupy the Delta? Can work windows in the Delta be refined to more precisely direct variability in time and space when

these species are present? An ERP funded study found that juvenile salmon utilize middle portions of the channels during migration through the Delta. However, the study was not able to determine how the fish ultimately migrate downstream over time, because of the vast distances the fish moved upstream and downstream during both ebb and flood tides. This "distance traveled" information showed that the fish do not "hold in position" on flood tides and then only migrate on ebb tides.

- What habitats in the legal Delta are critical for the delta smelt and other species considered in water management decisions. Does habitat use by these species vary in time and space (new projects or interpretations of existing data)? An ongoing delta smelt project is striving to contribute more information to the at-risk native species identified by the ERP. This project implements a state-of-the-art monitoring program to link key vital parameters for delta smelt collected by existing monitoring programs with survival to adulthood. This project make concurrent, linked measurements of the following population variables to help understand how environment, restoration, and management activities affect the fish: 1) growth efficiency and body condition; 2) impairments from exposure to toxic chemicals; 3) survival to the adult stage; 4) spawning success; and 5) food composition and abundance. Also, ERP continues to fund POD studies, that help expanded the knowledge base about stressors that are impacting delta smelt survival and recruitment in the Delta.

- What processes influence the interconnections between levee protection techniques, water quality, biological community characteristics and attainment of ecosystem restoration goals? Levee and bank protection continue to be a priority for the Delta. In many cases, restrictions to flow and floodplain inundation due to these structures is a barrier to habitat restoration and species recovery. Several projects explored non-traditional methods of protecting levees. Tule stands, brush boxes, brush bundles and ballast buckets with native plants were found to be effective techniques in reducing wave energy that would otherwise erode the levees. In 2007, the USACE issued interim guidance for control of vegetation on levees. This memorandum would strip the Delta levees of riparian vegetation.

Priority 8. Understand the implications for Delta water issues of climate and hydrologic variability.

It is self-evident that climate has enormous implications for water management in California. Although the CALFED Program cannot engineer climate, or control its variability, actions across all programs (ERP, Drinking Water Quality, etc.) must operate within the constraints imposed by climate. It is difficult to imagine successfully managing water issues in California for the next decades in the absence of a better

understanding long-term and short-term patterns and trends in climate and the implications of those patterns and trends for hydrology and issues linked to hydrology.

Future studies of climate variability should include controlling factors and linkages to issues throughout the watershed that are especially critical for the Delta. Climate variability is a confounding factor in interpreting the success of CALFED Program actions, therefore, understanding interactions between climate change, hydrologic variability and the issues that will affect the CALFED Program success are important.

Issues pertaining to long-term climate change were described by Mount et al. (2006) and are expected to influence future resource management in the Delta. Critical certainties and uncertainties have been identified for consideration within the context of various Delta planning efforts:

- *Sea Level Rise*. Delta hydrodynamics are heavily influenced by tides, and sea level is a key determinant of tidal influence in the Delta. Global climate change is expected to increase sea levels and temperatures and affect local weather patterns. As sea level rises, intrusion of brackish water into the Delta is expected to increase; this intrusion of seawater would raise water surface elevations in the Delta, exacerbating the differential between water surface elevation in channels and land elevations in Delta islands. It is generally predicted that rising sea level will negatively affect Delta hydrodynamics and habitat conditions. A recent memo on sea level rise by the ISB suggests that sea level rise this century is likely to be at least 70-100 cm, significantly greater (~200 cm) if ice cap melting accelerates (ISB 2007).

- *Regional Climate Change*. Global climate change influences local climate conditions, particularly temperature and precipitation patterns, with implications for future inflows from tributaries to the Delta. In California, changes in precipitation patterns (e.g. more rain and less snow) are expected to shift timing of tributary peak runoff from spring to winter. It is projected that extreme winter runoff events will become more frequent and intense, and freshwater inflows to the Delta in spring and summer will decrease; greater variations in flows between years are also expected. Cumulatively, these changes are expected to put additional pressure on the Delta's fragile levees and increase the intrusion of brackish water into the Delta, with corresponding declines in both water and habitat quality.

Changes in temperature and flow regimes within the Delta system are inevitable with increasing sea level, global warming, and regional climate change. The Delta habitats and species will require space to respond to changes. As sea level rises, habitats are expected to shift inland. Upland areas will become more important for this shift to occur. In addition, changes in regional climate are expected to result in precipitation

patterns of more rain and less snow, shifting tributary peak runoff from spring to winter and making extreme winter runoff events more frequent and intense (CALFED 2008).

Various monitoring and modeling studies during Stage 1 have helped to address temperature and flow regimes across the entire ERP focus area (refer to sections 3.1.1 Central Valley Streamflows, 3.1.2 Bay-Delta Hydraulics, and 3.4.1 Central Valley Stream Temperature). These efforts will give rise to the development of management plans over the short-term to address continuing ecological issues, including decline of delta smelt and longfin smelt, among other species; as well as consider the long-term outcomes and likely effects of future change.

Other Programs That Have Contributed To Meeting ERP Goals

ERP has developed collaborative relationships with a wide variety of programs, agencies, and groups. Many of the programs and/or agencies mentioned below have made significant contributions toward restoration and habitat protection within the Delta Region and/or increased the understanding of ecological processes, restoration techniques, and other parameters which contributed toward ERP.

Central Valley Project Improvement Act (CVPIA). In addition to the Anadromous Fish Restoration and Anadromous Fish Screening programs, the CVPIA, as passed by Congress in 1992, required the Secretary of the Interior to implement a wide variety of Central Valley Project operation modifications and structural repairs in the Central Valley for the benefit of anadromous fish resources. Sections 3406(b)(l) through (21) of the CVPIA authorized and directed the Secretary of the Interior, in consultation with other state and federal agencies, Indian tribes, and affected interests to take actions which would ultimately assist in protecting and restoring a wide variety of fish and wildlife resources, habitats, and ecological function associated with the Sacramento and other rivers in the Central Valley. CVPIA is jointly managed by the U.S. Bureau of Reclamation (USBR) and USFWS.

Many of the CVPIA actions to restore fish and wildlife and their habitats are synonymous and/or consistent with ERP actions and priorities. Approximately $15 million of CVPIA restoration funds were targeted for the purpose of protecting, restoring, and enhancing special status species and their habitats in areas directly or indirectly affected by the CVP. CVPIA programs that contribute to ERP goals and objectives include: AFRP, Dedicated Project Yield, Restoration of Riparian Habitat and Spawning Gravel, Clear Creek Restoration, Anadromous Fish Screen Program (AFSP), & Water Acquisition programs.

Other CVPIA provisions contain elements that relate to and support the AFRP and the fish doubling goal. Section 3406 (b)(21) of the CVPIA directs USBR and the Service to assist the State of California in installing fish screens on major unscreened or

inadequately screened water diversions that may be resulting in the loss of juvenile salmon and other fish species, thereby affecting overall production.

Many of these provisions and other provisions in the Act are designed to support both anadromous and non-anadromous fish species. For example, provisions 3406 (b)(4) Tracy Pumping Plant and (b)(5) Contra Costa Canal Pumping Plant involve infrastructure and operational improvements, such as fish screening and recovery facilities, that contribute to anadromous and non-anadromous fisheries restoration. In general, the non-anadromous fish addressed by the CVPIA fisheries program are located in the Delta. The provisions address structural changes in CVP facilities and mandate changes in water operations to support fisheries restoration through a combination of timed increases in flows; water banking, conservation, and transfers; and modified operations and new or improved control structures.

Most of the historic wetland areas in the Central Valley have been converted to other land uses over the past 150 years. Less than five percent of the more than 4 million original acres of seasonal and permanent wetlands now remain. These remnants in the Central Valley must be intensively managed to support waterfowl populations that depend on the Central Valley for wintering habitat. Section 3406(d) of the CVPIA (*Refuge Water Supply)* establishes the primary goal of providing water for wildlife refuges and states that the Secretary shall provide, either directly or through contractual agreements with other appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on 19 refuges, including National Wildlife Refuge Systems in the Sacramento and San Joaquin Valleys, Central Valley state wildlife management areas, and the Grasslands Resources Conservation District.

This increase in water supply and reliability has created new wetlands and enhanced existing wetlands, resulting in increases in populations of Federal and State listed species—particularly avian species—and other wildlife species such as the giant garter snake (*Thamnophis gigas*). Avian species that have benefited include the peregrine falcon (*Falco peregrinus*), southern bald eagle (*Haliaeetus leucocephalus washingtoniensis*), tri-colored blackbird (*Agelaius tricolor*) and white-faced ibis (*Plegadis chihi*). The better water supply and reliability for refuges has also reduced the concentration of salts and other contaminants, thereby improving the quality of water on the refuges, and the quality of water discharged from the refuges.

CVPIA - Terrestrial and Other Habitat Resources. The CVPIA Habitat Restoration Program (HRP) was developed under Section 3406(b)(1) of the CVPIA to address the needs of native fish and wildlife affected by the CVP that were not specifically addressed in other portions of the CVPIA. The HRP focuses on protecting native habitats that have been directly affected by construction and operation activities of the CVP and that have also experienced or are experiencing the greatest decline in species that are federally listed, proposed, or candidate for listing under the endangered species act. Other considerations include state-listed species and non-listed state and

federal species of special concern or other associated native wildlife species. To date, the HRP has funded nearly 90 new projects with a total budget of over $23 million dollars. Much of the focus of the HRP since 1992 has been on acquiring land either through fee title or conservation easement, and consequently, more than 100,000 acres of habitat has been protected through HRP funding including vernal pool, riparian, alkali scrub, foothill chaparral, valley-foothill hardwood, and grassland. The HRP has also funded 8 riparian restoration projects which have contributed to more than 1,000 restored acres. Additionally, more than 30 studies/surveys have been funded, with projects including captive breeding and reintroduction; distribution and status surveys; genetics studies; assessment of relocation efforts; and grazing impacts studies. Finally, more than 10 management/planning/outreach actions have been funded. The program has also supported pilot programs that contribute to the long-term scientific understanding of restoration actions.

CALFED Watershed Program. This program has many similar goals and objectives as ERP, and millions of dollars of Watershed Program funds have been allocated to projects in the Sacramento Valley Region. These include watershed assessments, watershed management plans, restoration projects, and the funding of watershed coordinators.

The Wildlife Conservation Board (WCB). WCB was created by legislation in 1947 to administer a capital outlay program for wildlife conservation and related public recreation. Originally created within the California Department of Natural Resources, and later placed with CDFG, the WCB is a separate and independent Board with authority and funding to carry out an acquisition and development program for wildlife conservation (California Fish and Game Code 1300, et seq.). WCB's three main functions are land acquisition, habitat restoration and the development of wildlife oriented public access facilities. The Wildlife Conservation Board offers grants under most of its programs. These include grants for restoration and enhancement of wildlife habitat, development of public access facilities for wildlife oriented uses, and protection of habitat through fee acquisitions and conservation easements.

These activities are carried out under the following programs, many of which have implemented projects that addressed ERP goals:

- California Forest Conservation Program
- California Riparian Habitat Conservation Program
- Ecosystem Restoration on Agricultural Lands
- Habitat Enhancement and Restoration Program
- Inland Wetlands Conservation Program
- Land Acquisition Program
- Natural Heritage Preservation Tax Credit Program
- Oak Woodlands Conservation Program
- Public Access Program
- Rangeland, Grazing Land, and Grassland Protection Program

Environmental Quality Incentive Program (EQIP) and Wetland Reserve Program (WRP); managed by the National Resource Conservation Service (NRCS). (EQIP) incentive payments compliment the objectives contained in the CALFED ERP while focusing on the role agricultural lands can play to provide habitat to fish and wildlife species. Approved projects optimize environmental benefits, while also addressing natural resource concerns, and are awarded based on criteria consistent with the goals of EQIP. Projects using WRP funding similarly compliment the objectives contained in the CALFED ERP and the objectives of the WRP.

The WRP objectives are to purchase conservation easements from willing sellers; restore and protect wetlands in agricultural settings; remove environmentally sensitive, marginal cropland from cultivation; assist landowners with restoration of wetland hydrology; and contribute to the national goal of no net loss of wetlands. Approved projects optimize environmental benefits while addressing natural resource concerns and are awarded based on their statewide rank consistent with the goals of WRP.

Central Valley Habitat Joint Venture (CVHJV). The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Delta and Yolo Basin. These objectives are consistent with the ERPP targets developed for this EMZ.

Riparian Habitat Joint Venture (RHJV). Loss of riparian habitat is the single greatest cause of recent declines in songbird populations in the western U.S. New possibilities for preserving this critical habitat, through partnerships, prompted California Partners In Flight to launch the Riparian Habitat Joint Venture in 1994, modeled on the waterfowl JVs but funded solely by its member organizations. To date, eighteen federal, state and private organizations have signed the landmark Cooperative Agreement to protect and enhance habitats for native landbirds throughout California. The RHJV, modeled after the successful Joint Venture projects of the North American Waterfowl Management Plan, reinforces other collaborative efforts currently underway which protect biodiversity and enhance natural resources as well as the human element they support.

Current priorities include projects on the Sacramento, San Joaquin, and other California rivers. The Riparian Bird Conservation Plan, summarizing current scientific knowledge on the requirements of 14 focal bird species, provides recommendations for habitat management and monitoring.

Local Watershed Planning Groups. Maintaining and restoring the ecological health of the Delta Region depends also on local watershed groups, including local landowners, concerned individuals, and local resource experts.

Changes Attributable To ERP

Consistent with the ERP Stage 1 strategy of establishing a firm scientific footing for restoration actions, many of the projects funded by ERP during Stage 1 were investigatory or exploratory in nature. Projects included studies or pilot projects that are region wide in their geographic scope or application. Many of the ERP-funded projects in the Delta Region addressed the cycling and transport of nutrients, detritus, and organisms; water quality; and dredging.

Approximately 555 acres of land were protected within the boundary of the Stone Lakes National Wildlife Refuge (NWR), which protect existing aquatic, wetland, and riparian habitats and restore a mosaic of aquatic, perennial and seasonal emergent wetland, riparian, and grassland habitats.

Liberty Island Acquisition has thus far resulted in the acquisition and protection of 4,941 acres of Liberty Island located in the Yolo Bypass. The island has naturally returned to tidal influence since breaching in 1997 and wildlife now use the habitat afforded by newly reestablished vegetation.

Together, projects in the Jepson Prairie, Liberty Island, Cache Slough, and Prospect Island areas can potentially meet and exceed most of the North Delta EMU habitat targets once carried out in full.

On Staten Island, 9,106 acres of critical agricultural wetlands were protected and employ wildlife-friendly management practices for waterfowl and sandhill cranes.

The Banta-Carbona Irrigation District Fish Screen contributed to the ERP target to reduce losses of juvenile salmon, steelhead and delta smelt in the South Delta EMU from entrainment at water intake structures. Monitoring of the fish screen has shown this project has succeeded in reducing out-migrating juvenile salmon and steelhead mortality rates.

Riparian habitat for the riparian brush rabbit and riparian woodrat on the Lower Stanislaus River is being restored which will contribute to the recovery of the riparian brush rabbit, an at-risk species identified by the ERP.

At Dutch Slough, 1,166 acres were acquired. These lands, when mature, will contribute to the goal of restoring tidal wetlands in the central and west delta. The project therefore has potential to meet some or all of the general target to protect and restore 50 to 100 acres of Antioch inland dune scrub habitat.

Application Of ERP Activities To Multi-Species Conservation Strategy (MSCS) Species

Projects to rear delta smelt for research needs were conducted during Stage 1. Combined with ERP funded POD studies, these projects have expanded the knowledge base for stressors that are affecting delta smelt survival and recruitment in the Delta. Multiple years of continuous monitoring is needed in order to make effective decisions about fish and wildlife population and habitat management. Data obtained from the projects funded by ERP address MSCS at-risk species. Comprehensive data was not collected on all MSCS species, although a substantial level of information was gathered from the various ERP projects, particularly in the arena of fisheries. Data collected on fish distribution and habitat provide critical information which can be used in future restoration efforts.

Extensive monitoring projects were conducted in the Delta Region; looking at a variety of resource parameters, either with ERP funding, or with funding from other sources. In the North and Central Delta radio telemetry was conducted to improve the understanding of juvenile anadromous salmonids migratory behavior in the Delta. The project demonstrated that the fish utilized middle portions of the channels during migration. In the Lower San Joaquin River and South Delta ultrasonic transmitters were used on adult Fall-Run Chinook Salmon to determine: the relationship between fish movements and dissolved oxygen and water temperature; identify milling and straying behaviors; and determine the rate at which salmon travel through the Sacramento–San Joaquin Delta.

A series of culture of delta smelt projects were funded by ERP in order to provide a supply of smelt for research without further diminishing the natural population. Another project is implement a state-of-the-art monitoring program to link key vital parameters for delta smelt collected by existing monitoring programs with survival to adulthood.

Current Knowledge

The Yolo Bypass remains an area of great interest and encompasses portions of the Yolo Basin EMZ and the Sacramento-San Joaquin Delta EMZ. The projects funded thus far have helped to better define the value of the bypass as seasonal habitat for MSCS fish species. The studies have also improved our knowledge of the role of the bypass in supporting local and Delta zooplankton species and organic carbon input which could benefit MSCS species in the Delta. The areas in which we have made significant progress in better defining the ecological problems, developing restoration strategies, and implementing restoration/management actions in the Yolo Basin EMZ include:

- The ecological and biological value of seasonal flooding.
- The role of wildlife refuges and wetlands in supporting dependent species.
- Better understanding of fish passage needs and stranding problems.
- The contribution of Cache and Putah Creeks to flooding.
- The control of invasive weeds species in upland areas.
- Watershed management and improvements at the local level.
- Restoration of perennial grasslands.
- Opportunities to reduce sediment and mercury input reduction to the Delta.

Generally, we know much more about the Yolo Basin EMZ now than prior to the beginnings of CALFED. This is a direct result of providing funding for a wide variety of monitoring, research, implementation, planning, and educational programs that focused on the Cache Creek, Putah Creek, Solano, and Willow Slough watersheds and the Yolo Bypass.

The CALFED Science Program and the IEP have been investigating the benefits of shallow water habitat in the Delta. Current evidence indicates that shallow habitats are dominated by submerged macrophytes and are generally unsuitable for the Delta's remnant native fish fauna. Therefore, it is strongly suggest that restoration projects in the Delta need to discourage submerged macrophyte domination regardless of what mechanisms are primarily responsible for low native fish use. Furthermore permanent water on Central Valley floodplains, such as that found in sloughs, also supports mainly alien resident fishes, which may be significant predators on juvenile native fishes, or otherwise alter the system in unfavorable ways. Thus, it is desirable to reduce such habitats as much as possible or to find ways to make them more favorable for native fishes.

The CALFED Science Program supported additional research into subsidence in the Delta. It was found that microbial oxidation and compaction of organic-rich soils in the Delta have led to significant regional subsidence in the Delta and subsidence is likely to continue into the indefinite future, particularly in the central and west Delta. The combination of continuing subsidence and rising sea level makes attaining ERP Delta habitat targets for the central and west Delta more difficult then originally thought.

Subsidence and sea-level rise will, to a certain extent, dictate where marsh habitat and the associated delta and tidal sloughs will be created.

Impediments to implementation

Subsidence: The main impediment to completing restoration plans in the North and East Delta is the lack of a common set of goals among all the stakeholder interests in the region. Subsidence is greatest in the Central and West Delta. Elevations below sea level put restoration and conservation investments in this area at high risk of loss during flooding due to catastrophic levee failures.

Contract timeliness and issues revolving around environmental compliance: One of the common complaints from project implementers was the time taken to obtain a contract to initiate a project. This sometimes shortened the amount of time that could be used for post-project monitoring and/or negatively affected cost share arrangements (cost share funds had to be turned back), as well as potentially increased costs of a project due to inflation/cost of living.

Land Ownership: Nearly all the land where restoration could be done is in private ownership. It continues to be difficult to finding welling sellers of land for restoration.

Funding: The current system of funding greatly constrains the opportunity to design, implement and monitor large channel-floodplain projects properly.

Lack of a comprehensive, effectiveness and implementation monitoring program: The problems with reporting and monitoring still hamper the clear assessment of ERP's progress toward achieving goals, objectives, and targets. There is no standardized monitoring procedures to evaluate project performance or program performance.

Status of Area Today

The Delta formerly supported broad expanses of tule marshes, riparian forests, and shallow-water habitats, intersected by permanent open water channels and secondary sloughs. At the start of CALFED, nearly all of that habitat was gone. It was replaced by intensive agricultural on levee-bounded islands. Of the channels only the primary open water channels remain, which have been broadened and deepened by dredging and levee building. Delta islands are separated by steep-banked waterways, which provide few shallow-water areas where natural vegetation can take root. Natural vegetation is generally limited to midchannel islands and a narrow band along levee edges. In many areas, even this remaining band of vegetation has been displaced by bank protection. The loss of islands and shoals negatively affects fish and wildlife habitats, and foodweb productivity. The reduction of upstream sediment continues thwart habitat formation or halt its lose. Except for a small amount of habitat naturally forming on Liberty Island

and the planned Dutch Slough project, the Delta is nearly the same as it was at the inception of CALFED.

The delta smelt, along with other pelagic fishes in the Delta, has been experiencing a sustained population decline, despite several wet years and corresponding conditions that should have reversed the population decline observed in the drought period of the late 1980s and early 1990s. The IEP, which monitors the abundance of estuarine fish species in the Bay and Delta, reports that abundance indices from 2002 to 2004 include record low levels of delta smelt and young-of-year striped bass, and near-record low levels of longfin smelt and threadfin shad, whereas the populations of marine and lower estuary species (including salmon) have increased to levels not seen in the past several decades. IEP monitoring has also demonstrated declining levels of zooplankton, such as copepods, that are the primary food of larval pelagic fish and older life stages of delta smelt. These declines became widely recognized and discussed as a serious issue, and collectively became known as the POD. The findings of IEP's monitoring activities have enabled IEP to develop an initial conceptual model hypothesizing that there are at least three factors that, individually or collectively, have lowered pelagic productivity: toxic effects (i.e. pesticides), exotic species effects (including food web impacts), and water project effects (including entrainment).

As previously stated, many of the ERP projects funded in the Delta Region involved research, monitoring, planning, and pilot demonstrations. These activities provide the Region with an established baseline of scientific and technical data and tools that would serve as a guide for future implementation.

Future Vision

While great successes have been made in the Delta Region, new circumstances have arisen and priorities have adjusted accordingly. There are new Delta Planning efforts to find solutions for the Delta. The Bay Delta Conservation Plan is under way to develop a strategy to implement a safe and reliable water supply and the Delta Vision is looking at developing a strategy for a comprehensive conservation plan for the Delta that includes power and commerce, as well as ecosystem. ERP has continued its work on the Delta Regional Ecosystem Restoration Implementation Plan by developing conceptual models that capture the current state of knowledge of habitats, processes, stressors, and species of the Delta. The intent of that effort is to evaluate broad restoration and conservation actions and develop a plan for implementation.

New research has found that the Delta is at increasing risk of catastrophic levee failures from seismic activity. Global warming and sea level rise research continues to shed new light on complex issues. With these, and other research and monitoring efforts, the priorities for the Delta are focused now, more than ever on an ecosystem base approach so that habitats and species have the ability to respond to changes in the environment. Solutions for the Delta will not be limited to the legal Delta, transitional

habitats areas will be needed in the future to respond to sea level rise and evolve into future tidal marshes.

Priority 1. Freshwater Flows and Natural Flow Regimes

- Revise the Ecological Flow Tool, originally developed for the Sacramento River, to include the Delta.

- Develop local projects to test the "Variable Delta" hypothesis to see if manipulating salinity and flows can help control invasive aquatic species and to see how native species use or avoid these conditions.

- Improve monitoring of in-Delta hydrodynamics and fish assemblage response to hydrologic conditions to assist with developing ecosystem management decisions and tools.

- Obtain needed information on water diversion and use, including groundwater use.

- Accelerate completion of in-stream flow analyses.

Priority 2. Channel Geometry

- Conduct further Delta Cross Channel operational studies.

- Conduct further experiments with salinity control gates in Suisun Marsh.

- Study Two-Gates and the effectiveness of barges as barriers.

- Study bubble curtain effectiveness as barriers, and their effects on other species.

Priority 3. X2:

- Examine the mechanics that demonstrate the importance of X2 for a number of estuarine species.

- Investigate whether the mechanism of gravitational circulation accounts for the X2-abundance relationships for specific species by recurring mortality during migration to nursery habitats during higher flows.

- Determine X2 mechanisms for additional species.

- Determine the importance of X2 and pelagic habitat quality in the spring and fall for delta smelt.

Priority 4. Decline in Productivity and the Aquatic Food Web:

- Determine how to alleviate the negative impacts of non-native species (e.g. *Corbula*) and contaminant toxicity on the pelagic foodweb.

- Determine how much tidal marsh restoration efforts in the Delta and Suisun Marsh can supplement pelagic fish production.

- Determine potential impacts of ammonia and other contaminants on primary productivity (studies underway by State and Regional Water Quality Control Boards).

Priority 5. Upland Areas:

- Acquire land and easement interests from willing sellers in the east and south Delta that will accommodate seasonal floodplain areas, and shifts in tidal and shallow subtidal habitats due to future sea level rise.

- Conduct research to determine scale and balance of flow, sediment, and organic material inputs needed to restore riverine ecosystem function.

- Develop a better understanding of species-habitat interactions, species-species interactions, and species' responses to variable ecosystem conditions in order to better determine natural versus human-induced responses of upland habitat restoration.

- Determine contaminant and runoff impacts of agriculture and urban areas, and anticipate effects on the ecosystem from future expansion of these land uses.

- Pursue large-scale riparian vegetation along waterways wherever feasible, including opportunities for setback levees.

Priority 6. Floodplains:

- Continue Aquatic Restoration Planning and Implementation (ARPI) activities such as habitat enhancement and fish passage improvements in the Yolo Bypass. Continue coordination with Yolo Basin Foundation and other local groups to identify, study, and implement projects on public or private land with willing participants, to create regionally significant improvements in habitat and fish passage.

- Continue working with the participants in the Yolo Bypass Strategic Plan process to ensure the project scope builds upon investments in the Lower Bypass.

- Continue implementing projects at the Cosumnes River Preserve, such as restoring active and regular flooding regimes and flood riparian forest habitat; measuring flora and fauna response to restoration; and monitoring surface and groundwater hydrology and geomorphic changes in restored areas.

- Pursue opportunities for land and easement acquisitions in the Yolo Bypass and along the lower Cosumnes and San Joaquin Rivers, which could be utilized as floodplain inundation areas in the near term or in the future.

Priority 7. Tidal Marsh (intertidal areas):

- Continue habitat restoration, property acquisition, planning, and monitoring on specified sites:
    - Hill Slough habitat restoration (Suisun Marsh)
    - Mein's Landing restoration (Suisun Marsh)
    - Blacklock restoration monitoring (Suisun Marsh)
    - Cache Slough complex, including Prospect and Liberty islands, and Lindsey Slough.
    - Yolo Bypass Wildlife Area (tidal and seasonal wetlands on 700 acres)

- Implement and monitor the Dutch Slough restoration project, which would restore up to 483 acres of emergent wetland (a portion of which would be tidal), and generate information on how to best restore tidal marsh habitat.

- Continue studies in the lower Yolo Bypass to greatly improve understanding of aquatic species' response to tidal wetland restoration. Evaluate physical and geomorphic processes and monitor connectivity and key ecological variables (comparing Yolo Bypass and Cosumnes River systems) to assess effects of seasonal and interannual hydrologic variability.

- Conduct studies to determine whether fish benefits from tidal marsh that have been demonstrated in the saline portion of the estuary are also true for the freshwater portion of the estuary.

- Conduct studies to determine whether inundation of marsh plains on the flood tide at night results in cooler water being returned to the channels on the ebb tide.

Priority 8. Subsided Lands/Deep Open Water Areas:

- Implement wildlife-friendly agriculture and wetland projects (e.g. in partnership with Farm Bill programs).

- Secure easements and land interests on which subsidence reversal projects can occur (e.g. in partnership with USGS).

- Conduct experiments on the creation and management of deep open water areas. Some potential locations include:
    - o Lower Sherman Island
    - o Little Egbert Tract

- Continue to monitor deep open water areas on Liberty Island for environmental conditions and species use

Priority 9. Water Diversions:

- Continue participation in the Sacramento Valley-Delta Fish Screen Program to reduce entrainment mortality of juvenile fish by installing state-of-the-art fish screens on Sacramento River and Delta diversions.

- Continue ERP coordination with State and Regional Water Quality Control Boards, and IEP, studies and activities geared toward determining population dynamic consequences of fish entrainment.

- Further investigation of role of export and inflow (E/I) ratios as dominant factor in particle fate, in relation to entrainment of pelagic organisms (including eggs and larvae) in SWP and CVP pumps and other diversions. (E/I ratio range of .17 to .35). Salmon smolts may not be accurately captured by this model because their behavior likely makes their fate substantially different from neutrally buoyant particles such as pelagic species' eggs and larvae.

- Continue monitoring pre-screen losses of delta smelt in Clifton Court to interpret the relation between salvage statistics and direct entrainment losses in the State Water Project

Priority 10. Non-Native Invasive Species:

- Continue implementing the CALFED NIS Strategic Plan and CDFG's California Aquatic Invasive Species Management Plan (CAISMP) to prevent new introductions; limit or eliminate NIS populations; and reduce economic, social and public health impacts of NIS infestation.

- Continue funding the Department of Boating and Waterways *Egeria densa* mapping program. Also, begin investigating whether non-chemical means of control are possible.

- Continue research and monitoring programs to increase understanding of the invasion process and the role of established NIS in the Delta's ecosystems including:
    - Investigate invasions by *Egeria* or *Microcystis* to newly restored areas.
    - Investigate recreating habitats that have a high variability in abiotic factors (e.g. salinity, flows, depth, etc.) as a means of limiting the overbite and Asian clams and *Egeria*.

- Continue studies on the effectiveness of local treatment of zebra and quagga mussels using soil bacterium.

- Standardize methodology for sampling programs to measure changes in NIS populations over a specific timeframe.

- Collect and analyze water quality sampling data (e.g. salinity and water temperature) for correlation analysis between NIS distribution and habitats.

- Complete an assessment of existing NIS introductions and identify those with the greatest potential for containment or eradication; this assessment also would be used to set priority control efforts.

- Establish a program to monitor for new invasions of non-native wildlife, and develop responses to quickly contain and control them.

- Continue investigating potential parasite(s) as a means to control invasive clam or mussel populations.

Priority 11. Contaminants and Toxics:

- Provide technical and financial support to the State Water Resources Control Board (SWRCB) and Central Valley Regional Water Quality Control Board (CVRWQCB) for TMDL implementation efforts that complement ERP goals:
    - Continue developing Best Management Practices (BMPs) to control methylmercury transport from restored wetlands
    - Assist in Cache Creek Settling Basin improvements to reduce the amount of methylmercury entering the Yolo Bypass and Delta.
    - Describe the impacts of upstream San Joaquin River algae loads on dissolved oxygen in the Stockton Deep Water Ship Channel

- Coordinate with the SWRCB, CVRWQCB, and San Francisco Regional Water Quality Control Board (SFRWQCB) in their comprehensive five-year strategic work plan for the Delta, including TMDL implementation and miscellaneous water quality studies.

- Participate in a comprehensive monitoring program, including collecting and analyzing water quality data.
- Study the relationships between contaminant exposure and organism effects, and the magnitude of these effects in terms of population impacts.
- Investigate the possibility of synergistic (rather than additive) impacts of multiple contaminants on species.
- Study and describe the potential effects of ammonia on primary production and on aquatic species in the Delta.
- Conduct selenium research to fill data gaps to refine regulatory goals of source control actions, and determine bioavailability of selenium under several scenarios
- Investigate the impact of endocrine disrupting chemicals (EDCs) on species' health and reproduction

Priority 12. Species:

- Investigate the feasibility and sustainability of establishing broodstocks or refuge populations of species at high risk of extinction.

- Investigate whether individual species' respective range of distribution can be extended or changed, so they may persist in changing future conditions

- Investigate whether species' genetic material can be manipulated to improve their resilience in changing future conditions

- Preserve species' genetic material in seed banks, and utilize it to maintain genetic diversity within species populations in the future

- Continue monitoring individual species' status and trends using new and existing data sets

- To the extent possible, limit interaction between wild and hatchery-reared fish.

Future Ecological Risks

The ecological risks of the past remain and in some instances are worse than they were prior to the establishment of CALFED. The risk of the collapse of what remains of the Delta ecosystem, as the POD may be indicating, is a very real possibility. Furthermore, the increasing risk of catastrophic levee failures from seismic activity, and the changes expected from global warming and sea level rise threaten the very existence of the Delta, as we know it.

Future Institutional Barriers

The lack of secure funding and the conflicts or concern posed by adjacent landowners with different land use goals will continue to hamper implementation. Without institutional as well as public support for efforts to recover the Delta, it will be difficult to reestablish a self-sustaining Delta ecosystem. However, the issue of Delta governance was recently resolved by the adoption of legislation establishing the Delta Stewardship Council. The ERP Implementing Agencies will continue to implement the ERP, and will inform as well as be part of future comprehensive Delta planning and restoration efforts.

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2. REGIONAL OVERVIEWS

2.2 Sacramento Valley Regional Overview

Sacramento Valley Regional Description

The Sacramento Valley Region (Figure 1) encompasses much of the Sacramento River, which flows for more than 300 miles from Lake Shasta to Collinsville in the Delta, where it joins the San Joaquin River. This river provides about 80 percent of the inflow to the Delta and is the largest and most important riverine ecosystem in the State of California. The Sacramento River provides essential habitat for many anadromous fish populations, including all runs of Chinook salmon (*Onchorynchus tshawytscha*) and steelhead (*O. mykiss*), for their spawning, holding, and rearing requirements. The Sacramento River corridor encompasses more than 250,000 acres of natural, agricultural, and urban lands upstream of Sacramento. Various irrigated crops, mostly rice, grains, alfalfa, and orchard crops, are grown on flat and gently rolling terrain adjacent to much of this area. Most of this cropland is irrigated with water diverted from the Sacramento River or its tributaries. Five National Wildlife Refuges (Sacramento, Delevan, Colusa, Sacramento River and Sutter) are either adjacent to or within five miles of the Sacramento River. There are also many refuges and wildlife areas under state, local, and private ownership/management within this zone.

The southern boundary of the Sacramento Valley Region lies along the southern end of the Yolo Basin, west of the Sacramento River, and the southern end of the American River watershed on the east side of the Sacramento River. The following ERP ecological management zones are included in this region: Sacramento River, North Sacramento Valley, Cottonwood Creek, Colusa Basin, Butte Basin, Feather and Sutter Basin, Yolo Basin and American River Basin. A portion of the Yolo Bypass in the Yolo Basin ecological management zone is not covered in the Sacramento River Valley section; rather, it is covered in the Delta and Eastside Tributaries section with the rest of the Yolo Bypass. Each of these ecological management zones has unique characteristics and stressors. Detailed descriptions and visions for each of these zones can be found in Volume II of the Ecosystem Restoration Program Plan (CALFED 2000b).

Unimpaired flow from the four major rivers in the Sacramento Valley Region (Sacramento, Feather, Yuba, and American Rivers) averaged 17.9 MAF and ranged from 5.1 to 37.7 MAF during the 1906-1996 period. The most intensive runoff occurs in the upper watershed of the Sacramento River above Lake Shasta and on the rivers originating on the west slope of the Sierra Nevada. These watersheds produce an annual average of 1 to more than 2 TAF of runoff per square mile. The two major tributaries to the Sacramento River along its lower reach are the Feather River (which also includes flows from the Yuba River) and the American River.

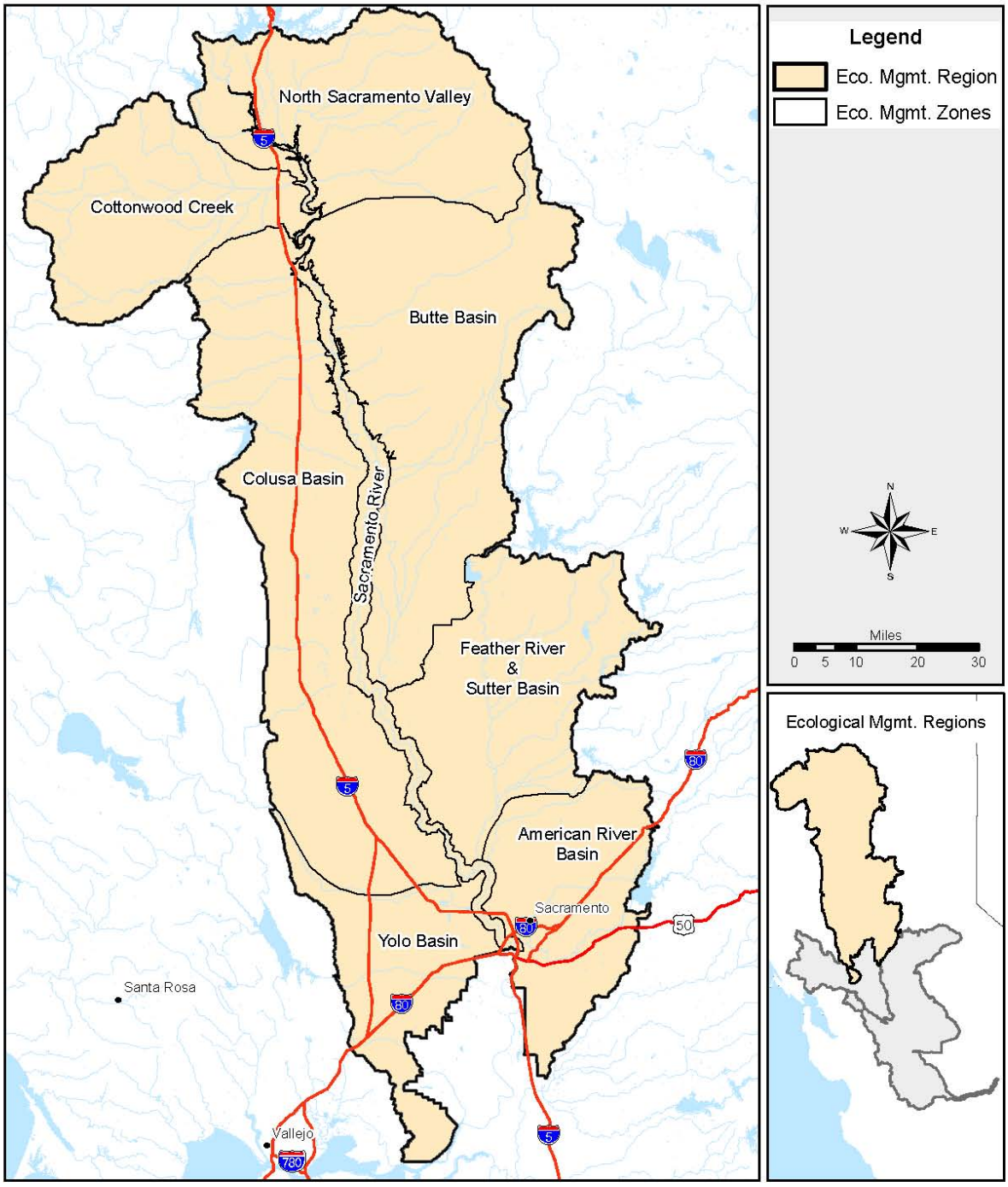


Figure 1. Sacramento Ecological Management Region

CALFED BAY-DELTA PROGRAM

California Department of Fish and Game
Ecosystem Restoration Program

Figure 1. Map of Sacramento Valley Region

Since 1900, a number of reservoirs have been constructed in this region, including Shasta, Oroville, Trinity, and Folsom; as well as numerous smaller reservoirs. Total reservoir capacity in or affecting the Sacramento Valley Region is approximately 15 MAF. These reservoirs have been operated to provide agricultural and domestic water supplies, flood control capacity and, more recently, recreation and ecological flows. Historically, wetlands covered an estimated 1,400,000 acres of the Sacramento Valley and were comprised of mostly riparian forests and semi-permanently flooded tule marshes. Approximately 170,000 acres of wetlands remain and are dominated by tule marsh. Some 500,000 acres of riparian forest historically fringed the entire length of the mainstream Sacramento River channel. Today, less than 5% of the mainstream riparian forest remains. As in the Delta, wetland plants and riparian forests provided food and shelter for aquatic and terrestrial biota and greatly increased the hydraulic residence time of the system.

Much of the annual runoff volume of the Sacramento River system is stored in reservoirs; therefore, Sacramento River and tributary flows are highly regulated and under the direct control of Reclamation, DWR, and others. The main purposes of the reservoirs are flood control and storage for subsequent release to downstream diverters and generation of electricity. Relative to the natural flow regime, the present river flows are lower in spring and winter but higher in summer and fall.

The ecological factors having the greatest influence on anadromous fish species in the Sacramento River include: streamflow; coarse sediment supply (including gravel for fish spawning and invertebrate production); stream channel dynamics (meander); flow quantity and timing; and riparian and riverine aquatic habitat. Stressors that have affected the health of the anadromous fish populations include: dams; harvest; high water temperatures during holding; spawning and egg incubation; toxins/contaminants from mine drainage and other sources; hatchery stocking; restricted access to the natural floodplain(s); reduced spawning habitat quantity and quality; and unscreened or poorly screened diversions.

Despite these modifications to the Sacramento Valley Region's environment, the Region contains a large diversity of both lowland and upland habitats and species. There are wetlands along sections of many Sacramento Valley Region waterways, as well as grasslands and wooded upland communities throughout the watershed. Over 100 special-status wildlife and plants occur here. The largest number of special-status plant species is found in grassland habitats, which includes vernal pools, with the next-largest number occurring in chaparral and montane hardwood. The majority of the special-status wildlife species are associated with grasslands and fresh-water emergent wetlands, lakes, and rivers on the valley floor. Many of these species have been listed by federal and state wildlife agencies because of habitat loss associated with agriculture, development and water projects.

Summary of ERP Investments and Regional Highlights

Since 1995, the ERP has funded 171 projects in the Sacramento Valley Region totaling over $250 million dollars (Table 1).

Table 1. ERP Investment in the Sacramento Valley Region

Program Region	# of Projects[1/]	Sum Of Total Amount ($)[1/]	Fund Source
Sacramento Valley	3	$719,884.00	Clean Water Act, Section 104(b)(3)
	19.5	$13,481,250.00	CUWA: Category III
	0.5	$50,000.00	CVPIA: Anadromous Fish Restoration Program
	1	$39,400.00	CVPIA: Habitat Restoration Program
	32.50	$59,923,461.24	Federal Bay Delta Act Funds - (Water and related resources)
	1	$400,000.00	Proposition 13: Mine Remediation
	35.52	$30,971,426.81	Proposition 204: Category III
	55.19	$97,336,981.00	Proposition 204: Chapter 7
	22.79	$47,129,197.00	Proposition 50
	171	**$250,051,600.05**	**All Funding Sources**

[1/] Does not include projects that are approved for funding but have not been executed.

Sacramento Valley Region ERP Stage 1 Accomplishments towards Regional Priorities

The ERP Strategic Plan (CALFED 2000a) included Draft Stage 1 actions for the Sacramento Valley (including the Sacramento River and its tributaries). The actions describe the critical processes, habitats and species that would be addressed for key tributary watersheds; the rationale for the selection of actions to be implemented during Stage 1; actions already being implemented as part of CALFED Restoration Coordination Program, CVPIA, or other restoration programs; and uncertainties about ecosystem structure and function that can be answered by designing restoration actions to maximize their information value.

Following the Strategic Plan, the ERP developed a Stage 1 Implementation Plan in August 2001 (CALFED 2001). The plan incorporated; 1) public involvement in setting restoration priorities; 2) local involvement in accomplishing restoration actions; 3) emphasis on adaptive management and information richness in the design of restoration actions; 4) coordination with other CALFED Program elements; and 5) coordination with non-CALFED Program restoration efforts, both public and private. The plan included restoration and science priorities from a regional perspective, consistent with the CALFED Program's regional approach.
Strategic Goals in the Plan were as follows: 1) Goal 1 - At Risk Species; 2) Goal 2 - Channel Dynamics and Sediment Transport; 3) Goal 3 - Harvestable Species; 4) Goal 4 -

Habitats; 5) Goal 5 - Non-native Invasive Species; and, 6) Goal 6 - Water and Sediment Quality.

Consistent with the overall Stage 1 Vision, implementation priorities for the Sacramento Valley Region focused on improving, restoring or maintaining the health and integrity of the Sacramento River riverine-riparian and tributary ecosystems to sustain or support important fish, wildlife, and plant communities. The majority of regional investments supported fish screen and fish passage improvements; local watershed stewardship; at-risk species assessments; riparian habitat and river channel restoration; and ecological processes restoration. Ecological processes to be restored included natural streamflow patterns and flow regime management; coarse sediment recruitment and transport; and reestablishment of natural floodplain and flood processes to allow for stream meander.

Consistent with the CALFED ERP's regional approach; the Draft Stage 1 Implementation Plan for ERP outlined the priorities, potential projects or programs, and science needs for regional issues and opportunities. Restoration Priorities are as follows:

Priority 1. Develop and implement habitat management and restoration actions in collaboration with local groups such as the Sacramento River Conservation Area Forum Non-Profit Organization.

Collaborative efforts to develop and implement habitat restoration with entities such as the Sacramento River Conservation Area Forum (SRCAF) remain a priority in the Sacramento Valley Region, as well as with the numerous watershed groups that work on the tributaries and the River itself. The area in which the SRCAF has interest provides habitat for fish passage, rearing and spawning, bank habitat for bank swallows (*Riparia riparia*) and dense riparian forests for species such as the yellow-billed cuckoo (*Cocczyus americanus*) and other Neotropical migratory birds. Other opportunities include fisheries and floodplain interactions in the Sutter Bypass that may affect spring-run Chinook, fall-run Chinook, late fall-run Chinook (*Onchorynchus tshawytscha*), Central Valley steelhead (*Onchorynchus mykiss*), and Sacramento splittail (*Pogonichthys macrolepidotus*).

ERP has worked collaboratively with a wide variety of funding sources and agencies. For example, ERP and CVPIA/AFRP have jointly contributed millions of dollars to the Sacramento Valley Region to address fisheries, river channel, and floodplain habitat needs. The CALFED Watershed Program and the Wildlife Conservation Board similarly funded many restoration and planning projects in the Region, thereby addressing not only those programs' goals but also many of the goals, milestones and targets of ERP (Table 2 and Figure 2).

NOTE: Table 2 and Figure 2 summarize the number of projects and expenditures that were actually implemented during Stage 1 by topic area and this chapter summarizes

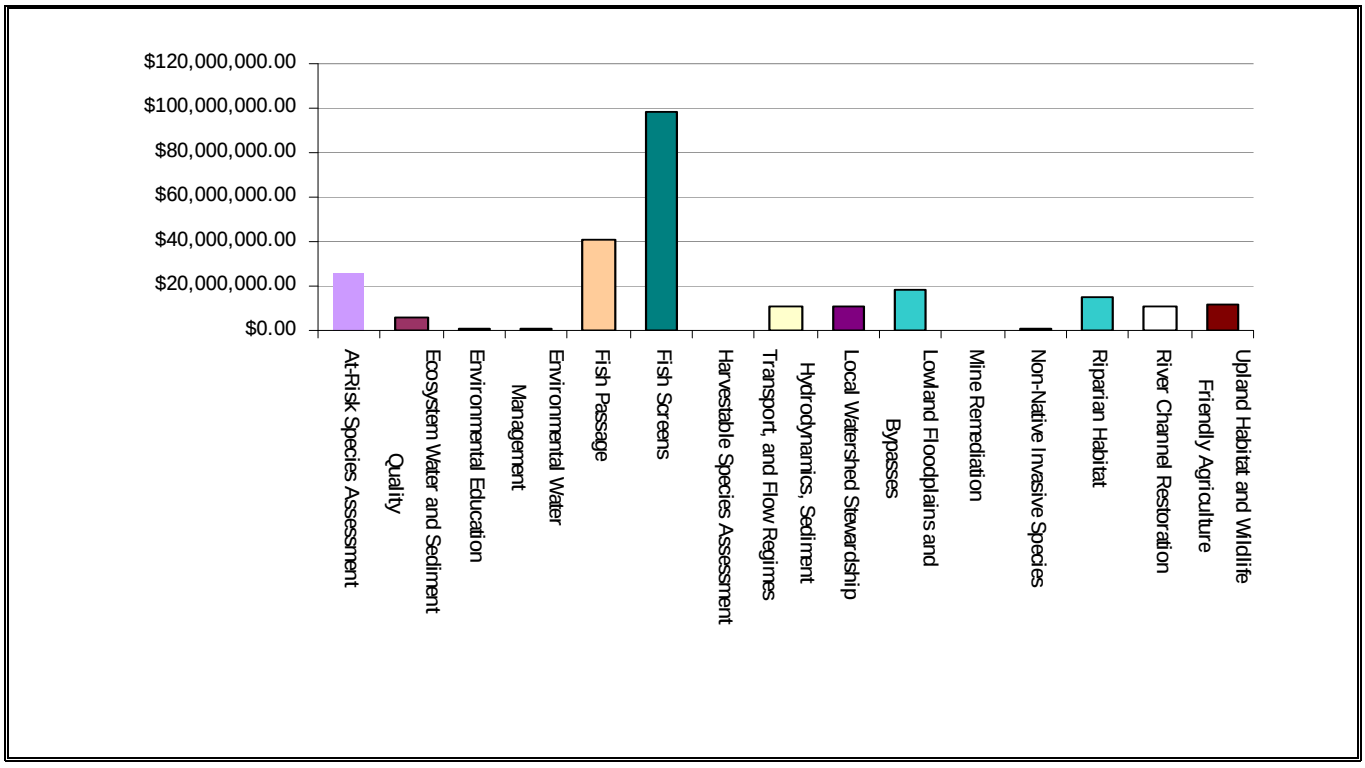
overall progress in meeting Plan priorities. Additional detailed discussion of individual projects can be found within the various Ecosystem Management Zone chapters.

Table 2. Sacramento Valley Region, ERP Restoration Investment By Topic Area.

TopicArea	Number of Projects[1/]	Expenditures[1/]	Percent of Total Regional Expenditures[1/]
At-Risk Species Assessment	21	$25,628,702.00	12.28%
Ecosystem Water and Sediment Quality	5	$6,053,586.00	2.92%
Environmental Education	6	$702,690.08	3.51%
Environmental Water Management	3	$776,100.00	1.75%
Fish Passage	11	$40,551,429.39	6.43%
Fish Screens	46	$98,093,657.96	26.90%
Harvestable Species Assessment	1	$120,000.00	0.58%
Hydrodynamics, Sediment Transport, and Flow Regimes	9	$10,830,205.00	5.26%
Local Watershed Stewardship	30	$11,148,101.17	17.54%
Lowland Floodplains and Bypasses	9	$18,194,614.00	5.26%
Mine Remediation	1	$400,000.00	0.58%
Non-Native Invasive Species	1	$539,836.00	0.58%
Riparian Habitat Restoration	16	$14,867,951.87	9.36%
River Channel Restoration	7	$10,861,688.58	4.09%
Upland Habitat and Wildlife Friendly Agriculture	5	$11,283,038.00	2.92%
Totals	**171**	**$250,051,600.05**	**99.96**

[1/] Does not include projects that are approved for funding but have not been executed.

Figure 2. Sacramento Valley Region ERP Restoration Investment by Topic Area



- *Riparian habitat and channel meander.* Restoration along the mainstem Sacramento River and tributaries in collaboration with local groups continues to be a focus for this region. Protection and restoration efforts on the mainstem Sacramento River and its priority tributaries, including Battle, Clear, Cottonwood, Deer, Mill, Butte, Big Chico Creeks, and the Feather, Yuba, Bear, and American Rivers, emphasized maintaining and/or improving habitat for threatened and endangered species, while also maintaining water quality in the source area streams that eventually flow into the Bay-Delta.

  Many of the tributary watersheds, including the mainstem Sacramento River, have active watershed groups and/or conservancies, many with non-profit status. Through a combination of technical support and selective funding of watershed group formation, ERP has implemented local watershed stewardship projects that have supported ongoing watershed assessment, planning, and monitoring activities. The development of watershed restoration plans helps to guide restoration projects to meet ERP targets for at-risk species; habitats; ecological processes including Central Valley streamflows; Central Valley stream temperatures; coarse sediment supply; stream meander; natural floodplains and flood processes; and riparian and riverine aquatic habitat. The plans also help to identify and deal with stressors including non-native invasive species, contaminants, and water diversions, dams and other structures.

  As part of its commitment to protect and restore the Sacramento River meander corridor, ERP identified providing assistance to the SRCAF as a priority action. The Program goal of SRCAF is to preserve remaining riparian habitat and reestablish a continuous riparian ecosystem along the Sacramento River between Redding and Chico, and to reestablish riparian vegetation along the river from Chico to Verona. SRCAF guides ecosystem planning, coordination, and habitat restoration activities on the mainstem of the Sacramento River and strives to ensure that riparian habitat management addresses both the dynamics of those riparian ecosystems, as well as the realities of local agricultural issues and possible third party impacts. The SRCAF technical advisory team reviews all restoration proposals within the SRCAF footprint (essentially the 100-year floodplain of the River). Most importantly, SRCAF continues to provide technical review of ecosystem restoration projects that affect natural processes along the Sacramento River for consistency with regional restoration goals.

- *Sutter Bypass.* The Sutter Bypass is an important migration route for spring-run and fall-run Chinook salmon that spawn in Butte Creek. In most years, almost all populations of upper Sacramento River migratory fish are potentially affected by the Sutter Bypass. Under certain hydrologic conditions, bypass flooding may cause stranding and loss of juvenile fish and other aquatic resources. The Sutter Bypass planning has been completed, and projects are currently in progress that will contribute toward the ERP Vision to ensure fish passage and promote

Past and ongoing real-time flow monitoring projects in the lower Sutter Bypass 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 help reach the vision for the Sutter Bypass. This vision is to 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, in order to maintain important ecological processes, functions, habitats, and important species.

- *Protect and manage gabbro-soil chaparral habitat.* Although some effort was made, the goal of protecting and managing gabbro-soil chaparral habitat in El Dorado County to benefit federally-listed plant species and other at risk was not fulfilled during Stage 1 ERP implementation. The Pine Hill Ecological Preserve project planned to acquire 248 acres of the Kanaka Valley Property to add to the existing reserve in western El Dorado County, which was established to protect an extremely rare natural plant community known as Gabbroic Northern Mixed Chaparral. This project was unable to find any willing sellers, and the ERP partners of the project (the American River Conservancy) report that they do not expect to find any willing sellers in the immediate future.

- *Evaluate restoration in the Sacramento River corridor.* During Stage 1, ERP funded the Sacramento River Monitoring and Assessment Project, initiated in April 2007, to systematically evaluate performance among a mosaic of restoration projects. The overall goal of this project is to evaluate whether the habitat and populations of certain endangered and other at-risk species are recovering; whether the ecological processes are being rehabilitated, protected and restored, and whether the impacts from non-natives invasive species are being reduced for ERP funded project sites within the Sacramento River EMZ. This level of information is critical for the evaluation of species of concern such as Valley elderberry longhorn beetle and Chinook salmon (both MSCS species), and assessing the overall success of ERP within the Sacramento River EMZ.

A scorecard approach will provide a means to track changes over time. When completed, this program will be exceptionally valuable to resource managers and the ERP to prioritize, plan, and design future ecosystem and riparian restoration projects.

Priority 2. Restore fish habitat and fish passage, particularly for spring-run Chinook salmon and steelhead trout, and conduct passage studies.

Spring-run Chinook salmon and steelhead benefit from actions to augment in-stream gravel supplies and gravel quality, and actions to improve up and downstream fish passage and streamside habitat. During Stage 1 of ERP implementation, great progress has been made to improve fish passage in the Sacramento Valley Region by assessing remaining fish passage issues and improving existing fish passage facilities. Extensive fish habitat restoration has occurred within certain geographic areas, and plans are readily available to continue restoration efforts.

- *Replenish spawning gravel.* Numerous projects, from various funding sources, (ERP, CVPIA, and Watershed Program) have assessed coarse sediment supplies and needs linked to erosion and deposition for purposes of maintaining or improving fish spawning areas. CVPIA projects have been implemented to increase the availability of spawning gravel and rearing habitat for Chinook salmon and steelhead trout in the reach of the mainstem Upper Sacramento River from Keswick Dam downstream to Red Bluff Diversion Dam, Clear Creek, and in the reach of the American River downstream of Nimbus Dam. The conditions in the regions where gravel was placed have been monitored and compared with control sites/conditions in adjacent areas.

- *Monitor and reduce fine sediment loads.* Fine sediment loads within the Clear Creek watershed are being monitored to assess the potential impact to instream habitat quality. However, additional projects are needed elsewhere in the Region to assess potential adverse ecological effects, particularly on salmonids, of anthropogenic fine sediment loads in spring-run Chinook salmon streams. Where appropriate, project should determine anthropogenic sources and magnitudes of loads; as well as develop, test, implement, and evaluate actions to reduce fine sediment loads from human activities.

- *Facilities improvements and fish passage programs*. Many projects from various funding sources, (ERP, CVPIA/Anadromous Fish Passage Program and AFRP, and the Wildlife Conservation Board) were funded to improve fish passage for salmonids by improving existing facilities or constructing new fish passage and protection facilities, creating exclusion barriers, repairing weirs, and removing physical barriers to upstream and downstream migration.

Four projects (in three phases) were funded to enhance the survival of returning adult salmon to the spawning habitat between the Anderson-Cottonwood Irrigation District (ACID) diversion dam (near Redding, California) and Keswick Dam on the Sacramento River by constructing two fish ladders and improving a screen at the ACID dam, improving fish passage. Two of the four projects were full-scale implementation projects which included the construction of the fish passage facilities, construction management, mitigation, and monitoring of the new facilities. Installation of the fish screens and ladders reduced entrainment of anadromous fish and promotes unimpaired/safe passage for all runs of Chinook salmon, steelhead trout, green and white sturgeon, all priority MSCS species.

Many of the proposed projects that would benefit anadromous fish in Butte Creek are complete or in progress. Partnerships with several landowners and agricultural water districts along the creek have resulted in the removal of the Western Canal, McPherrin, McGowan, and Point Four Dams and screening modification or construction on five other diversions along this tributary, as well as the construction of a canal siphon along Butte Creek to aid in fish passage for spawning and rearing. These efforts, coordinated and partially funded through CALFED, have built strong partnerships within the valley between agencies and landowners. They also led the returning runs of spring-run Chinook salmon reaching their highest level in several years. Ongoing projects in the Butte Creek Watershed include the Butte Sink White Mallard Dam and Associated Diversions Evaluation project funded by AFRP.

Another major salmon recovery project within the Sacramento River Region is on Battle Creek. This program is in the developmental and planning stages, with the goal of increasing existing and establishing new salmon runs on this tributary. Several dams, which have historically been operated primarily to maximize hydroelectric power development, are planned for removal. These changes are anticipated to contribute significantly to an increase in salmon runs on this tributary. The primary partner for this project is Pacific Gas and Electric Company (PG&E), who is the majority landowner within the project area. Other partners include the Battle Creek Working Group and the Battle Creek Watershed Conservancy; CALFED agency partners, including the California Department of Fish and Game (CDFG), US Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), US Bureau of Reclamation (BOR); and other interested parties.

At the Sutter National Wildlife Refuge, the southern-most refuge in the Sacramento National Wildlife Refuge Complex, the USFWS is making fish-friendly improvements to diversions. Ducks Unlimited is obtaining funding to replace approximately 40 water control structures that regulate the water level in ponds. In addition, the pond bottoms will be reconfigured to improve marsh

management. Ducks Unlimited is also working with the Sacramento National Wildlife Refuge Complex and Sutter Extension Water District to supply 60 cfs of additional water to the Sutter Bypass and be able to handle it in a fish friendly way.

The Lower Butte Creek-Sutter Bypass Pumping Plants Fish Screening Project will reduce losses of adult and juvenile anadromous fish from the lower Butte Creek system by screening three large DWR pumping plants located in the Sutter Bypass. Projects in the Sutter Bypass are constructing a model of the salmonid population and assessing the need for screens at the approximately 40 unscreened diversions on the east side of the Sutter Bypass, replacing fish ladders to handle debris and wider range of flows, rebuilding flashboard dams, and making fish-friendly improvements to diversions.

Fish passage improvements continue on Clear Creek, a tributary to the Sacramento River. By releasing more water from Whiskeytown Dam to increase flow in the creek; removing McCormick-Saeltzer Dam in the year 2000; supplementing the gravel supply which was blocked by Whiskeytown Dam; implementing methods to control erosion having negative impacts to salmonid habitat; removing stranding sites; and restoring the stream channel, the Clear Creek Restoration Program has contributed significantly to the increase in spawning escapements of fall-run Chinook in Clear Creek. A small but increasing population of spring-run Chinook is now located in Clear Creek, and steelhead populations are increasing.

- *Monitor passage flow.* The Real-Time Flow Monitoring Project continues to support "real-time" operation and maintenance of flow monitoring stations on five Sacramento River tributaries. These stations provide data on minimum instream flows and water quality for the recovery of spring-run Chinook salmon and Central Valley steelhead, and the 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.

- *Fish stranding studies.* Fish stranding was studied in the active stream channels, floodplains, shallow ponds and borrow areas. The data from those studies was then used to develop programs to reduce or eliminate that stranding developed. The Yuba River Replacement Barrier Project studied temporary and permanent barrier construction near the Yuba Goldfields to prevent adult fish from migrating into and becoming trapped in the Yuba Goldfields, while allowing water to flow from the Goldfields into the river. In the Sutter Bypass, an important migration route for spring-run and fall-run Chinook salmon from Butte Creek, bypass flooding may cause stranding and loss of juvenile fish and other aquatic resources under certain hydrologic conditions. Project planning has been

Priority 3. Conduct adaptive management experiments in regard to natural and modified flow regimes to promote ecosystem functions or otherwise support restoration actions.

Efforts to address natural and modified flow regimes to promote ecosystem functions and favorable biological responses are critical to the current and future management of the Sacramento Valley Region. Projects were implemented that improved the scientific basis for flow-related actions. This in turn improves our ability to effectively manipulate and manage supplemental flows.

- *Mechanistic models as restoration tools.* Projects were implemented that made progress on developing methods, including a combination of simulation models and physical measurements to evaluate flow, sediment transport and other fluvial processes, to address ecological function and native habitats and species in the Bay-Delta ecosystem. Studies 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 improve process understanding and support the development of ecologically-based plans to restore conditions in the rivers, sloughs and floodplains sufficient to meet restoration targets for Chinook salmon, steelhead, sturgeon, and splittail.

- *Instream flow programs.* Instream flow studies have been implemented 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 Sacramento Valley. For example, projects on the Yuba River eliminated or substantially reduced 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 of a flushing flow event on the floodplain and on instream habitat condition and to reactivate fluvial geomorphic processes which have been lacking since the completion of Whiskeytown Dam in 1963. These processes are fundamental for creating and maintaining the habitats of the Clear Creek ecosystem to support and to recover aquatic and riparian species, particularly

In addition to ERP-funded projects, the CVPIA has invested substantial funds into assessing instream flow requirements for anadromous fish in the Central Valley. In December 1994, the USFWS, Ecological Services, Instream Flow Assessments Branch proposed using the Service's Instream Flow Incremental Methodology (IFIM) to identify the instream flow requirements for anadromous fish in selected streams within the Central Valley of California. Subsequently, several Central Valley streams, including Clear Creek, Battle Creek, Butte Creek, and the Sacramento and lower American Rivers have been studied via the IFIM process. Specific goals of these studies are to determine the relationship between streamflow and physical habitat availability for all life stages of Chinook salmon (fall, late-fall, winter-runs) and to identify flows at which redd dewatering and juvenile stranding occur. The instream flow requirements for white and green sturgeon may also be studied; however, the inclusion of these species depends upon the availability of resources and sufficient data to enable identification of the habitats used by them.

- *Streamflow management plans and managed flow fluctuations.* A variety of projects were implemented to address this priority, with an emphasis on some of the major tributaries to the Sacramento River.

  The ERP Strategic Goal 2 included restoring the variability of the flow regime and associated river processes, "as an important component of restoring ecological function and supporting native habitats and species in the Bay-Delta ecosystem". The Sacramento River Ecological Flows Study was formulated to address CALFED program goals and hopefully lead to restoration and conservation of species and an eventual decrease in regulation. The project built upon an earlier review of Sacramento River ecological flow issues conducted by Dr. Matt Kondolf for CALFED in 2000. The Study specifically did not focus on returning the river to some historic and un-altered flow regime. Instead, the 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. Maintaining or restoring the critical elements of these ecological processes and characteristics could contribute to better informed future development of scarce resources while still providing for human needs.

  The Sacramento River Ecological Flows Study distilled existing information and current conceptual models and hypotheses about ecological flow needs in the Sacramento River. A series of field investigations and modeling applications were designed to address data gaps and to refine estimates of ecological flow needs, including:

- A gravel study designed to characterize gravel quality, mobilization, and routing;
- An off-channel habitat study to estimate sediment deposition rates in, and resultant terrestrialization of, off-channel habitats; and
- A bank study to examine the effects of natural and rip-rapped banks on aquatic habitat;
- A numerical chute cutoff model to predict the flows required to create a chute cutoff;
- A refined meander migration model; and
- A sediment transport model that predicts the grain size distribution of both the surface and subsurface as a function of sediment supply and bed mobilization and scour.

The Sacramento River Ecological Flows Tool (SacEFT) was also developed to facilitate the analysis of ecological tradeoffs associated with different suites of management actions and was one of the products of the overall study.

Restoration 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, Central Valley stream temperatures, coarse sediment supply, natural floodplains and flood processes, and stream meander; habitats including riparian and riverine aquatic habitat and freshwater fish and essential fish habitat; stressors including dams and other structures, stranding, and water diversions; and species including fall-run Chinook salmon, spring-run Chinook salmon, steelhead, green sturgeon, and American shad. 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, coarse sediment supply, and riparian and riverine aquatic habitat.

Several research and monitoring projects have contributed information which will assist in achieving the ERP targets to develop and implement an ecologically based streamflow regulation plan for the American Basin creeks and lower American River, and have contributed new modeling information which will assist in achieving temperature reduction targets identified in the ERP for the lower American River below Nimbus Dam. The Development of a River Corridor Management Plan (RCMP) for the Lower American River Project contributed toward the ERP target for streamflow, stream temperature, and riparian and

riverine aquatic habitat. In addition, the project completed the ERP programmatic action that called for the development of a riparian corridor restoration and management plan for the lower American River.

The vision for Clear Creek included increasing water releases from Whiskeytown Dam, which is also identified as an action required under CVPIA. To achieve this vision, an interdisciplinary team has worked directly with local entities. The Clear Creek Coordinated Resource Management Planning group, comprised of local landowners and stakeholders, and the Clear Creek Technical Team have met since 1995 to plan, implement, and monitor projects using a multi-disciplinary restoration approach to benefit anadromous salmonids and the ecosystems upon which they depend. Because of this effort, and CVPIA directives to manage flows in the creek for the benefit of anadromous fish, increased minimum flows during the winter are largely responsible for the average four-fold increase in fall-run Chinook spawning escapement in Clear Creek over the baseline period (1967 to 1991).

The benefit of increased summer flows for threatened spring-run Chinook and steelhead was demonstrated in rotary screw trap catches and in snorkel counts of adult spawners and their redds; monitoring which, in part, has been funded by ERP. 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.

These management decisions, along with other actions implemented on Clear Creek, have contributed to addressing the ERP Targets for Ecological Processes, including Central Valley streamflows, Central Valley stream temperatures, coarse sediment supply, natural floodplains and flood processes, and stream meander; habitats, including riparian and riverine aquatic habitat and freshwater fish and essential fish habitat; stressors, including dams and other structures, stranding, and water diversions; and species, including fall- and spring-run Chinook salmon, and steelhead.

In addition, as previously mentioned, Clear Creek was one of three watersheds that were assessed by an Adaptive Management Forum in 2001. The Forum, sponsored by the University of California (Davis) Center for the Environment, reviewed the science behind the large-scale restoration projects on Clear Creek and the Merced and Tuolumne Rivers' restoration efforts. This process provided interconnected conceptual models depicting the current understanding of the science and geomorphic functions in the river; the river's Chinook salmon population dynamics; effects of measures to improve geomorphic and ecosystem

function; and the potential to increase Chinook salmon population abundance and resiliency.

- *Environmental water acquisitions.* There has been substantial effort to prioritize and implement environmental water acquisition in other forums/programs (such as CVPIA), which has addressed this ERP priority at some level. This includes the assessment and prioritization of water acquisition opportunities evaluated in the CALFED EWP, a sub-program of ERP. However, ERP has not specifically addressed this priority with funded projects. 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 their biological and ecological benefits.

Priority 4. Restore geomorphic processes in stream and riparian corridors.

Physical processes in the Sacramento Valley Region related to fluvial geomorphology and hydrology are extremely important in the restoration of ecosystems. We need better scientific understanding and basis for potential restoration actions. Success in restoring riparian and aquatic communities depends on how well the physical processes that maintain dynamic stream channels are understood. Understanding the relationships between fluvial processes and riparian regeneration will improve the success of immediate and future restoration efforts.

ERP investments in this arena tended to focus on specific watersheds for which proposals were submitted (and subsequently funded), as opposed to identifying and prioritizing where assessment of geomorphic processes was needed within the entire Region.

- *Tributary assessments.* On Lower Clear Creek, there is ongoing monitoring of the response of avian populations, geomorphic processes, and riparian habitat to all implemented restoration phases of the Lower Clear Creek Restoration Project. Several species addressed in the MSCS are found on Clear Creek, such as yellow warbler *(Dendroica petechia*), song sparrow (*Melospiza melodia*) and yellow-breasted chat (*Icteria virens*). Response to restoration is contributing to the base of knowledge about their requirements for future CALFED and otherwise-funded riparian restoration projects. Geomorphological and riparian habitat monitoring are providing information on how to adaptively manage for and design future restoration projects, as well as assessing the need for gravel injection or flows that are needed to inundate the floodplain.

  The Lower Clear Creek Floodway Rehabilitation Project (Phase 3B) is an on-going full-scale implementation project. The reconstructed bankfull channel is

designed to function geomorphically within newly constructed floodplain surfaces completed in Phases 2A and 2B of the Floodway Project. This project contributes to the ERP targets for streamflows, stream meander, natural floodplain and flood processes, freshwater fish habitat and essential fish habitat, dams and other structures. This project can provide an opportunity to test the hypothesis that streamflow and sediment can be managed for ecosystem health and function on a highly regulated river. The careful evaluation of project data and the revisions made as a result of this evaluation can assist CALFED in its work with similar highly regulated Central Valley streams.

As previously mentioned, conceptual proposals were developed for Clear Creek, via the Environmental Water Program, to assess the benefits of a flushing flow event on the floodplain and on instream habitat condition, and to reactivate fluvial geomorphic processes which have been absent since the completion of Whiskeytown Dam in 1963.

The Cottonwood Creek watershed is a large west side tributary to the Sacramento River. It is unregulated and is a substantial contributor of spawning gravel to the upper Sacramento River. An ERP project on Cottonwood Creek provided a cursory geomorphic analysis of approximately 20 miles of lower Cottonwood Creek and documented long-term changes in the lower alluvial reaches attributable to aggregate extraction in excess of annual replenishment rates.

- *Intensive process and mechanistic studies*. There has been effort to conduct mechanistic studies in other forums/programs (such as the CALFED Water Storage Program) that have addressed this ERP priority at some level. However, ERP has not specifically addressed this priority with funded projects. The long-term environmental implications of each of these approaches need to be better understood. Studies that compare implications across strategies are especially needed.

- *Riparian vegetation research project.* There have been efforts to conduct mechanistic studies in other forums/programs (such as the CALFED Water Storage Program) that have addressed this ERP priority at some level. Funding from ERP specifically for riparian vegetation research has been limited. Many of the ERP-funded restoration projects that included riparian restoration did collect information on restoration success. However, this information has not been consolidated and analyzed, and additional scientific studies are needed to determine appropriate conditions for the germination and establishment of riparian woody plants along the Sacramento River.

  The following ERP projects have provided some insight into this priority and the degree to which it has been addressed. The Sacramento River Ecological Flows

Study did consolidate riparian research information on the mainstem Sacramento River and 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. A focal species approach was used to explore linkages among ecosystem processes, resultant habitats, and biotic needs. For each focal species, the project identified the different life history stages that occur in the Sacramento River, the habitats used by each of those life history stages, the ecological processes that create and maintain those habitats, and the management actions (e.g. changes in the flow regime or bank protection) that influence those ecological processes and habitat conditions. Fremont cottonwood, a primary element in the Sacramento River's riparian habitat, was a focal species for the project. Results of the study provided resource agency managers additional insight and information to manage for this habitat type.

On Lower Clear Creek, monitoring is continuing to assess the response of avian populations, geomorphic processes, and riparian habitat to all implemented restoration phases of the Lower Clear Creek Restoration Project. Riparian habitat monitoring is providing information on how to adaptively manage for and design future restoration projects.

The goal of the Sacramento River Riparian Monitoring and Assessment Consolidated Project is to evaluate whether the habitat and populations of certain endangered and other at-risk species are recovering; whether the ecological processes are being rehabilitated, protected and restored; and whether the impacts from non-natives invasive species are being reduced for ERP-funded project sites within the Sacramento River EMZ. This level of information is critical for evaluating species of concern such as Valley elderberry longhorn beetle and Chinook salmon (both MSCS species), and assessing the overall success of ERP within the Sacramento River EMZ. Once gathered, the information will be invaluable to ERP and its partners, including federal, state and local agencies, and non-profit groups who are involved in Sacramento River restoration efforts.

- *Natural floodplains and flood processes.* A priority for this Region has been the development of floodplain management plans, including feasibility studies to construct setback levees that would restore and improve opportunities for rivers to inundate their floodplain on a seasonal basis, on tributaries within the Sacramento River basin. In 2001 the CALFED Watershed Program funded the preparation of the Butte Creek Watershed Floodplain Management Plan (FMP) and the final report was completed in May 2005. Flood flows from Little Chico Creek are also diverted into Butte Creek, so the Butte Creek Watershed FMP was developed to establish a strategy to reduce flooding and flood-related hazards

The Geomorphic Model for Demonstration and Feasibility Assessment of Setback Levees: Bay-Delta River Systems project developed a meander migration model to examine the relationship between setback distance and habitat formation through a measure of the land reworked. 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.

Five projects revolving around the Chico Landing to Colusa subreach of the Sacramento River and one project on the Beehive Bend subreach sought to comprehensively facilitate the recovery of ecological processes within the floodplain, including the regeneration of native riparian habitat. The projects' overarching goal was to balance large-scale conservation strategies with other land uses, primarily agriculture. Studies were undertaken to investigate hydrology, geomorphology, biological indicators, recreation access, and cultural resources. Many of these investigations produced not only site-specific management recommendations for the particular properties acquired, but enabled effective placement of these properties into a floodplain context, a necessary step for analyzing the potential for recovery of ecological processes and a primary objective in developing conservation management plans for river systems. This information has direct relevance to current and future planning activities for these subreaches of the Sacramento River and could be applied to other reaches.

Recognized as one of the last remaining natal streams for spring-run Chinook salmon, Deer Creek has been identified by USFWS, CALFED, and CDFG as a priority watershed. The Lower Deer Creek Restoration and Flood Management Feasibility Study and Conceptual Design is a planning project that uses a collaborative approach between resource agencies, irrigation districts, landholders, and watershed groups to develop a flood management plan for lower Deer Creek. Instream habitat quality has declined since levee construction in 1949 (Deer Creek Watershed Conservancy 2002). The objective of this project is to develop a conceptual design for a flood control alternative for lower Deer Creek that uses managed floodplain inundation as a restoration tool. Implementation of this project will help CALFED achieve ERP strategic goals 1, 2, and 4, as well as its Science Program Goal. This type of project is listed as a milestone for the ERP Multi-Species Conservation Strategy for the Sacramento River Basin and this project directly addresses Sacramento Region priorities 1, 2, 3, 4, and 7 as described in the Draft Stage 1 Implementation Plan.

Priority 5. Implement actions to prevent, control and reduce impacts of non-native invasive species in the region.

Invasive species are a problem throughout the Sacramento Valley Region. To address and manage non-native invasive species (NIS) issues, the Bay-Delta Authority created the Non-native Invasive Species Program (NISP), which is a subprogram of ERP. The goals of the NISP are to 1) prevent new introductions, 2) limit the spread or eliminate populations through management, and 3) reduce the harmful ecological, economical, social and public health impacts resulting from infestation of NIS. The NISP is providing technical assistance and coordination to regional efforts and watershed groups focusing on assessment and monitoring for NIS to improve rapid response to new invasions. The NISP is also active with other partners to achieve research and technology transfer. The NISP will use the results from ERP funded research, technical assistance, and implementation and restoration projects and continue working with state agencies to implement California's Aquatic Nuisance Species Management Plan.

Actions to improve our knowledge of the distribution of these unwanted species were implemented as well as actions to begin control or eradication.

- *Manage Arundo donax* and *Tamarix spp*. In the Sacramento River tributaries, efforts were made to reduce the negative impacts of these plants and to protect beneficial uses of downstream areas at risk of invasion. The program-wide *Arundo* Eradication and Coordination Project is an ongoing effort to help control invasive riparian plants in order to allow native riparian plant species to propagate naturally. This project, which is projected to end in 2009, plans to remove giant reed (*Arundo donax)* from the banks of the Lower American River, North Fork American River, and Arcade, Dry, Morrison and Elder Creeks. This project is expected to provide immediate benefits when completed. Significant progress was also made in determining physical and chemical eradication methods for managing salt cedar (*Tamarix chinensis)* on watershed tributaries and recommending prescriptions for active restoration following eradication. Another ERP project, *Arundo Donax: Survey and Eradication*, identified and eradicated areas infested by giant reed and salt cedar on Deer Creek, Red Bank Creek and Reed's Creek (Tehama County).

  Additional progress on this issue has been made by watershed groups and other conservation-oriented entities. For example, the Redding Rotary Club has received funds from various sources to remove giant reed from sites within Shasta County; their goal is to eradicate the plant from Shasta County, in its entirety, by 2010. Similarly, the Cottonwood Creek Watershed Group identified the presence of giant reed and salt cedar during their Watershed Assessment process (funded by ERP). The group subsequently obtained funds from the Natural Resource Conservation Service (NRCS) to map nearly all riparian habitat

within the watershed boundary; this inventory and map included location information on non-native plant species, with an emphasis on giant reed and salt cedar.

The Sacramento River Riparian Monitoring and Assessment Consolidated Project will evaluate whether the habitat and populations of certain endangered and other at-risk species are recovering; whether the ecological processes are being rehabilitated, protected and restored; and whether the impacts from non-native invasive species are being reduced for ERP-funded project sites within the Sacramento River Ecological Management Zone. Information from this monitoring project will be used for future restoration effort planning.

- *Northern Pike Eradication.* In September 2007, the Lake Davis Pike Eradication Project was completed to remove northern pike (*Esox lucius*) from Lake Davis, on the Feather River. Northern pike is a nonnative invasive fish species that have had a significant impact on the sport trout fishery at Lake Davis; and which, if they escaped from Lake Davis, could have irreversible negative impacts on downstream and Bay-Delta aquatic ecosystems, including those fish species (Chinook salmon, steelhead, delta smelt, and splittail) whose populations have already declined significantly. The results of the Lake Davis water quality monitoring program indicate that all of the chemicals in the pesticide formulation have dissipated to below detectable levels. The pike appear to be eradicated from Lake Davis. Nearly one million rainbow trout were expected to be planted in 2008 and the lake is open to fishing.

Priority 6. Continue major fish screen projects and conduct studies to improve knowledge of the implications of fish screens for fish populations.

CALFED and CVPIA (Anadromous Fish Screen Program, or AFSP) have funded numerous fish screen projects in the Sacramento Valley and have screened most of the large diversions on the Sacramento River. The ERP alone has provided over $98 million for screen and passage projects. During Stage 1 ERP Implementation, CALFED and CVPIA focused on completing ongoing projects and maintaining existing investments.

- *Continue and complete ongoing fish screen construction.* During Stage 1 of ERP implementation, over 45 fish screen projects were completed ranging from planning and feasibility, to full scale implementation. The goal of screening all water diversions greater than 250 cfs in the Sacramento River Basin has been met, with the exception of diversions at BOR District 2035 and Natomas Mutual Water District. The goal of screening 25% of the 903 diversions in the Sacramento River Basin that are less than 250 cfs has fallen short of expectations. Only approximately 10% of these diversions have been screened to date.

Completion of various phases of several major fish screen construction projects on the Sacramento River, including the Reclamation District No. 108's Wilkins Slough Positive Barrier Fish Screen and the Combined Pumping Plant and Fish Screen Projects, Glenn-Colusa Irrigation District Interim and Long-term Fish Screens, planning and feasibility phases of Reclamation District No 2035's Fish Screen Project, Pleasant Grove-Verona Water Company Diversions, Sutter Mutual Water Company's Tisdale Positive Barrier Fish screen Pumping Plants Project , planning and feasibility phases towards consolidating and screening Natomas Mutual Water Company's diversions, Anderson-Cottonwood Irrigation District Fish Screen and Ladders projects, and the City of Sacramento Water Diversions support reduced entrainment risks and enhance protected fish passage on the Sacramento River.

Additional studies have been funded for the preparation of planning, feasibility, and engineering studies for the protection of existing screened facilities on the Sacramento threatened by bank retreat and sedimentation. Ongoing projects will continue to complete long-term planning and environmental documents for protection of the Princeton-Codora-Glenn/Provident Irrigation District screened pumping plant, and M&T/Llano Seco Pumping and Fish Screen Facility.

- *Comprehensive studies of how effectively fish screens protect species* are still needed to better prioritize allocation of expenditures. A pilot project was implemented to test the feasibility of an innovative fish screen design for smaller (<50 cfs) diversions in the Central Valley of California, resulting in the fabricating, testing, and hydraulically balancing the screen system. A key objective of the AFSP, as reflected in the 2008 work plan, is to obtain loss monitoring data for the purpose of better prioritizing fish screening efforts.

Priority 7. Develop conceptual models to support restoration of river, stream and riparian habitat.

The Sacramento Region has restoration activities in progress in all ecological management zones. There is a history of some fish monitoring in each basin and stream; and CALFED agencies, local agencies and stakeholder groups have reasonable knowledge of what activities are underway within most basins. However, conceptual ecosystem models are largely not well developed for individual watersheds, nor can comparisons be effectively made of restoration success at the regional scale. Developing regional measures of restoration success, will require more monitoring, and a better understanding of historic data; as well as greater knowledge of basic processes, populations and communities, stressors, and the ecological implications of restoration actions.

- *Compare conceptual models and develop restoration performance measures for tributary streams and rivers*. Additional systematic knowledge of restoration

- *Annual population estimates*. Annual estimates of fish populations on the Sacramento River are a key ingredient in management actions to protect fish in the Delta. There is a strong need to understand and reduce the uncertainties in those estimates through more field studies and data analysis, as well as by using advanced field methodologies and modeling capabilities. Models and basic studies that might allow better connection of management actions and specific stressors to population responses of key species of native fish are critical to protecting fish and managing water supplies.

  There are many monitoring efforts within the Sacrament Valley Region continuing to gather information on fish populations. ERP has been able to fund some of these worthwhile efforts which would otherwise have ceased to operate. Additional, long term funding is needed to maintain this critical data collection effort.

  The Upper Sacramento River Basin Chinook Salmon Escapement Monitoring Program is an example of an ongoing project that provides annual monitoring of abundance, migration timing, and distribution of adult winter, spring, late-fall, and fall-run Chinook salmon returning to spawn in the Upper Sacramento River Basin. Multiple years of continuous monitoring is needed in order to make effective decisions about fisheries management. Data obtained from this project also helps achieve ERP goals of recovery of at-risk native species and maintaining and/or enhancing populations of selected species for sustainable commercial and recreational harvest. This project also meets a MSCS milestone to monitor adult anadromous salmonid returns in each watershed within the MSCS focus area of the Sacramento River.

  The Butte Creek, Big Chico Creek, and Sutter Bypass Chinook Salmon and Steelhead Evaluation Project developed adult spring-run and fall-run Chinook salmon escapement estimates for Butte and Big Chico creeks; monitored outmigration timing and relative abundance of age-0+ juvenile spring-run

Chinook salmon within Butte and Big Chico creeks, including the Sutter Bypass; documented outmigration of yearling spring-run; and documented relative growth and residence time of juvenile spring-run in the Butte Creek system, including the Sutter Bypass, through coded-wire tagging (CWT) of juvenile salmon collected at the Parrott-Phelan Diversion Dam (PPDD). Monitoring of the Upper Butte Creek portion of the project area is continuing, but monitoring of lower Butte Creek within Sutter Bypass was not continued. This project contributed valuable technical information toward the ERP species target for spring-run Chinook salmon, fall-run Chinook salmon, and steelhead trout.

The Clear Creek Juvenile Salmonid Monitoring Project provided essential information on the status, trends, and habitat use of juvenile salmonids, and the Clear Creek Anadromous Salmonid Monitoring Program is an ongoing project that provides essential information on the status and trends for all life stages of anadromous salmonids on Clear Creek. Information from these projects has thus far fed into management decisions made by the Clear Creek Restoration Team, which is comprised of regulatory agencies, land management agencies, and local government, on restoration projects and future efforts.

- *Understand and compare salmon/steelhead life histories, needs, and responses to restoration.* The CALFED Science Conference summary noted that significant differences exist in Chinook salmon and steelhead life histories and environmental requirements. Efforts to better understand these differences and their mechanistic causes and implications are needed. During Stage 1 implementation, life history patterns and stock composition of steelhead in the Yuba River were successfully characterized to support ecosystem restoration and species recovery programs.

- *Genetic assessments.* On-going development of molecular genetic techniques to type fish(salmonids, splittail, etc.) from the Sacramento Basin are critical to understanding restoration needs, managing water to protect fish and to making decisions about the status of fish populations.

  The *Genetic Comparison of Stocks Considered for Re-establishing Steelhead in Clear Creek* project obtained fine-scale information on the genetic diversity of steelhead/rainbow trout from several locations in order to determine the preferred sources of founding stock for re-establishing a self-sustaining steelhead population in Clear Creek after removal of the McCormick-Saeltzer Dam. Once McCormick-Saeltzer Dam was removed in 2000, steelhead were able to access the uppermost portions of lower Clear Creek (below Whiskeytown Dam) for spawning. This project contributed to the ERP Species target of investigating the feasibility of using native rainbow trout currently isolated above dams to rebuild or recreate a steelhead run, as well as contributed to our knowledge of steelhead populations.

- *Juvenile life history requirements.* There is a generic need to understand juvenile life history requirements of salmonids, splittail and delta smelt in the Sacramento River and tributaries. The *Clear Creek Juvenile Salmonid Monitoring* project provided essential information on the status, trends, and habitat use of juvenile salmonids, and the *Clear Creek Anadromous Salmonid Monitoring Program* is an ongoing project providing essential information on the status and trends of anadromous salmonids on Clear Creek for all life stages. Information from these projects has thus far fed into management decisions made by the Clear Creek Restoration Team, which is comprised of regulatory agencies, land management agencies, and local government, about restoration projects and future efforts

- *Implications of mine wastes for restoration.* One essentially unstudied potential impediment to restoring native communities in the Sacramento Valley is the presence of mine wastes in areas undergoing restoration, although it must be acknowledged that other programs have done some research and toxic discharge management in the Sacramento Valley in areas such as the Iron Mountain Mine. Researchers from the CALFED directed action mercury study found that during certain months, the Sacramento River is the predominant source of methylmercury to the Delta. Mercury and other metal mines are common in the Sacramento watershed, and in a few cases, significant levels of contamination have been documented. Contaminated sediments can be transported far downstream from these historic activities, and can have both toxicity and environmental justice implications.

- *Transformations of mine waste products*. Transformations of mine waste products such as mercury can have implications for the delta as well. Contaminated sediments have the potential to stall restoration efforts, or prevent full recovery of sensitive species. It is possible to mitigate such effects, but prioritizing what to mitigate and where, for example, relative to other needs requires understanding and comparison of the concentrations, distribution, fate and effects of contaminated sediments in and among the tributary rivers and streams of the Sacramento River. Further work, particularly in the tributaries, is needed to identify sources of bioavailable mercury. Several ERP-funded mercury projects emphasize research and monitoring, planning, and public education rather than implementation. Therefore, there are no immediately measurable benefits to water quality, such as reductions in mercury or methylmercury concentrations or loads, or reduced concentrations of methylmercury in biota that can be attributed to these efforts.

- *Pilot projects for mine waste source control.* Proposition 13 provided some funds for restoration and source control of mine wastes at abandoned mine sites, but new information on treatment and remediation techniques are needed. Pilot-

- *Pesticides.* Toxicity testing shows that pesticide toxicity could be an important impediment to survival of some species in the tributaries of the Sacramento River. Greater understanding of pesticide occurrence, distribution, and effects under conditions typical of Sacramento stream and river environments is a critical need for addressing this threat.

- *Develop research and pilot/demonstration* projects that test and evaluate restoration and management practices that reduce contaminants and other stressors (fine sediments, pesticides, and nutrients) from agricultural lands.

- *Green Sturgeon.* Green sturgeon are an at-risk species native to the Sacramento River, yet little is known about the habitat needs of this species and its responses to restoration. The ERP funded research to conduct telemetric, physiological, reproductive, and genetic studies to provide state and federal agencies such as NMFS and CDFG with information on the size of the population and its critical habitat within the Sacramento-San Joaquin watershed. This information will inform a recovery plan for the species. The distribution of spawning adults and juveniles will be continuously monitored using automated listening stations situated throughout the Sacramento River as well as the Bay-Delta Estuary.

Priority 8. Implement environmental education actions throughout the geographic scope.

- *Education programs*. Several environmental education projects were implemented in the Sacramento Valley Region supporting the development of curriculum and outreach programs advocating and implementing local conservation, restoration and monitoring activities. These projects, including those encompassing Battle, Butte, Cottonwood, Sulphur, and Clear Creeks were comprehensive learning projects focused on the complexities of local watershed stewardship with an emphasis on building collaborative networks within local communities.

  Many of the watershed groups, and other entities such as Resource Conservation Districts, SRCAF, the Nature Conservancy, state and national parks and AFRP also recognize the benefit of providing environmental education and actively implementing education programs and support. For example, the Cottonwood Creek Watershed Group and the Stillwater Churn Creek Alliance meet monthly and provide information to their stakeholders on issues of interest in their respective watersheds. Many of these groups also participate in annual

Watershed Festivals; provide newsletters to their constituents; and maintain websites to provide electronic information to all who are interested.

Other Programs Contributing to ERP Vision

ERP has developed collaborative relationships with a wide variety of programs, agencies, and groups. Many of the programs and/or agencies mentioned below have made significant contributions toward restoration and habitat protection within the Sacramento Valley Region and/or increased the understanding of ecological processes, restoration techniques, and other parameters which contributed toward ERP.

Central Valley Project Improvement Act (CVPIA). In addition to the Anadromous Fish Restoration and Anadromous Fish Screening programs, the CVPIA, as passed by Congress in 1992, required the Secretary of the Interior to implement a wide variety of Central Valley Project operation modifications and structural repairs in the Central Valley for the benefit of anadromous fish resources. Sections 3406(b)(l) through (21) of the CVPIA authorized and directed the Secretary of the Interior, in consultation with other state and federal agencies, Indian tribes, and affected interests to take actions which would ultimately assist in protecting and restoring a wide variety of fish and wildlife resources, habitats, and ecological function associated with the Sacramento and other rivers in the Central Valley. CVPIA is jointly managed by the U.S. Bureau of Reclamation (BOR) and USFWS.

Many of the CVPIA actions to restore fish and wildlife and their habitats are synonymous and/or consistent with ERP actions and priorities. Approximately $15 million of CVPIA restoration funds were targeted for the purpose of protecting, restoring, and enhancing special status species and their habitats in areas directly or indirectly affected by the CVP. CVPIA programs that contribute to ERP goals and objectives include: AFRP, Dedicated Project Yield, Restoration of Riparian Habitat and Spawning Gravel, Clear Creek Restoration, Anadromous Fish Screen Program (AFSP), & Water Acquisition programs.

Other CVPIA provisions contain elements that relate to and support the AFRP and the fish doubling goal. A program to provide spawning gravel and riparian habitat for anadromous fish (Section 3406(b) (13)) authorizes the implementation of gravel restoration projects on the Upper Sacramento, American, and Stanislaus rivers in the Central Valley. Section 3406 (b)(21) of the CVPIA directs USBR and the Service to assist the State of California in installing fish screens on major unscreened or inadequately screened water diversions that may be resulting in the loss of juvenile salmon and other fish species, thereby affecting overall production. Actions that are related specifically to the restoration of fisheries on Clear Creek are identified in Section 3406(b)(12) of the CVPIA.

Many of these provisions and other provisions in the Act are designed to support both anadromous and non-anadromous fish species. For example provisions 3406 (b)(4) Tracy Pumping Plant and (b)(5) Contra Costa Canal Pumping Plant involve infrastructure and operational improvements, such as fish screening and recovery facilities, that contribute to anadromous and non-anadromous fisheries restoration. In general, the non-anadromous fish addressed by the CVPIA fisheries program are located in the Delta. The provisions address structural changes in CVP facilities and mandate changes in water operations to support fisheries restoration through a combination of timed increases in flows; water banking, conservation, and transfers; and modified operations and new or improved control structures.

Most of the historic wetland areas in the Central Valley have been converted to other land uses over the past 150 years. Less than five percent of the more than 4 million original acres of seasonal and permanent wetlands now remain. These remnants in the Central Valley must be intensively managed to support waterfowl populations that depend on the Central Valley for wintering habitat. Section 3406(d) of the CVPIA (Refuge Water Supply) establishes the primary goal of providing water for wildlife refuges and states that the Secretary shall provide, either directly or through contractual agreements with other appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on 19 refuges, including National Wildlife Refuge Systems in the Sacramento and San Joaquin Valleys, Central Valley state wildlife management areas, and the Grasslands Resources Conservation District.

This increase in water supply and reliability has created new wetlands and enhanced existing wetlands, resulting in increases in populations of Federal and State listed species—particularly avian species—and other wildlife species such as the giant garter snake (*Thamnophis gigas*). Avian species that have benefited include the peregrine falcon (*Falco peregrinus*), southern bald eagle (*Haliaeetus leucocephalus washingtoniensis*), tri-colored blackbird (*Agelaius tricolor*) and white-faced ibis (*Plegadis chihi*). The better water supply and reliability for refuges has also reduced the concentration of salts and other contaminants, thereby improving the quality of water on the refuges, and the quality of water discharged from the refuges.

CVPIA - Terrestrial and Other Habitat Resources. The CVPIA Habitat Restoration Program (HRP) was developed under Section 3406(b)(1) of the CVPIA to address the needs of native fish and wildlife affected by the CVP that were not specifically addressed in other portions of the CVPIA. The HRP focuses on protecting native habitats that have been directly affected by construction and operation activities of the CVP and that have also experienced or are experiencing the greatest decline in species that are federally listed, proposed, or candidate for listing under the endangered species act. Other considerations include state-listed species and non-listed state and federal species of special concern or other associated native wildlife species. To date, the HRP has funded nearly 90 new projects with a total budget of over $23 million dollars. Much of the focus of the HRP since 1992 has been on acquiring land either

through fee title or conservation easement, and consequently, more than 100,000 acres of habitat has been protected through HRP funding including vernal pool, riparian, alkali scrub, foothill chaparral, valley-foothill hardwood, and grassland. The HRP has also funded 8 riparian restoration projects which have contributed to more than 1,000 restored acres. Additionally, more than 30 studies/surveys have been funded, with projects including captive breeding and reintroduction; distribution and status surveys; genetics studies; assessment of relocation efforts; and grazing impacts studies. Finally, more than 10 management/planning/outreach actions have been funded. The program has also supported pilot programs that contribute to the long-term scientific understanding of restoration actions.

CALFED Watershed Program. This program has many similar goals and objectives as ERP, and millions of dollars of Watershed Program funds have been allocated to projects in the Sacramento Valley Region. These include watershed assessments, watershed management plans, restoration projects, and the funding of watershed coordinators.

The Wildlife Conservation Board (WCB). WCB was created by legislation in 1947 to administer a capital outlay program for wildlife conservation and related public recreation. Originally created within the California Department of Natural Resources, and later placed with CDFG, the WCB is a separate and independent Board with authority and funding to carry out an acquisition and development program for wildlife conservation (California Fish and Game Code 1300, et seq.). WCB's three main functions are land acquisition, habitat restoration and the development of wildlife oriented public access facilities. The Wildlife Conservation Board offers grants under most of its programs. These include grants for restoration and enhancement of wildlife habitat, development of public access facilities for wildlife oriented uses, and protection of habitat through fee acquisitions and conservation easements.

These activities are carried out under the following programs, many of which have implemented projects that addressed ERP goals:

- California Forest Conservation Program
- California Riparian Habitat Conservation Program
- Ecosystem Restoration on Agricultural Lands
- Habitat Enhancement and Restoration Program
- Inland Wetlands Conservation Program
- Land Acquisition Program
- Natural Heritage Preservation Tax Credit Program
- Oak Woodlands Conservation Program
- Public Access Program
- Rangeland, Grazing Land, and Grassland Protection Program

Environmental Quality Incentive Program (EQIP) and Wetland Reserve Program (WRP); managed by the National Resource Conservation Service (NRCS). (EQIP) incentive payments compliment the objectives contained in the CALFED ERP while focusing on the role agricultural lands can play to provide habitat to fish and wildlife species. Approved projects optimize environmental benefits, while also addressing natural resource concerns, and are awarded based on criteria consistent with the goals of EQIP. Projects using WRP funding similarly compliment the objectives contained in the CALFED ERP and the objectives of the WRP.

The WRP objectives are to purchase conservation easements from willing sellers; restore and protect wetlands in agricultural settings; remove environmentally sensitive, marginal cropland from cultivation; assist landowners with restoration of wetland hydrology; and contribute to the national goal of no net loss of wetlands. Approved projects optimize environmental benefits while addressing natural resource concerns and are awarded based on their state wide rank consistent with the goals of WRP.

Central Valley Habitat Joint Venture. The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Butte, Colusa, American, and Sutter Basins. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

Riparian Habitat Joint Venture. Loss of riparian habitat is the single greatest cause of recent declines in songbird populations in the western U.S. New possibilities for preserving this critical habitat, through partnerships, prompted California Partners In Flight to launch the Riparian Habitat Joint Venture in 1994, modeled on the waterfowl JVs but funded solely by its member organizations. To date, eighteen federal, state and private organizations have signed the landmark Cooperative Agreement to protect and enhance habitats for native landbirds throughout California. The RHJV, modeled after the successful Joint Venture projects of the North American Waterfowl Management Plan, reinforces other collaborative efforts currently underway which protect biodiversity and enhance natural resources as well as the human element they support.

Current priorities include projects on the Sacramento, Owens, South Fork Kern, San Joaquin, and other California rivers. The Riparian Bird Conservation Plan, summarizing current scientific knowledge on the requirements of 14 focal bird species, provides recommendations for habitat management and monitoring.

Local Watershed Planning Groups. Maintaining and restoring the ecological health of the Sacramento Valley Region depends heavily on local watershed groups, including local landowners, concerned individuals, and local resource experts. Significant watershed planning groups in this Region include the Clear Creek Coordinated Resources Management Program, the Battle Creek Watershed Conservancy and the Battle Creek Working Group, the Mill Creek Conservancy, the Deer Creek Watershed Conservancy, the Sacramento River Watershed Program, the Cow Creek Watershed Management Group, the Cottonwood Creek Watershed Group, the Stillwater-Churn

Creek Watershed Alliance, the Big Chico Creek Alliance, and the Butte Creek Conservancy.

Changes Attributable To ERP

Some projects provided an immediate benefit to natural resources. The repair of the Anderson Cottonwood Irrigation District (ACID) dam and ladders resulted in unimpaired passage and accessibility of several miles of habitat for winter-run Chinook and other runs of anadromous fish. The numerous fish screens funded by ERP and its partners realized immediate benefits by reducing the potential for entrainment. Riparian habitat projects provided, at a minimum, foraging habitat for a variety of Neotropical migratory birds within two to three years of implementation.

This being said, many of the projects funded in the Sacramento Valley Region involved research, monitoring, planning, and pilot demonstrations. These activities provide the Region with an established baseline of scientific and technical data and tools which will serve as a guide for future implementation. State-of-the-art analytical tools to evaluate salmonid migration patterns were developed and compliment existing monitoring efforts conducted by the state and other entities. Large scale channel-floodplain projects such as those implemented on Clear Creek brought reconstruction of channel and floodplain morphology to improve ecological processes and improve conditions for anadromous salmonids. Spawning gravel augmentation on the Sacramento River and selected tributaries have created additional spawning opportunities for salmonids. Reductions in contaminants were not only technically feasible on a large scale but water quality improvement is possible at comparatively modest costs. These demonstrated technologies and practices have gained acceptance, albeit variable, among local land managers and farmers in the Sacramento Valley, partly as a result of pre-project outreach, but also due to the technical support provided by various agencies and the role of watershed groups, resource conservation districts, and environmental education facilities.

As an example, a total of 77 projects have been funded by ERP that would benefit the Sacramento River EMZ. The projects are focused on evaluating and obtaining more information on stream meander, natural floodplain and flood processes, Central Valley stream temperatures, riparian and riverine aquatic habitat, freshwater fish habitat and essential fish habitat, and water diversions, all of which provided building blocks towards implementation. Some of these projects benefited the entire Sacramento Valley Region, including various habitat inventories, fish population data collection, and model development.

In total, 18 projects have been funded by the ERP that would benefit the American River EMZ. The majority of these projects have been focused on research and monitoring (10 projects). The research and monitoring projects have provided valuable information that should guide future implementation projects during stage 2. The

remaining projects have been focused on planning (5 projects), implementation (2 projects), and education (1 project). Three of the planning projects led to full scale implementation projects, and two of the planning projects have resulted in watershed plans that should also guide future restoration projects in the EMZ.

Application of ERP Activities to Multi-Species Conservation Strategy (MSCS) Species

Multiple years of continuous monitoring is needed in order to make effective decisions about fish and wildlife population and habitat management. Data obtained from the projects funded by ERP indirectly addresses ERP goals to recover at-risk native species and maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest.

Comprehensive data was not collected on all MSCS species, although a substantial level of information was gathered from the various ERP projects, particularly in the arena of fisheries. Data collected on fish distribution, run timing, response to gravel injection, and habitat use all provided critical information that can be used in future restoration efforts. The fish monitoring projects on the Sacramento River and some of the tributaries also contributed towards meeting the MSCS milestones to monitor adult anadromous salmonids returns in each watershed.

Extensive monitoring projects were conducted in some areas within the Sacramento Valley Region; looking at a variety of resource parameters, either with ERP funding, or with funding from other sources. For example monitoring of fish populations, riparian habitat, Neotropical migratory birds, wetlands, response of these parameters to restoration efforts, and geomorphological conditions of the stream is currently being implemented on Clear Creek. Overall, the monitoring and implementation projects on Clear Creek addressed and/or will substantially address the ERP targets of coarse sediment supply, stream meander, natural floodplains and flood processes, riparian and shaded riverine aquatic habitats, freshwater fish habitats, and essential fish habitats, as well as dams and other structures. Battle Creek has a comparable monitoring program, with projects providing critical management information for CALFED Goal 1 – At Risk Species and CVPIA priority species: winter-, spring-, fall-, and late-fall-run Chinook salmon and steelhead trout.

In some cases, guilds of species were evaluated, as opposed to single species. The *Songbird Population Responses to Riparian Management and Restoration at Multiple Scales: Comparative Analysis, Predictive Modeling, and the Evaluation of Monitoring Programs* is an ongoing research effort designed to evaluate the results of past and current riparian bird system research and monitoring across the entire CALFED region. Information learned from this study will contribute to the successful implementation of ERP riparian and riverine aquatic habitat targets for the Feather River/Sutter Basin EMZ.

In the Feather River Sutter Basin EMZ, an implementation project is currently in progress that will contribute toward the ERP Vision to ensure fish passage and promote recovery of MSCS Species. Planning has been completed that also contributes toward the vision of ensuring passage of adult salmon, including spring-run Chinook. In addition, research and monitoring projects have been completed in the EMU that will contribute new knowledge to the ERP Vision for the EMU that would improve streamflow and ERP targets for species (spring-run Chinook salmon, fall-run Chinook salmon, steelhead trout, and giant garter snake).

Planning projects 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, habitats, stressors, and species including fall-run Chinook salmon, spring-run Chinook salmon, steelhead, green sturgeon, and American shad. In addition, intense research on the Upper Yuba River has provided new information for ERP targets for ecological processes; habitats; stressors, such as dams and other structures; and species, such as Chinook salmon and steelhead.

Some projects directly addressed single MSCS species. The *Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed* is a multi-phased project that has contributed important biological information on green sturgeon. In addition, *Spawning Areas of Green Sturgeon in the Upper Sacramento River* provided information useful for management activities. Green sturgeon is classified as an MSCS species and a CALFED at-risk species.

The Sacramento River Ecological Flows Study distilled existing information and presented conceptual models and hypotheses about ecological flow needs in the Sacramento River. This project also utilized indicator species, several of which were MSCS species, in the development and application of its modeling and analysis efforts.

New Knowledge and Relationship to Original Goals, Objectives and Targets

For a variety of reasons, some watersheds within the Sacramento Valley Region were studied more intensively than others and/or obtained funds for implementation. Staff involved with such programs as ERP and AFRP over the last ten+ years have found that comprehensive planning, in the form of conceptual plans, watershed assessments, and watershed management plans, are crucial to laying the foundation for successful restoration work and for setting restoration priorities; as is stakeholder involvement and cooperation. Areas such as Clear Creek had developed conceptual plans for restoration in the early years of ERP, which later made it competitive for funding and the successful implementation of several restoration projects. The Feather River Sutter Basin EMZ implemented several research and monitoring projects that will contribute new knowledge to the ERP Vision for that EMU, of improving streamflow, and ERP targets for several MSCS species (spring-run Chinook salmon, fall-run Chinook salmon, steelhead trout, and giant garter snake). Planning projects 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, habitats, stressors, and species including fall-run Chinook salmon, spring-run Chinook salmon, steelhead, green sturgeon, and American shad. In addition, intense research on the upper Yuba River has provided new information for ERP targets for ecological processes, habitats, stressors such as dams and other structures, and species such as Chinook salmon and steelhead.

The Yolo Bypass remains an area of great interest and encompasses portions of the Yolo Basin EMZ and the Sacramento-San Joaquin Delta EMZ. The projects funded thus far have helped to better define the value of the bypass as seasonal habitat for MSCS fish species. The studies have also improved our knowledge of the role of the bypass in supporting local and Delta zooplankton species and organic carbon input which could benefit MSCS species in the Delta. The areas in which we have made significant progress in better defining the ecological problems, developing restoration strategies, and implementing restoration/management actions in the Yolo Basin EMZ include:

- The ecological and biological value of seasonal flooding.
- The role of wildlife refuges and wetlands in supporting dependent species.
- Better understanding of fish passage needs and stranding problems.
- The contribution of Cache and Putah Creeks to flooding.
- The control of invasive weeds species in upland areas.
- Watershed management and improvements at the local level.
- Restoration of perennial grasslands.
- Opportunities to reduce sediment and mercury input reduction to the Delta.

Generally, we know much more about the Yolo Basin EMZ now than prior to the beginnings of CALFED. This is a direct result of providing funding for a wide variety of monitoring, research, implementation, planning, and educational programs that focused on the Cache Creek, Putah Creek, Solano, and Willow Slough watersheds and the Yolo Bypass.

Projects funded by the 2004 ERP monitoring solicitation will further provide new information on the degree to which targets and objectives are being met. For example, the goal of the Sacramento River Riparian Monitoring and Assessment Consolidated Project is to evaluate whether the habitat and populations of certain endangered and other at-risk species are recovering, whether the ecological processes are being rehabilitated, protected and restored, and whether the impacts from non-natives invasive species are being reduced for ERP funded project sites within the Sacramento River Ecological Management Zone. This level of information is critical for the evaluation of species of concern such as Valley elderberry longhorn beetle and Chinook salmon, and assessing the overall success of ERP within the Sacramento River Ecological Management Zone. Once implemented, the information will be invaluable to ERP and its partners, including federal, state and local agencies, and non-profit groups who are involved in Sacramento River restoration efforts.

Restoration practices, such as riparian planting, non-native species control, fish screen design, ecological flow management, and gravel augmentation have all benefited by ERP funding, in coordination with its partners due to the adaptive management process and lessons learned by early phases of project implementation.

Impediments to implementation

Contract timeliness and issues revolving around environmental compliance: One of the common complaints from project implementers was the time taken to obtain a contract to initiate a project. This sometimes shortened the amount of time that could be used for post-project monitoring and/or negatively affected cost share arrangements (cost share funds had to be turned back), as well as potentially increased costs of a project due to inflation/cost of living. Several project implementers were not aware of environmental documentation and permitting requirements, some of which also applied to data collection projects, which delayed project initiation in some cases.

Public vs. Private Ownership: In upper portions of the watersheds of the Sacramento Valley Region, most of the ownership is public (U.S. Forest Service, Bureau of Land Management). However, much of the restoration work that needs to be done is in private ownership. Building a relationship of trust with landowners can be a rewarding albeit long process. In some cases, trust cannot be obtained, which impedes ERP's ability to comprehensively implement its goals. For example, non-native weed control requires the treatment of all plants from the uppermost location and downstream. If access cannot be obtained for the entire length of stream, then the successful implementation of weed control is impaired.

Public Access for Monitoring: The scientific and economic value of the project, and the effects on habitat, may not be fully known if adequate public access is not available to implement effective monitoring on a more or less indefinite basis. Poor public access access can also substantially increase project costs for implementation and monitoring, or limit the effectiveness of the placement of gravels and data collected by monitors.

Spawning gravel costs, as an example of the escalating cost of restoration: For gravel augmentation projects there is a competitive demand for material with other development activities like road and structure building, resulting in higher project costs. Additionally, the material which is currently permitted for extraction in the proximity of the restoration projects is in adjacent-to-river locations. Rapid extraction of these sites may lead to more channel failures and added future costs to conservation of the fish resources. Reviewers within the funding agencies have suggested that alternative sources of material with a more beneficial reclamation potential should be researched.

Funding: The current system of funding greatly constrains the opportunity to design, implement and monitor large channel-floodplain projects properly. The Adaptive

Management Forum (for Clear Creek and the Merced and Tuolumne Rivers) suggested funding agencies to explore ways to ensure the necessary long term commitment of resources that will ensure success.

Lack of a comprehensive, effectiveness and implementation monitoring program: In most projects there is no description of how monitoring will coordinate with efforts associated with the implementation of other projects within the same or other basin rivers. Attribution of a measured change in condition to a specific project may be difficult, especially for biological responses. Without some careful coordination, interpretation of the observed changes in river condition will be difficult. The monitoring efforts for all restoration projects need to be coordinated in order to tease apart the specific responses to individual projects.

There is also no effectiveness and/or implementation monitoring plan for the Sacramento Valley Region or for the entire ERP project area. This makes program-wide analysis of success difficult, if not impossible.

Status of Area Today

Dams within the Sacramento Valley Region continue to provide water supplies, flood control capacity and, more recently, recreation and ecological flows. ERP, along with its partners, have provided additional tools, such as those obtained in the Sacramento River Ecological Flows Study, which distilled existing information and present conceptual models and hypotheses about ecological flow needs in the Sacramento River. Impacts caused by unscreened diversions are diminished due to the number of screens that were put in place along the Sacramento River and its tributaries. Additional work is needed on addressing the needs to provide ecological flows for riparian habitat recruitment, habitat succession, and rearing habitat. Because the dams have blocked natural recruitment of sediment for decades, extensive, prolonged gravel augmentation still needs to occur below dams on the River's tributaries, as well as below Shasta Dam itself.

Historically, wetlands covered an estimated 1,400,000 acres of the Sacramento Valley and were comprised of mostly riparian forests and semi-permanently flooded tule marshes. Currently, approximately 170,000 acres of wetlands remain and are dominated by tule marsh. Some 500,000 acres of riparian forest historically fringed the entire length of the mainstream Sacramento River channel. Today, less than 5% of the mainstream riparian forest remains. As in the Delta, wetland plants and riparian forests provided food and shelter for aquatic biota and greatly increased the hydraulic residence time of the system.

As a result of the efforts of ERP and its partners (such as the Wildlife Conservation Board, CDFG, USFWS, and the Nature Conservancy, to name a few), several thousand acres of habitat has either been purchased, protected via conservation easements,

and/or restored to native habitat. Key areas that this has been implemented include the mainstem Sacramento River, Deer Creek, and Mill Creek. Review processes, such as those provided by SRCAF, help to ensure that riparian habitat considerations are addressed within the 100-year floodplain of the River. Additional work needs to occur in this arena, however, including the riparian resources of Cottonwood Creek (which is an ERP milestone), and in the realm of non-native weed control. The valley floor portions of such watersheds as Thomes Creek and Stony Creek are dominated by *Arundo* and *Tamarisk*, as opposed to native riparian vegetation.

Ecological factors having the greatest influence on anadromous fish species in the Sacramento River include streamflow, coarse sediment supply (including gravel for fish spawning and invertebrate production), stream channel dynamics (meander), flow quantity and timing, and riparian and riverine aquatic habitat. Stressors that have affected the health of the anadromous fish populations include dams, harvest, high water temperatures during holding, spawning and egg incubation, toxins/contaminants from mine drainage and other sources, hatchery stocking, restricted access to the natural floodplain(s), reduced spawning habitat quantity and quality, and unscreened or poorly screened diversions.

As previously stated, many of the ERP projects funded in the Sacramento Valley Region involved research, monitoring, planning, and pilot demonstrations. These activities provide the Region with an established baseline of scientific and technical data and tools which would serve as a guide for future implementation. State-of-the-art analytical tools to evaluate salmonid migration patterns were developed and compliment existing monitoring efforts conducted by the state and other entities. The "tools" provided by ERP funding have allowed agencies, watershed groups, and other entities to more forward with planning and project implementation that otherwise may not have occurred. This being said, some monitoring and data collection efforts, such as fisheries monitoring, riparian habitat restoration monitoring, bird community data collection, and flow gauge operation are not perpetually funded and are at risk of not continuing. There is therefore a need to actively address perpetual funding needs of some of these critical data collection efforts.

Some ERP projects addressed issues revolving around toxins and other contaminants; however, this issue needs to be addressed more comprehensively and in cooperation with other entities, such as the State Water Resources Control Board.

Future Vision

SRCAF's regional approach along the Sacramento River and other regional endeavors should be encouraged. For instance, in the northern Sacramento Valley, contiguous aquifer systems underlie several counties. As a result, one country's use of the resource may impact another county. Therefore, regional coordination and cooperation is essential for the individual users, as well as for the benefit of the region as a whole.

Restoration activities, particularly on habitat types used by species with extensive migration needs (e.g. waterfowl, Neotropical migratory birds, anadromous fish) and/or large home ranges, need to be more effectively coordinated within the Region.

ERP should also consider strategic plans, such as those recently developed by SRCAF, and tributary/watershed assessments and management plans when determining Region-wide priorities. Watershed (tributary and mainstem Sacramento River) management plans should be developed in the CALFED Ecological Management Zones in the Central Valley that don't already have plans. Several of the Ecological Management Zones have completed watershed management plans (thanks to funding primarily from the CALFED Watershed Program and AFRP), and they are a very useful tool for watershed groups and agencies when assessing and prioritizing restoration steps in the tributary watersheds. The ERP should investigate these documents and assess ERP goals and activities that are consistent with the goals, objectives, and actions identified within these documents.

As previously stated, there is no effectiveness and/or implementation monitoring plan for the Sacramento Valley Region or for the entire ERP project area. This makes program-wide and region-wide analysis of success difficult, if not impossible. Project monitoring is not coordinated, i.e. similar projects have different degrees of pre- and post-project monitoring, or use different monitoring techniques that make it difficult to cumulatively assess success or failure of comparable projects. Coordination is also needed with other restoration efforts, such as CVPIA which implements a wide variety of restoration and monitoring projects throughout the Central Valley. Lack of coordination can lead to duplication of effort and/or problems with data analysis. It is vital that the ERP Plan develop a structure for regional implementation and effectiveness monitoring structure for the ERP Plan that is consistent with and in collaboration with existing local restoration program integration efforts.

There are also currently numerous watershed groups within the region compiling valuable data and involved in restoration projects within their watersheds. However, these are only a piece of the larger fabric of the greater Sacramento River watershed. These data and projects must be woven together to provide a more comprehensive view of the entire watershed. This will allow for more informed decision-making and better protection and use of the resources.

Although the ERP did not specify actions to improve or support educational and interpretive facilities, public education about ecosystem management is an important way to develop additional support for habitat restoration. The Pacific Flyway Center, Turtle Bay Museum, and the Sacramento River Discovery Center are examples of how the general public can become informed and support wildlife habitat restoration and management. There still needs to be long-term educational outreach to local agencies, educators, and landowners. The consistent exposure provided by long-term

educational programs has proven to be very effective in permanently changing peoples' perceptions of environmental issues and needs.

Many future actions can be targeted at State-owned and other public land within this Region. However, it is important to integrate local property rights and landowner concerns in future planning and project implementation. Landowner awareness of implementation practices and their engaged participation in watershed restoration projects is essential. For example, managing the bypasses for the benefit of fish and wildlife must be balanced with use for flood control and farming.

Forums for local elected officials and landowners will be needed, in conjunction with state and federal agency representatives, to learn about regional water management issues, regional water supply planning assumptions, and future water quality and water supply reliability projections. These regional forums will help establish a broad foundation for intensifying regional collaboration across local government boundaries and water district service areas. This type of outreach will not only alleviate concerns that the program is operating in a vacuum and lessen fears and suspicions of the program in general, but will also help to build positive partnerships to assist in the implementation of program goals.

Regional coordination should help to develop the Sacramento Valley's capacity to provide input about CALFED program needs and priorities within the region to the CALFED agencies. The Sacramento Valley Region is comprised of thousands of acres of open space and agricultural lands. Local governments should play a bigger role in the Sacramento Valley Region because the land use authority granted through their police powers gives them the ability to develop policies that may affect the CALFED program. The coordination of local governments with watershed groups; agencies and other entities that manage the natural resources; and local water and special districts, will be vital to developing a consensus for the region.

In a similar vein, the projects funded by ERP involving the agricultural community have not only been beneficial to natural resources, but have also created a better foundation of trust and cooperation between the environmental and agricultural communities. ERP should continue to actively explore ways in which both communities can work together on restoration that meets the needs of landowners and the resource.

Tools such as Safe Harbor Agreements (SHA) and Habitat Conservation Plans should be used when appropriate. Since 2004, several safe harbor agreements have been developed within the Sacramento Valley Region (in Red Bank Creek and Cottonwood Creek, for example, and a programmatic SHA to be managed by SRCAF). These can be an effective tool to provide habitat for listed species while also addressing landowners' concerns.

Upon review of the projects funded by ERP within the Sacramento Valley Region, it is apparent that some watersheds are well underway with a comprehensive plan for restoration and protection (as stated above), while others have received little to no funding or restoration effort. Stage 2 efforts should look at what has been comprehensively accomplished (e.g. where have screens been put in place or where riparian restoration has occurred) and identify and prioritize the next phases of restoration activity on a Region-wide scale, especially on those parameters that transcend watershed boundaries. For example, some protection of blue oak woodland has been achieved, via land purchase or conservation easement, on the east side of Tehama County. There are other areas with equally high quality blue oak woodland habitat warranting protection in other areas of the Sacramento Valley Region. As development continues to be an issue of concern, particularly around small towns and cities (as they expand), a program to protect natural resources on large landholdings should be explored.

Support for the continued existence of watershed groups and other groups that work at a watershed scale (such as resource conservation districts) is critical. Formation of new watershed groups in some areas of the Sacramento Valley Region, not currently covered, would also be very beneficial. Watershed groups in the Sacramento Valley Region have completed a huge amount of work in the realm of planning, landowner outreach and coordination, and restoration project implementation, thereby benefiting not only the resources but also the missions of many resource agencies and programs such as ERP. In some cases, it is likely that little or no progress would have been made in resource protection over the last ten years if it were not for the existence of a proactive watershed group. An effective watershed group also provides a forum through which resource agencies can build relationships of trust with other agencies, landowners and other stakeholders. ERP can support these valuable entities by coordinating with state and federal watershed management efforts.

Projected increases in recreational uses of the Sacramento Valley Region should not be ignored by ERP, nor should the projected increase in the (human) population of the Region. ERP should consider these two parameters carefully in order to proactively identify areas requiring protection, as well as implement projects where activities such as recreation and development can still occur while also addressing the needs of the ecosystem. Studies on recreation on the River should be expanded and/or regularly implemented to better gauge both recreational and the natural resources needs so as to avoid conflicts. This should also be done with development needs and will require close coordination with local planning agencies and governments (county, city).

Close coordination will be needed to deal with water quality. Aquatic and terrestrial contaminants will become increasingly challenging to address. The Sacramento River and some of its tributaries have TMDL listing and/or have impaired water quality. Issues, such as mercury contamination, still need to be addressed; as does how to

incorporate processes such as the State Water Resources Control Board agricultural waiver, which was implemented since the 2000 ERP Plan began.

ERP Stage 1 provided some funding to address non-native species, but it was sporadically distributed; addressed only certain species; and/or was implemented in only specific geographic areas. Several "scares" from such non-native species as northern pike (*Esox lucius*) and quagga mussel (*Dreissena bugensis*) since 2000 have brought the need for coordinated noxious/non-native species management to the forefront. Species such as *Arundo* and salt cedar (*Tamarix chinensis*) need to be managed or eliminated on a regional scale across the landscape, starting at the uppermost infestation location, in order to reduce the likelihood of re-establishment of non-native species in the stream channel/watershed. More funding, time and effort is needed for the CALFED Non-Native Invasive Species (NIS) Program to become more effective in this issue. Since 2000, noxious weed programs implemented by such agencies/groups as the California Department of Food and Agriculture and the California Invasive Plant Council have made progress in addressing the non-native species issue. In addition, watershed assessments completed since 2000 contain crucial information on the presence of non-native species within the Region's watersheds—all of this needs to be revisited and actively addressed in the future by ERP and its partners.

Additional coordination is needed on the upper portions of watersheds within the Sacramento Valley Region. A small number of ERP projects addressed restoration needs in the upper elevations of such watersheds as Butte, Mill, Deer and Antelope Creek, but more attention is needed to maintain and protect these areas. Most, if not all, of the mid- to high-elevation areas of the Region are under the threat of catastrophic fire impacts; and better coordination is needed to identify resources of concern, particularly in private land areas, as well as address degraded areas. In particular, meadow protection and restoration is urgently needed, as meadows provide habitat for a wide variety of species at higher elevations. They also perform functions which improve water quality; water which is used downstream in a wide variety of ways. Coordination is needed during response to fires in this region in order to inform fire managers of resources at risk, as well as guide restoration efforts. There is a system to provide this service on public lands (U.S. Forest Service and Bureau of Land Management—Burned Area Response and the role of resource advisors on fires) and this model should be explored for the large, undeveloped areas of private land.

The vision statements of some of the Sacramento Valley Region EMZ's need to be corrected. The following language is found in the ERPP, Volume II: Ecological Management, Zone Visions from the Final Programmatic EIS/EIR, Technical Appendix, July 2000 version (ERP Zone document):

> From the Sacramento-San Joaquin Delta Ecological Management Zone Vision (page 92), the Suisun Marsh/North San Francisco Bay Ecological Management Zone Vision (Page 138), and the American River Basin Ecological Management

___e Vision (Page 295): *"Striped Bass:* T*he vision for striped bass is to maintain healthy populations consistent with restoring native species, to their 1960s levels of abundance to support a sport fishery in the Bay, Delta, and tributary rivers…"*

From the Sacramento-San Joaquin Delta Ecological Management Zone Vision (page 93), the Suisun Marsh/North San Francisco Bay Ecological Management Zone Vision (Page 138), the Feather River/Sutter Basin Ecological Management Zone Vision (Page 269), and the American River Basin Ecological Management Zone Vision (Page 295): *"American Shad: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, to support a sport fishery similar to the fishery that existed in the 1960s and 1970s…"*

From the North Sacramento Valley Ecological Management Zone Vision (Page 196): *"…The vision focuses on restoring spring-run Chinook salmon and steelhead to populations levels of the late 1960s and early 1970s…"*

From the Butte Basin Ecological Management Zone Vision (page 242): *"…The vision for the Butte Basin Ecological Management Zone focuses on restoring physical processes and habitats and reducing stressors to meet spring-run Chinook salmon and steelhead population levels of the late 1960s and early 1970s…"*

Striped Bass: The language found within this vision appears to contradict other programs AND language within the ERP Zone document. For example, the ERP Zone document states, on page 171, within the Sacramento River Ecological Management Zone Vision (Page 171), that *"…The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission striped bass policy…"*

The Vision statements above, which strive for population goals of the 1960's and 1970's, contradict direction found within the 1993 CDFG document, *Restoring Central Valley Streams, A Plan for Action*, which does not identify meeting population numbers from the 1960s and 1970s, as well as doubling targets for anadromous salmonids identified within CVPIA (AFRP, Final Restoration Plan). These vision statements need to be revisited and corrected during Stage 2 development of the ERP.

Future Ecological Risks

As of 2007, the anadromous fish populations in the Central Valley are experiencing a significant decline. The federal Pacific Fisheries Marine Council (PFMC) and the National Marine Fisheries Service (NMFS) closed the already-open ocean sport fishery between Horse Mountain and Point Arena on April 1, 2008. In addition, they closed the April 5 sport fishing openers in San Francisco and Monterey port areas (south of Point Arena to

the U.S.-Mexico Border). These emergency actions were taken to protect Sacramento River fall Chinook salmon which returned to the Central Valley in 2007 at record low numbers. It is clear that more attention must be given to restoration needs within the Sacramento Valley Region to better ensure habitat and instream conditions of high quality for all populations of anadromous fish. Likewise, flow management must ensure that all ecological processes are maintained, keeping the area in a state of dynamic equilibrium to the extent possible.

Because such a limited amount of riparian habitat remains, compared to historical conditions, certain populations of Neotropical migratory birds, such as yellow warbler, bank swallow, and yellow-billed cuckoo, are in danger of extirpation from the valley floor due to a combination of habitat fragmentation, predation, parasitism, and contaminants. Actions are needed to protect these species and others similarly affected.

Development pressure is having localized effects on habitat, and is affecting flow management (e.g. ineffective stormwater management and non-point source pollution). With development comes an increased need for water and waste disposal, all of which can negatively affect natural resource needs. Local governments (counties, cities) must be engaged in proactively protecting open areas and using ecological principles when designing and implementing local planning efforts. Natural resources, such as gravel and timber, must also be proactively managed to meet the needs of wildlife and ecosystem processes and human populations/communities alike. Much of the mid- to upper elevations of the Sacramento Valley Region are rated as either high or extremely high fire hazard due to buildup of fuels, decadent brush stands, or historical fire suppression efforts. Care needs to be taken to reduce the effect of catastrophic fire while also maintaining habitat parameters (such as snags and coarse woody debris) across the landscape.

Some stream segments of the Sacramento River and its tributaries are listed as "impaired" by various contaminants (U.S. Environmental Protection Agency, accessed January 2, 2000). Being "impaired" means that a water quality standard for beneficial uses (for example, as a source of drinking water or for recreation or industrial use) is not being met. Impaired water bodies are mainly affected by nonpoint sources of contaminants from agriculture or from a combination of point and nonpoint sources from abandoned mines. Water-quality objectives are usually not met only during conditions of stormwater-driven runoff. The Clean Water Act requires States to maintain a listing of impaired water bodies for the purpose of establishing a Total Maximum Daily Load (TMDL). The most prevalent listings in the Sacramento River Basin are for organophosphate pesticides and mercury, for which TMDLs currently are being considered. Acid mine drainage has been a serious environmental problem in the northern portion of the Sacramento River Basin (Alpers et al 2000a,b). Several streams are listed as impaired because of high concentrations of metals such as cadmium, copper, lead, and zinc. Metals concentrations in previous years have been toxic to fish

in the upper Sacramento River near and downstream from Redding (Alpers et al 2000a,b). Recent mitigation efforts at one of the more contaminated sites in the Spring Creek drainage near Shasta Lake have significantly lowered concentrations of metals in the Sacramento River, and no toxic effects to fish were observed during the course of this investigation (Alpers et al 2000a,b). However, elevated levels of metals such as copper can still be measured in in streambed sediment in the upper Sacramento River Basin downstream from Redding (MacCoy and Domagalski, 1999). Copper and other metals may still affect aquatic organisms.

Mercury is currently considered the most serious water-quality problem in the Sacramento River, some tributaries of the Sacramento River, and downstream locations including the San Francisco Bay (Domagalski et al 2000). Mercury can enter streams or aquatic systems through either atmospheric deposition or transport from geological or man-made sources. Several processes contribute to the subsequent bioaccumulation of mercury in fish tissue. Because of the presence of mercury in the tissue of certain fish species, advisories have been posted for several water bodies, and more advisories are planned, both within the Sacramento River Basin and in the San Francisco Bay.

Future Institutional Barriers

In addition to issues around securing funding and previously mentioned barriers, another impediment to making further gains comes primarily from conflicts or concern posed by adjacent landowners with different land use goals. Tension between agricultural landowners and restoration proponents along the Sacramento River is due to the conversion of farmland into riparian forest and valley oak savanna. There is a perception that restoration efforts will increase 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.

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2. REGIONAL OVERVIEWS

2.3. San Joaquin Valley Regional Overview

San Joaquin Valley Regional Description

The 290-mile-long San Joaquin Valley occupies the southern half of the Central Valley and has an average width of 130 miles. The San Joaquin River basin is bounded on the west by the Coast Ranges and on the east by the Sierra Nevada. The San Joaquin River flows west from the Sierra Nevada, turns sharply north at the center of the valley floor, and flows north through the valley into the Sacramento-San Joaquin River Delta. See Figure 1 for a map of the San Joaquin Valley Region.

On the arid west side of the basin, relatively small intermittent streams drain the eastern slopes of the Coast Ranges but rarely reach the San Joaquin River. Historically, under more natural conditions, Ingram, Del Puerto, and Orestimba Creeks reached the San Joaquin. The limited natural runoff from westside sloughs is augmented by contaminated agricultural drainage and spill flows. On the eastside, many streams and three major rivers drain from the west slope of the Sierra Nevada and flow into the San Joaquin River. The major eastside tributaries south of the Delta are the Stanislaus, Tuolumne, and Merced rivers. Secondary streams south of the Merced River include Bear Creek and the Chowchilla and Fresno rivers and the upper San Joaquin River.

The Stanislaus, Tuolumne, and Merced rivers flow through extensive and biologically valuable grassland/vernal pool complexes located in eastern Stanislaus and Merced counties. Two important National Wildlife Refuges (NWR), Merced NWR and San Joaquin River NWR, are located in this zone. In addition to their overall ecological values, the Stanislaus, Tuolumne and Merced Rivers provide habitat for many fish, wildlife, and plant species. They are particularly important as spawning and rearing areas for Chinook salmon. Other at-risk species in the San Joaquin Region include riparian brush rabbit, San Joaquin Valley woodrat, Neotropical migratory birds, and western yellow-billed cuckoo. Important ecological processes for this area include: streamflow; stream meander; floodplain processes; coarse sediment supply including gravel recruitment, transport, and cleansing; and water temperature.

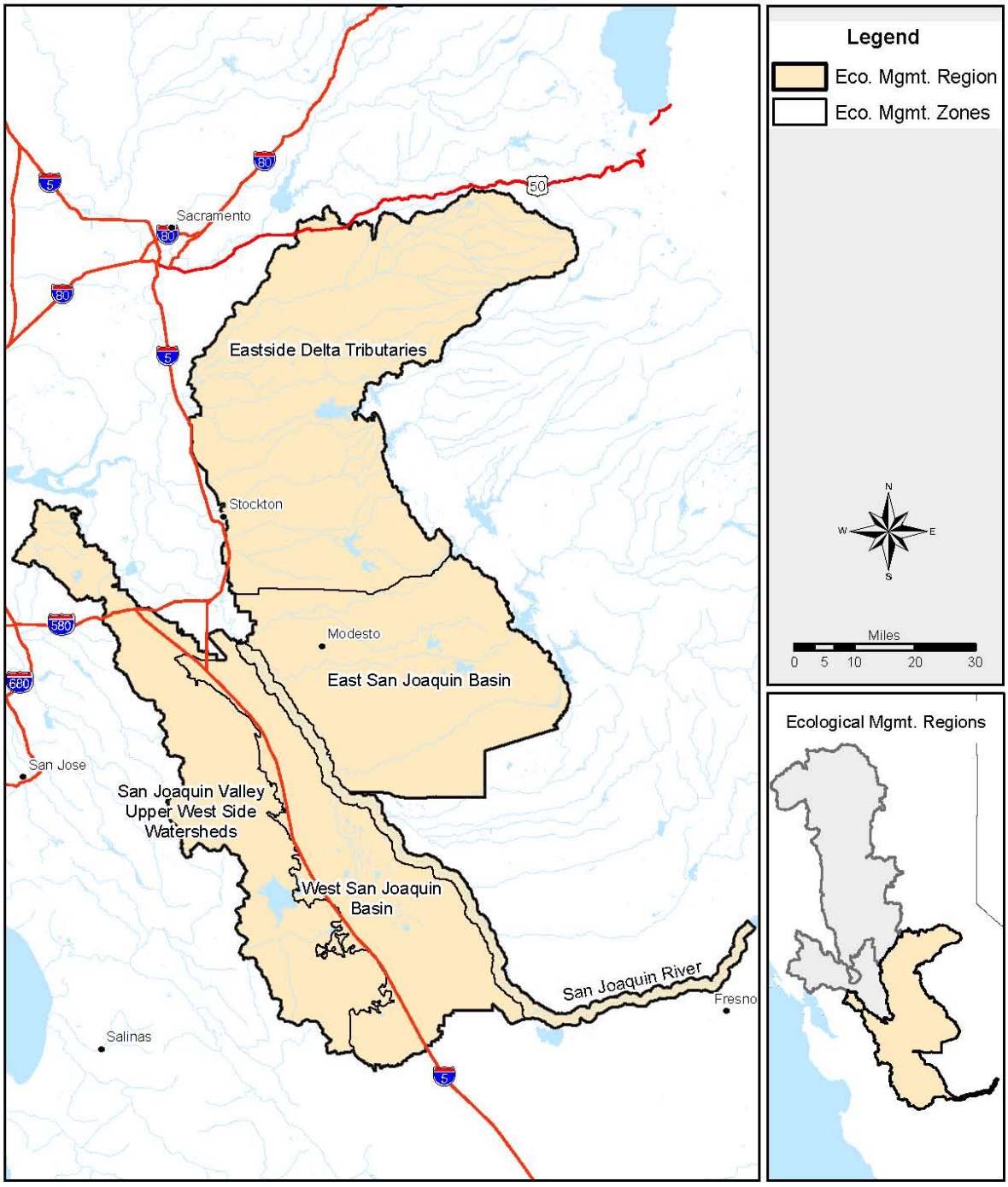

Figure 1. San Joaquin Ecological Management Region

CALFED BAY-DELTA PROGRAM

California Department of Fish and Game
Ecosystem Restoration Program

Figure 2.3.1. Map of San Joaquin Valley Region

The San Joaquin River and its tributaries are the second most significant contributors to flows of the Bay-Delta system. Much of the river's natural flow has been diverted and stream flow is discontinuous along the river, with significant sections being dry or extremely low during much of the year. The mid-portion of the river receives substantial inputs from the Sacramento River, acting as a conduit for water that is then diverted to Southern California. It is important to rehabilitate the ecological integrity of the San Joaquin River below Friant Dam to improve the health of the Bay-Delta system and particularly to improve conditions for the anadromous fish that annually migrate into and out of the Stanislaus, Tuolumne, and Merced rivers and potentially could utilize the upper mainstem.

Significant changes have been made in the hydrological conditions of the basin since agricultural development began in the 1850s. New Melones Dam, completed by the U.S. Army Corps of Engineers (Corps) in 1978 and approved for filling in 1981, is now the largest storage reservoir in the Stanislaus basin, with a gross capacity of 2.4 million acre-feet (af). The U.S. Bureau of Reclamation (Reclamation) operates the project as part of the federal Central Valley Project (CVP). Downstream of the New Melones Dam, Tulloch Reservoir, with a gross storage capacity of 68,400 af, regulates water releases from the New Melones Dam. Goodwin Dam, downstream, regulates releases from Tulloch Reservoir and diverts water for power and irrigation to South San Joaquin Irrigation District and Oakdale Irrigation District.

The Tuolumne River is the largest tributary in the San Joaquin River basin, with an average annual runoff of 1.95 million AF and a drainage area of approximately 1,900 square miles, including the northern half of Yosemite National Park. The lower Tuolumne River below La Grange Dam is divided into two geomorphic zones based largely on channel slope and bedload material (McBain & Trush 1998). The lowermost area, the sand-bedded zone, extends from the mouth upstream for 24 miles. The upper area, the gravel-bedded zone, extends from river miles 24 to 52.

On these three tributaries, stream-flow and available natural spawning habitat limits salmon production. Physical habitat for salmon spawning and rearing has been lost or degraded because of channel changes caused by many years of low-flow releases. These changes include siltation of spawning gravel; lack of spawning gravel recruitment below the reservoirs; removal of bankside riparian vegetation, thereby reducing stream shading and bank stability; and in-channel mining, which has removed spawning gravel, altered the migration corridor, and created excellent habitat for salmon predators.

Water quality is a significant concern in the main stem of the San Joaquin River, because flows can be low and because of agricultural drainage input with high salt and contaminant (primarily selenium) concentrations. Contamination and salinization are important issues in the San Joaquin Valley. They stem from a combination of irrigation, geology and high evaporation rates. Salt build-up will inevitably impact agricultural potential. Salinization can be alleviated by draining soils into buried perforated pipe,

collecting drain waters, and disposing of those contaminated waters. However, the waters draining from the saline soils are especially high in selenium. When drainage is halted, selenium can accumulate in the internal reservoir of ground water, which will eventually impact the quality of this resource. When drainage water is collected, its release can result in increasing selenium contamination of surface water resources, exceedance of water quality criteria, contamination of food webs, and possible effects on ecological integrity. No feasible engineering solutions have yet been demonstrated for treating irrigation drainage to remove selenium, at least at the scale necessary to alleviate the problem of waste disposal. A thorough, balanced, systematic program is needed to understand the irrigation drainage problem and potential solutions in the San Joaquin.

Summary of ERP Investment and Regional Highlights

Since 1995, the CALFED Ecosystem Restoration Program has funded 54 projects in the San Joaquin Region at a total cost of nearly $78 million (Table 1).

Table 1. San Joaquin River ERP Restoration Investment by Fund Source

Program Region	# of Projects[1/]	Sum Of Total Amount[1/] ($)	Fund Source
San Joaquin Valley	0		Clean Water Act, Section 104(b)(3)
	2	5,054,100.00	CUWA: Category III
	0		CVPIA: Anadromous Fish Restoration Program
	0		CVPIA: Habitat Restoration Program
	20.27	10,794,578.78	Federal Bay Delta Act Funds - (Water and related resources)
	2	7,177,428.00	Proposition 13: Dissolved Oxygen
	0		Proposition 13: Flood Protection Corridor Program
	11.73	24,471,245.51	Proposition 204: Category III
	13	28,900,494.61	Proposition 204: Chapter 7
	4	2,007,051.84	Proposition 50
	0		Proposition 84
	53	**78,404,898.74**	**All Funding Sources**

[1/] Does not include projects that are approved for funding but have not been executed.

San Joaquin Region ERP Stage 1 Accomplishments towards Regional Priorities

The ERP Strategic Plan (CALFED 2000a) included Draft Stage 1 actions for the San Joaquin River Habitat Corridor and San Joaquin River Basin. The actions describe the critical processes, habitats and species that will be addressed for key tributary watersheds; the rationale for the selection of actions to be implemented during Stage 1; actions already being implemented as part of CALFED Restoration Coordination Program, CVPIA, or other restoration programs; and uncertainties about ecosystem structure and function that can be answered by designing restoration actions to maximize their information value.

Following release of the Strategic Plan, the CALFED Ecosystem Restoration Program developed a Stage 1 Implementation Plan (Plan) in August 2001 (CALFED 2001). The Plan incorporated; 1) public involvement in setting restoration priorities; 2) local involvement in accomplishing restoration actions; 3) an emphasis on adaptive management and information richness in the design of restoration actions; 4) coordination with other CALFED Program elements; and 5) coordination with both public and private non-CALFED Program restoration efforts. This Plan included restoration and science priorities from a regional perspective, consistent with the CALFED Program's regional approach. Strategic Goals in the Plan were: 1) Goal 1 – At-Risk Species; 2) Goal 2 - Channel Dynamics and Sediment Transport; 3) Goal 3 - Harvestable Species; 4) Goal 4 - Habitats; 5) Goal 5 - Non-native Invasive Species; and, 6) Goal 6 - Water and Sediment Quality.

Table 2 and Figure 1 summarize the number of projects and expenditures that were actually implemented during Stage 1 by topic area. A summary of overall progress in meeting Plan priorities follows below. Additional detailed discussion of individual project activities can be found within the various Ecosystem Management Zone chapters.

Table 2. San Joaquin River ERP Restoration Investment by Topic Area

Topic Area	Number of Projects[1/]	Expenditures[1/] ($)	Percent of Total Expenditures[1/] (%)
At-Risk Species Assessment	2	5,715,944	7.3
Ecosystem Water and Sediment Quality	7	10,837,270	13.8
Environmental Education	4	128,383	0.2
Environmental Water Management	4	6,576,925	8.4
Fish Screens	2	814,700	1
Harvestable Species Assessment	2	424,863	0.5
Hydrodynamics, Sediment Transport, and Flow Regimes	9	13,282,565	16.9
Local Watershed Stewardship	4	1,985,207	2.5
Lowland Floodplains and Bypasses	4	4,830,428	6.2
Non-Native Invasive Species	1	652,030	0.8
Riparian Habitat	5	22,510,729	28.7
River Channel Restoration	8	10,385,852	13.3
Shallow Water and Marsh Habitat	1	260,000	0.3
Total Projects and Expenditures	**53**	**78,404,898**	**100**

[1/] Does not include projects that are approved for funding but have not been executed.

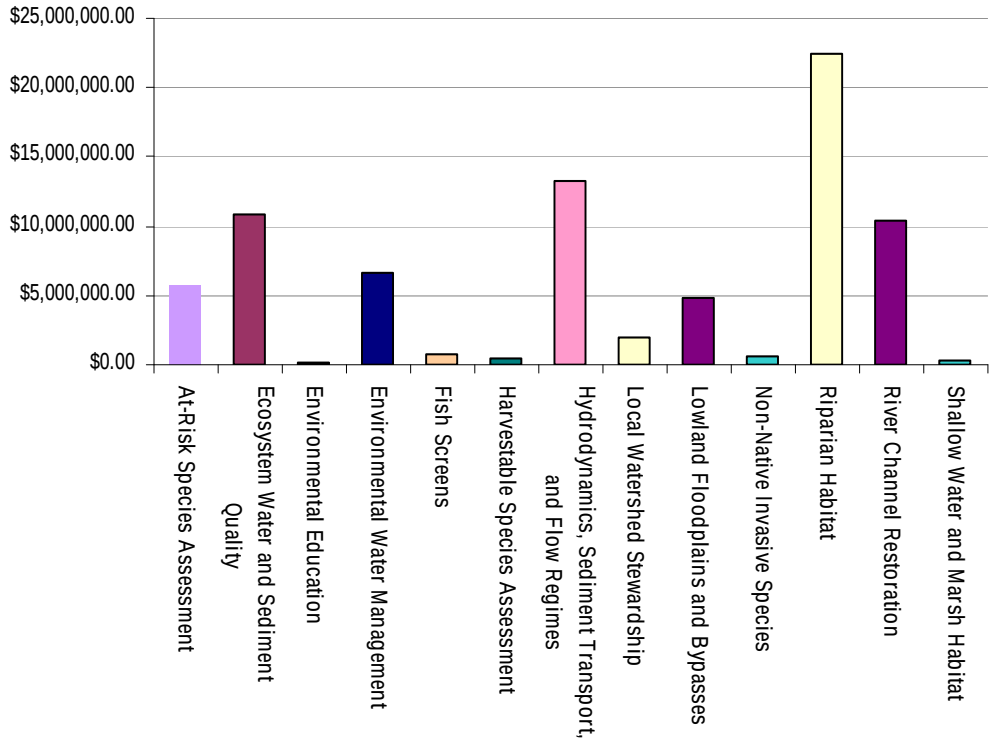

Figure 2.3.2. San Joaquin River ERP Restoration Investment by Topic Area

Priority 1. Continue habitat restoration actions including channel-floodplain reconstruction projects and habitat restoration studies in collaboration with local groups.

- *Channel-floodplain reconstruction projects.* Physical processes in the San Joaquin Region related to fluvial geomorphology and hydrology are still extremely important to restoration efforts here. Over the past several years, the CALFED Bay Delta Program Ecosystem Restoration Program, USFWS Anadromous Fish Restoration Program, have jointly contributed millions of dollars to the design and implementation of large-scale river channel and floodplain habitat restoration efforts in the San Joaquin basin. River restoration is still largely exploratory and it is important to learn as much as possible from every restoration project. The ERP and CALFED sought to maximize the information gained from these projects by incorporating adaptive management into project planning, design, implementation and monitoring.

  Channel floodplain reconstruction efforts in the Merced and Tuolumne rivers attempted to address similar issues; as the channel beds are infrequently mobilized; the channels lack habitat complexity, deep in-channel mining pits dominate the mining reaches, and floodplains have been mined or converted.

A strategy was initiated to develop publicly supported, technically sound, and implementable restoration plans to improve geomorphic and ecological function in two of the regional rivers (Tuolumne and Merced rivers) with another restoration plan under development (Stanislaus River). These plans were formed by evaluating the many biological and geomorphic watershed processes affecting river ecosystem health and salmonid habitat. There are differences in each river system, as well as similarities under diverse settings, which posed a challenge for study.

The Tuolumne River was identified in the Ecosystem Restoration Program Stage 1 Implementation Plan as a demonstration stream for the ERP. The FERC Settlement Agreement and Lower Tuolumne River Corridor Restoration Plan was a combined effort of two irrigation districts, state and federal agencies, and environmental groups. Implementation of the Settlement Agreement and Restoration Plan has continued this tradition, with all participants contributing to the restoration effort.

The Turlock and Modesto Irrigation Districts took the lead on large scale floodway restoration projects; California Department of Fish and Game has added spawning gravels and conducted biological monitoring on the river; the Friends of the Tuolumne acquired land from willing sellers and is conducting floodplain restoration and spawning gravel augmentation; the National Resource Conservation District purchased floodway easements on the lower Tuolumne River; and the Tuolumne River Preservation Trust and San Joaquin River National Wildlife Refuge coordinated land and conservation easement purchases on the lower river.

In 2001, Adaptive Management Forums were sponsored and conducted by UC Davis Center for the Environment to review the science behind the large scale restoration projects on the Merced and Tuolumne River restoration efforts. This process provided interconnected conceptual models depicting current understanding of the science and geomorphic functions in the river, the rivers' Chinook salmon population dynamics, effects of measures to improve geomorphic and ecosystem function, and the potential to increase Chinook salmon population abundance and resiliency.

Several channel-floodplain restoration projects and monitoring studies are progressing or were completed in the regional rivers. Channel-floodplain projects, scaled to contemporary flow conditions, were combined with planting native riparian vegetation on the reconstructed floodplain and maintaining coarse sediment supply to improve in-channel and floodplain geomorphic and riparian processes.

Close coordination among the restoration participants (grant managers, restoration program managers, and project applicants) could improve project management, save costs, and allow more efficient construction techniques.

The performance measures for the geomorphic components of a reconstruction project have been whether the constructed channel met design specifications. This is a necessary standard, but incomplete in terms of evaluating the overall effectiveness of these large-scale projects.

The Adaptive Management Forum pointed out that although individual projects are carefully thought through and planned, they are not designed and implemented with a tributary-scale, ecosystem perspective. Major projects, such as gravel augmentation, channel and floodplain re-construction in the gravel reach, and filling in gravel pits are not integrated into an overall assessment of their effect on meeting the primary objectives of the restoration plans such as the creation and maintenance of fall-run Chinook salmon habitat and self-sustaining, dynamic, native woody riparian corridors. Projects in the gravel-bedded upper sections or the river channel are not linked to projects downstream in the sand-bed reach or, at a larger scale, through the lower San Joaquin River to the Sacramento-San Joaquin Delta.

In addition, restructuring of channel and floodplain morphology and its evolution under the specified flow regime is not linked to any quantitative expectations for species recovery. Issues of perspective, scale, and project-level quantitative response are critical to establishing realistic expectations for individual projects and defining appropriate criteria of success or failure for the restoration effort in each of the regional rivers.

- *Gravel Augmentation Projects*. Regional gravel augmentation projects appear to be well designed and they are likely to meet the project objectives. Sediment plans help to quantify the volume of coarse sediment augmentation needed to maintain sediment supplies stored in the channel; assess the effects of coarse sediment management on the river channel form and geomorphic processes and anticipated biological response to changes in habitat conditions.

  Augmentation projects are now designed to benefit both Chinook salmon and steelhead. Both species require gravel for spawning, although of slightly different sizes. A range of material sizes would be added to the channel to ensure appropriate spawning habitat for both species.

  In the Tuolumne River, project proponents provided evidence that the amount of salmon spawning habitat (areas of gravel) has declined by over 70% from estimated historical levels, and 17% since 1988. Since the salmon and trout require gravel to spawn and this material is currently disappearing from the river,

addition of the material is a reasonable, maybe the only possible, method of ensuring continued availability of spawning habitat for the salmonid fishes of the system. The transport of sediment through the gravel-bedded reach should improve habitat conditions. However, an improved flow regime and hydrology would be necessary to adequately distribute gravels and provide the desired habitat improvements.

In the Stanislaus, instream spawning habitat was created using 25,000 tons of material in approximately 17 locations. This is the largest instream project ever conducted on the Stanislaus River and it is expected to provide additional spawning habitat, improved rearing habitat, and reduced predator habitat.

DWR staff are developing additional bedload transport models on completed restoration projects, to help predict how the restored channels will respond to future high flows. Transport models will be included in future projects, and some existing models are being considered for use.

An assessment of the restored spawning habitat in the Robinson Ranch Project indicated that number of Chinook salmon spawners has returned to the pre-1997 flood levels and that stream bed complexity (e.g. mounds of gravel dispersed over the gravel bed) is an important feature that determines spawner use. The Robinson Ranch egg survival study will verify the size of the gravels placed in the river and the survival of eggs in the restoration gravels as well as in nearby unrestored gravels. These results, along with similar studies in the Stanislaus and Tuolumne Rivers, will help determine the appropriate gravel sizes needed for future gravel augmentation projects.

- *Non-native Invasive Species*. The California Department of Food and Agriculture's (CDFA) purple loosestrife (*Lythrum salicaria*) program discovered an extensive infestation in the Tuolumne River. This infestation is a direct seed source threatening further expansion in the south Delta. Because of the success of the CDFA Purple Loosestrife Control Project, the department proposes to expand the program to "Implementation Full Scale" status. Because most infestations are small and scattered, and control efforts to date have been successful, a full scale project should be able to eliminate the infestations along the San Joaquin River and its tributaries within three years. Infestation will need to be monitored for regrowth for another three years after the last plant is detected. The Tuolumne River infestation is the biggest challenge and will require the most time and resources to eradicate. Treatments done to date have significantly reduced plant numbers/densities and, with more years of treatment, will continue to shrink populations and exhaust the seed bank. This project is needed to continue to build on the control, containment, and local eradication successes accomplished to date. Otherwise, purple loosestrife will start to spread again and the situation will revert to what it was in 1999.

- *Riparian and riverine aquatic habitat restoration and research*. The cumulative result of human activity in the region over the last century and a half has been the loss of about 90 percent of the area's historic riparian forests. Several acquisition projects preserved large parcels and restored new and remaining forested areas. These projects all benefit the adjacent riverine aquatic habitats as well as provide critical wildlife habitat for migratory songbirds, waterfowl, and these at risk species: bald eagle (*Haliaeetus leucocephalus*), bank swallow (*Riparia riparia*), Chinook salmon (*Oncorhynchus tshawytscha*), giant garter snake (*Thamnophis gigas*), least Bell's vireo (*Vireo bellii pusillus*), riparian brush rabbit (*Sylvilagus bachmani riparius*), steelhead (*Oncorhynchus mykiss*), Swainson's hawk (*Buteo swainsoni*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), willow flycatcher (*Empidonax traillii*) and a host of other species.

  The San Joaquin River NWR is located west of Modesto, California, within the historic floodplain of the confluences of the San Joaquin, Stanislaus, and Tuolumne Rivers. The original refuge land base of 1,638 acres has grown tremendously. Recent land acquisitions have increased the refuge size to 6,642 acres within an approved refuge boundary of 12,877 acres. This refuge played a key role in the recovery and March 2001 de-listing of the Aleutian Canada goose by providing critical habitat for the species. The refuge's land conservation effort and research led to the reintroduction and captive breeding program for the endangered riparian brush rabbit. Radiotelemetry monitoring showed that riparian brush rabbits have survived after being released on the Refuge, and that released rabbits are reproducing successfully.

  In addition to the riparian brush rabbit, a pair of least Bell's vireo (*Vireo bellii pusillus*) songbirds have nested two years in a row (2005 and 2006), in the three year old restored riparian understory. Their return was credited to the success of the riparian restoration. Promoting a dense herbaceous understory, resulting in virtually complete coverage, was highly successful in suppressing invasive weeds. Three thousand linear feet of levee side were planted to provide refugia in times of flooding for the endangered riparian brush rabbit. These restoration efforts incorporated a riparian planting design that will benefit riparian brush rabbit, Neotropical migrant birds, anadromous fish, and the Sacramento splittail, as well as providing native understory plant species that will aggressively prevent colonization by non-native plants.

  Funded research led to an ecological model that can be used to predict the effect of alternative restoration strategies and make it possible to optimize restoration

activities in terms of cost and ecological benefits, such as when and where seedling recruitment will be successful given certain assumptions about flow.

Priority 2. Restore geomorphic processes in stream and riparian corridors.

Success in restoring riparian communities depends on how well the physical processes that maintain dynamic stream channels are understood. A better scientific understanding of, for example, the relationships between fluvial processes and riparian regeneration, will improve the success of immediate and future restoration efforts.

- *Hydrologic and sediment transport models as restoration tools for the main stem San Joaquin River and its tributaries below Friant Dam.* Since Friant Dam became fully operational in the late 1940s, approximately 60 miles of the river have been dried up in most years, eliminating salmon above the river's confluence with the Merced River. A historic agreement to restore water flows for salmon in the San Joaquin River below Friant Dam near Fresno while undertaking one of the West's largest river restorations was announced in 2006. The Settlement Agreement is based on two goals and objectives: a restored river with continuous flows to the Sacramento-San Joaquin River Delta and naturally reproducing populations of Chinook salmon; and a water management program to minimize water supply impacts to San Joaquin River water users.

  Accomplishing these goals will require funding and constructing extensive channel and structural improvements in many areas of the river, including some that have been without flows (except for occasional flood releases) for decades.

- *Hydrologic and sediment transport models as restoration tools for the mainstem San Joaquin River and its tributaries below Friant Dam.* To evaluate hydrologic and sediment transport, bedload transport models are being developed on completed restoration projects by DWR staff which will help predict how the restored channels will respond to future high flows. Transport models will also be included in future projects.

- *Tributary Assessments.* Regional tributaries developed restoration plans and coarse and fine sediment management plans. Each of these plans conducted baseline assessment and restoration principles or attributes of alluvial river integrity were developed. Restoration plans were developed to improve geomorphic and ecological function in two of the regional rivers (Tuolumne and Merced rivers) with another restoration plan under development (Stanislaus River). These plans are formed using the baseline studies and evaluation of the many biological and geomorphic watershed processes affecting river ecosystem health and salmonid habitat.

- *San Joaquin Floodplain evaluation.* Restoration efforts along the San Joaquin River included constructing setback levees within the floodplain easements. This allows the natural floodwater to inundate these areas, improving floodplain conditions and returning the areas to a more natural setting. The project also restored natural riparian wetlands and targeted sediment reduction. By using wetland filtration, the project helps to retard runoff and reduce soils erosion and sedimentation into the San Joaquin River system.

  Land acquisitions along the lower San Joaquin River floodplains provided protection and enhancement of the flood protection corridor. The completed Grayson River Ranch project exemplifies the efforts put towards easement projects in the San Joaquin region. This particular project included: extensive habitat restoration, reconnecting the floodplain with the river by breaching an agricultural berm; creating a high–water slough accessible to fish for spawning and rearing; and planting native, riparian vegetation. A partnership among NRCS, ESRCD, FOTT, and the landowner, along with funding from CALFED, completed the 140–acre restoration project.

- *Biological Value of Floodplain Habitats.* The number of smolt-sized outmigrants from the Stanislaus and Tuolumne rivers is highly correlated with flow magnitude between February and mid-June (Mesick et al. 2007). These results suggest that adult recruitment is highly dependent on fry survival in the tributaries, and that fry survival in the tributaries is highest during prolonged periods of flooding. Prolonged flooding probably improves fry survival by providing autochthonous food resources; providing refuge from predators; reducing water temperatures, particularly during downstream migrations in May and June; slowing the rate of disease infestation; diluting contaminants; and reducing 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 become inundated on an annual basis. However, other benefits such as reduced water temperatures and contaminant dilution would probably only occur during high flows.

  The benefits to fish populations from floodplain inundation are thought to be linked to reduced predation rates, increased habitat availability, and food supply (Bennett and Moyle 1996). In January of 2007, the CVPIA USFWS Anadromous Fish Restoration Program office requested a study of floodplain inundation as a function of flow for the entire anadromous reach on the Tuolumne, Stanislaus, Merced, or the San Joaquin River using existing data. The study objective was twofold. First, the data would be used for analyses of the relationship between floodplain inundation and tributary smolt. Second, the estimated amount of available functional floodplain habitat would be used to estimate the amount of habitat to be restored to achieve the doubling goal for Chinook salmon. The lower Tuolumne River was chosen for this study, as appropriate GIS data from a

previous study was available for the reach between La Grange Dam at river mile (RM) 52 and just upstream of the Santa Fe Bridge, at RM 21.5, near the town of Empire. Snorkeling surveys suggest that most fall-run Chinook salmon and rainbow trout rear in this reach (TID and MID Annual Reports). Additional studies would evaluate whether flows and floodplain inundation affect the production of smolt-sized outmigrants relative to predation rates, as well as food resources and smoltification timing.

Priority 3. Improve rearing and spawning habitat and downstream fish passage on tributary streams and the mainstem San Joaquin River, particularly for Chinook salmon steelhead trout and splittail.

The San Joaquin River and its tributaries support the southernmost spawning populations of Chinook salmon in the Central Valley and have been the focus of restoration for decades. A variety of stressors detrimental to the survival of juvenile and adult fish have been identified in the San Joaquin River. A better understanding of these stressors, and actions to abate the problems, are needed.

- *Facilities improvements and fish passage programs.* Several fish screens were constructed in the Merced River. Channel floodplain reconstruction efforts improved fish passage in the Merced and Tuolumne rivers by increasing refugia and channel habitat complexity and reducing predation by isolating deep in-channel mining pits.

  The DWR Fish Passage Improvement Program collected data to identify and evaluate the potential to modify or remove structures that impede migration and spawning of anadromous fish species in waterways within the Central Valley and Bay Area of California. Currently, there are several old gravel pit ponds in the river channel of the lower Stanislaus River. The Fish Passage Improvement Program (FPIP) seeks to improve fish passage for downstream migrating juvenile salmon and steelhead, enhance rearing habitat for salmon and steelhead, and restore the natural riverine habitat at Oakdale Recreation Area.

- *Fish Screens*. The USBR completed their environmental documentation and signed a Finding of No Significant Impact and Final Environmental Assessment July 16, 2007 for the Patterson Fish Screen. When implemented this will screen the Patterson Irrigation District's intake diversion near Patterson allowing Chinook salmon, steelhead, and other native fish species to pass by the intake diversion without risk of entrainment.

Priority 4. Implement actions to improve understanding of at-risk species in the region.

- *Resource Assessment and Monitoring Programs and Salmonid-life History Studies.* Resource assessments and monitoring are recognized actions important to the CVPIA AFRP as well as the ERP. On the Stanislaus River accomplishments included the collection of both juvenile and adult passage data, initiation of a pilot project to coded-wire tag emigrating juvenile salmonids, and an evaluation of environmental variables effecting fish passage for a juvenile Chinook salmon rotary screw trap monitoring and outmigration study. This study evaluates the long-term benefits of habitat restoration actions.

  A portable Alaskan weir demonstrated it could provide exceptional data on the timing and magnitude of salmonid populations and has enumerated passage of both steelhead and spring-run Chinook, providing data where data has been more difficult to obtain.

  On the Merced River, a rotary screw trap monitored natural and hatchery juvenile Chinook salmon movement. The monitoring of juvenile outmigration provides some assessment of the effectiveness of restoration actions.

  Evidence collected to date strongly suggests that elevated winter and spring flow levels in the Tuolumne River, over longer durations, provide both seasonal, and cumulative (winter and spring flows combined) smolt out-migration production benefits. Tuolumne River smolt out-migration production abundance 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.

  The Stanislaus River Gravel augmentation project and egg survival research study provided information toward the best spawning gravel size composition.

- *Protect and better understand at risk species in the region and other at risk life-history studies*. The San Joaquin River NWR is playing a key role in riparian brush rabbit recovery efforts through the captive breeding program and by providing critical habitat for the species. Further research, through River Partners, designed plantings that provided optimal habitat for this species, as well as Neotropical migrant birds, anadromous fish, and the Sacramento splittail. The success of the riparian research, cultivation practices and weed suppression approach to successful restoration was credited with the return of riparian dependant species.

Priority 5. Develop understanding and technologies to reduce the impacts of irrigation drainage on the San Joaquin River and reduce transport of contaminant (selenium) loads carried by the San Joaquin to the Delta and the Bay

- *Dissolved Oxygen (DO).* The San Joaquin River Dissolved Oxygen Technical Working Group (TWG) provides a public forum for discussing and disseminating technical information generated by numerous funded studies focused on understanding and solving the low DO impairment in the Stockton Deep Water Ship Channel. The TWG serves to inform the stakeholders involved in the DO TMDL process, and to encourage collaboration between the various scientists and engineers involved in managing and executing the various studies. There are nearly two hundred scientists and stakeholders participating in the TWG meetings and message boards, many of whom have prepared technical materials in support of the DO TMDL process. Current studies include: Aeration Demonstration Project; Algal Dynamics - Nitrification Mechanisms; Biological and Ecological Effects of Dissolved Oxygen; Conceptual Model for Dissolved Oxygen in the San Joaquin River; Model of Dissolved Oxygen in the Stockton Deep Water Ship Channel; San Joaquin River Dissolved Oxygen Depletion Modeling; and Upstream DO TMDL Project.

- *Reduce the impacts of irrigation drainage on the San Joaquin River habitats and reduce transport of contamination (selenium) loads carried by the San Joaquin to the Delta and the Bay*. The CVPIA mandate to increase water supply reliability for refuges has reduced the concentration of salts and other contaminants, thereby improving the quality of water on the refuges, and the quality of water discharged from the refuges.

  In the western portion of the San Joaquin region, a selenium removal demonstration project showed how micro-algae could be used to reduce nitrate and selenium in agricultural runoff. Selenium removal rates in the pilot study were as high as 80 percent. The next phase is to be funded by the CALFED Drinking Water Program.

  In the western San Joaquin region agreements with water districts and wetland managers resulted in a salinity data network, management program, water quality model, and habitat assessment methodology. An important goal of the project was to optimize the wetland habitat while minimizing adverse effects on water quality of discharge from the wetlands. A wetland drainage monitoring system provided data for a model to forecast salt loading from wetlands into the San Joaquin River. Information on quality of water discharge enables water managers to adjust their operations on a day-to-day basis.

Another project completed watershed assessment in Panoche-Silver Creek Watershed and tested Best Management Practices to reduce loading of sediment, selenium, and other contaminants during high-flow events. The monitoring contributed toward an Action Plan and is being implemented for both drainages with some water quality improvement discernable in the early phase.

The Biological Agricultural Systems Cotton Program provided farmers with a means to reduce the use of pesticides and fertilizers and thus improve water quality. This voluntary community-based program showed great promise for reducing chemicals in agricultural runoff with resulting improvement in water quality of Westside tributary streams.

The demonstration projects completed during Stage 1 and described above, show conclusively that sediment and other contaminant discharges to Westside tributaries can be substantially reduced. These reductions in contaminants are not only technically feasible on a large scale; but are cost-effective as well, in that significant water quality improvement is possible at comparatively modest costs. These demonstrated technologies and practices have gained wide acceptance among local land managers and farmers in the West Basin, mostly as a result of the excellent educational outreach.

Priority 6. Conduct adaptive management experiments in regard to natural and modified flow regimes to promote ecosystem functions or otherwise support restoration actions.

Efforts to address natural and modified flow regimes to promote ecosystem functions and favorable biological responses are important in the San Joaquin Region. In particular, research is needed that augments and improves the scientific basis for flow-related actions and which improves our ability to effectively manipulate and supplement flows.

- *Mechanistic models as restoration tools*. CVPIA AFRP funded a 2-dimensional hydraulic and topographic model to help evaluate salmon spawning and rearing habitat benefits created by a large scale channel restoration project on the Merced River. The monitoring and modeling effort will document the benefits of the restoration activities on the Robinson Segment of the Merced River Habitat Enhancement project.

  Physical modeling experiments to guide river restoration projects and evaluate the implications of restoring dam-impacted rivers were conducted by Stillwater Sciences at the hydraulic modeling facilities at the University of California's Richmond Field Station. The primary goal of the project is to assist in the design of future gravel augmentation, dam removal, and channel-floodplain reconstruction projects by addressing two areas of inquiry in the field of fluvial

geomorphology. One is to develop a mechanistic understanding of river channel response to episodic delivery of bedload size sediments, as occurs in both gravel augmentation and dam removal projects; and the other is to establish quantitative relationships between equilibrium channel geometry and a range of discharges and sediment supply events, whether natural or regulated. This will provide a guide for designing and reconstructing "scaled-down" channels in restoration projects that aim to restore active fluvial geomorphic processes (e.g. bedload sediment transport, bar formation and migration, bank erosion and lateral channel migration) on regulated streams. Progress on both sets of questions would represent significant advances in geomorphic science as well as applied river restoration practice. The results of the experiments will also be used to calibrate and refine numerical models to serve as tools for designing and assessing river restoration actions

- *Instream flow program***.** Temperature field observations were used to develop a temperature model and apply it to the Stanislaus, Tuolumne, Merced, and San Joaquin Rivers. Geometric, flow, and meteorological data, as well as other information, was also required for temperature modeling. Through an extensive process of model testing and application, the models have been calibrated for a wide range of conditions. The project objective is to produce a basin-scale model capable of examining conditions over multiple tributaries (including main stem reservoir operations and management options for downstream river reaches).

- *Vernalis Flow Requirement.* The state's Bay-Delta water quality requirements include year-round flow objectives for the lower San Joaquin River at Vernalis, in addition to the 31-day spring pulse flow. These Vernalis flows are designed in part to protect the delta smelt, listed under the federal Endangered Species Act, by improving spawning habitat in the upper Delta and transporting larval delta smelt through the Delta into Suisun Bay. The Vernalis flows are also intended to protect migrating Chinook salmon in the spring and fall. The only facility that is required to release flows to meet the requirement is New Melones Reservoir on the Stanislaus River, which is operated by the USBR.

- *Environmental water acquisition***.** The Environmental Water Account (EWA) is a multi-objective program that prioritizes protection of listed species in the Bay-Delta estuary beyond the regulatory baseline through environmentally beneficial changes in SWP/CVP operations at no uncompensated cost to the project's water users. The EWA provides species protection and contributes to ESA regulatory commitments for State Water Project (SWP) and Central Valley Project (CVP) operations. The EWA has been primarily focused on the ERP's objective to reduce the adverse impacts of diversions at the state and federal pumps in the Delta. The EWA depends on the continuing availability of the regulatory baseline, as defined in the CALFED Record of Decision; 2) the availability of sufficient EWA assets to replace contract water deliveries affected by operational

Other Programs Contributing to ERP Vision

Central Valley Project Improvement Act (CVPIA)

Approximately $15 million of CVPIA restoration funds contributed to ERP goals for protecting, restoring, and enhancing special status species and their habitats, as they relate directly or indirectly to effects of the Central Valley Project. CVPIA provisions that contribute to ERP goals and objectives include restoration of anadromous and Delta native fish populations through instream flow enhancement, habitat rehabilitation, and fish passage solutions; improved refuge water supplies and farmland management to benefit wetlands and waterfowl; and incentives for other fish and wildlife conservation.

Several CVPIA provisions support the Anadromous Fish Restoration Program (AFRP) and its fish population doubling goals. For example, section 3406 (b)(2) of the CVPIA dedicates 800 thousand acre-feet of CVP yield for instream flow enhancement, including in the Stanislaus River, and to help maintain water regulatory standards in the Delta; and section 3406 (b)(3) provides for acquisition of additional water for these purposes. Section 3406 (b)(13) provides for improved anadromous fish spawning gravel and riparian habitat restoration projects on certain Central Valley streams, including the Stanislaus River. Section 3406 (b)(21) directs Reclamation and the Service to help the State of California install fish screens on major unscreened or inadequately screened water diversions that may be causing losses of juvenile salmon and other fish species, thereby affecting overall production. Although these programs generally support the AFRP, additional species or geographic areas may also benefit.

Many of these provisions are designed to support both anadromous and non-anadromous fish species. Provisions 3406 (b)(4) (Tracy Pumping Plant) and (b)(5) (Contra Costa Canal Pumping Plant) involve infrastructure and operational improvements, such as fish screening and recovery facilities that contribute to anadromous and non-anadromous fisheries restoration. In general, the non-anadromous fish addressed by the CVPIA fisheries program are located in the Delta. The provisions address structural changes in CVP facilities and mandate changes in water operations to support fisheries restoration through a combination of timed increases in flows; water banking, conservation, and transfers; modified operations; and new or improved control structures.

Section 3406(c)(1) of the CVPIA (CVPIA - San Joaquin River Fisheries) requires the Secretary of the Interior to ”develop a comprehensive plan to reestablish where

necessary and to sustain naturally reproducing anadromous fisheries from Friant Dam to its confluence with the San Francisco Bay/Sacramento-San Joaquin Delta Estuary." The restoration of this section of the San Joaquin River has been the focus of a long-term lawsuit that was recently settled. Because of the 18-year long litigation, no other specific goals were set by the CVPIA program for the San Joaquin River. Planning for the restoration of fisheries in the San Joaquin River between Friant Dam to the Mendota pool confluence with the San Francisco Bay is now independently coordinated by the San Joaquin River Restoration Program (SJRRP) and partially funded by the CVPIA Restoration Fund.

Most of the historic wetland areas in the Central Valley have been converted to other land uses over the past 150 years. Less than five percent of the more than 4 million acres of seasonal and permanent wetlands now remain. Almost 70 percent of the San Joaquin Valley lowlands, which supported permanent and seasonal marshes, lakes, and riparian areas, have been converted to irrigated agriculture, with wetland acreage reduced to 120,300 acres. The remaining wetlands in the Central Valley must be intensively managed to support waterfowl populations that depend on the Central Valley for wintering habitat. Section 3406(d) of the CVPIA (Refuge Water Supply) establishes the primary goal of providing water for wildlife refuges, and states that the Secretary shall provide, either directly or through contractual agreements with other appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on 19 refuges, including National Wildlife Refuge Systems in the Sacramento and San Joaquin Valleys, Central Valley state wildlife management areas, and the Grasslands Resource Conservation District.

The increase in water supply and reliability has created new wetlands and enhanced existing wetlands, resulting in increased populations of Federal and State listed species—particularly avian species—and other wildlife species such as the giant garter snake. Avian species that have benefited include the peregrine falcon, southern bald eagle, tri-colored blackbird and white-faced ibis. The increase in water supply and reliability for refuges also has reduced the concentration of salts and other contaminants, thereby improving the quality of water on, and discharged from, the refuges.

CVPIA - Terrestrial and Other Habitat Resources. USBR and the USFWS established three programs to restore terrestrial and other habitats: the Habitat Restoration Program (HRP), the Land Retirement Program (LRP), and the Trinity River Restoration Program (TRRP). These three programs implement actions that protect sensitive species, restore historic habitat types, and improve water quality in CVP watersheds.

The CVPIA Habitat Restoration Program (HRP) was developed under Section 3406(b)(1) of the CVPIA to address the needs of native fish and wildlife affected by the CVP that were not specifically addressed in other portions of the CVPIA. The HRP focuses on protecting native habitats that have been directly affected by construction and

operation activities of the CVP and that have also experienced or are experiencing the greatest decline in species that are federally listed, proposed, or candidate for listing under the endangered species act. Other considerations include state-listed species and non-listed state and federal species of special concern or other associated native wildlife species. To date, the HRP has funded nearly 90 new projects with a total budget of over $23 million dollars. Much of the focus, since 1992, has been on acquiring land either through fee title or conservation easement. Consequently, more than 100,000 acres of habitat has been protected through HRP funding including vernal pool, riparian, alkali scrub, foothill chaparral, valley-foothill hardwood, and grassland. The HRP has also funded 8 riparian restoration projects which have contributed to more than 1,000 restored acres. More than 30 studies/surveys have been funded, with projects including captive breeding and reintroduction; distribution and status surveys; genetics studies; assessment of relocation efforts; and grazing impacts studies. Furthermore, more than 10 management/planning/outreach actions have been funded. The program has also supported pilot programs that contribute to the long-term scientific understanding of restoration actions.

The CVPIA ROD committed to completing a 15,000 acre Land Retirement Demonstration Project (Project) at two sites in the San Joaquin Valley. To date the Land Retirement Program has acquired 9,203 acres at the two Project sites (an additional 1,228 acres on Prospect Island was purchased in 1995, before the Demonstration Project was initiated). The Project, in consultation with the Service in 1999, had specific performance criteria for monitoring the impacts of retired lands on biota (selenium contaminant levels) and physical parameters (groundwater level, water quality, and soil chemistry). The Land Retirement Program's restoration goal for retired agricultural lands is to demonstrate the creation of upland wildlife habitat (San Joaquin Valley alkali sink) and alkali scrub habitat characterized by salt-tolerant native shrub vegetation. Reports of the final five years of monitoring will be available in 2008.

Under Section 3408(h), the CVPIA - Land Retirement Program's two principal objectives are to decrease drainage problems in the San Joaquin Valley and to enhance wildlife habitat and the recovery of endangered species through the purchase of sensitive areas of land from willing sellers. The CVPIA authorizes Interior to acquire irrigated agricultural lands that are drainage-impaired and that receive CVP water. These lands are then retired from agricultural production. The CVPIA Land Retirement Program was established to implement this provision. The main goals of the CVPIA Land Retirement Program are to (1) improve water conservation by district, or improve the quality of an irrigation district's agricultural wastewater, and (2) reduce agricultural drainage and improve water quality in the San Joaquin River, and use retired lands to create additional wildlife habitat in the San Joaquin Valley.

Other Programs

In addition to the CVPIA, the following programs have also made significant contributions towards restoration within the San Joaquin Region:

- *Department of Water Resources and Department of Fish and Game: Delta State Water Project Pumping Plant Fish Protection Agreement (Four Pumps Agreement)*

- *Natural Resource Conservation Service* (NRCS) NRCS has been a partner in programs that have contributed to ecosystem restoration in San Joaquin County, Including working as a partner in Lower Cosumnes & Lower Mokelumne River Watershed to reduce non-point source pollution resulting from urban and residential land uses, and assisting with the Lower Mokelumne River Restoration Project to eradicate NIS species, reduce erosion and restore riparian vegetation.

- *Environmental Quality Incentive Program (EQIP) and Wetland Reserve Program (WRP).* EQIP incentive payments complement the objectives contained in the ERP, while focusing on farms. Approved projects will optimize environmental benefits while addressing natural resource concerns and are awarded based on criteria consistent with the goals of NRCS' Environmental Quality Incentive Program. The Wetland Reserve Program (WRP) also complements the objectives contained in the CALFED Ecosystem Restoration Program. The WRP objectives are to purchase conservation easements from willing sellers; restore and protect wetlands in agricultural settings; remove environmentally sensitive, marginal cropland from cultivation; assist landowners with restoration of wetland hydrology; and contribute to the national goal of no net loss of wetlands. Signups for both programs are held at local service centers located in the CALFED solution area. Applications are ranked using state wide ranking criteria. Approved projects optimize environmental benefits while addressing natural resource concerns and are awarded based on their state wide rank consistent with the goals of EQIP and WRP.

Changes Attributable to ERP

Most of the projects funded in the San Joaquin Region involved research, monitoring or pilot demonstrations. These activities provide the Region with an established baseline of scientific and technical data and tools which will serve as a guide for future implementation. State of the art analytical tools to evaluate salmonid migration patterns were developed and compliment existing monitoring efforts conducted by the state. Large scale channel-floodplain projects reconstructed channel and floodplain morphology to improve ecological processes. Spawning gravel augmentation and riffle projects have created additional spawning opportunities for salmonids. Water quality demonstration projects indicated that not only is it technically feasible to substantially

reduce sediment and other contaminant discharges on a larger scale in the Region, but water quality improvement is possible at comparatively modest costs.

Application of ERP Activities To Multi-Species Conservation Strategy (MSCS) Species

In the region, implementation projects supplied sediment to rivers and streams necessary to provide spawning gravels and rehabilitation of related ecological processes (e.g stream meander and floodplain habitat such as riparian habitats. Projects restored and preserved riverine aquatic habitats; sought to reduce adverse effects of non-native fish species; and provided conditions for growth of riparian vegetation and shaded riverine habitat along section of rivers. Land acquisitions protected and enhanced seasonal wetlands. Fish screens reduced adverse effects of diversions on fish. Habitat conditions were enhanced for the riparian brush rabbit in occupied habitat areas at and near Caswell State Park on the Stanislaus River, and three additional populations were established.

New Knowledge and Relationship to Original Goals, Objectives and Targets

Channel-floodplain Reconstruction Projects and Gravel Augmentation

Project-specific performance measures related to channel-floodplain reconstruction need to be expanded and linked with fish population monitoring at the broader scale to enable inference between physical habitat changes and any subsequent changes in fish abundance. Current data are insufficient to assess what effect habitat restoration may have had on the fish population. For example, the Merced River Salmon Enhancement Project (RM 40 – 44.5), which has been jointly funded by 4-Pumps and the AFRP, may have contributed to increased survival of salmon smolts (based on DFG studies with coded-wire-tagged hatchery fish). This project has three completed subprojects, which include the 1996 Magneson Predator Isolation Project, the 1998 Ratzlaff Predator Isolation Project, and the 2001 Robinson Ranch Channel Reconstruction Project. There is not adequate monitoring data for these projects to ascertain whether improved survival was due to the predator isolation projects, the channel reconstruction project, or both.

The lack of post-project data for these projects, and the resulting inability to assess restoration effectiveness, illustrates the importance of sufficient project monitoring. To increase scientific understanding of managed alluvial river systems, in general, or the effectiveness of specific design or management elements, in particular, are essential to improve restoration effectiveness through adaptive management. Well-designed monitoring and reporting plans are the only way to collect that information. The following experiments can provide important information for channel-floodplain projects:

- Low flow investigations – Influence of flow levels on Chinook salmon survival

- Riparian vegetation – Improve restoration success and understanding; evaluate as fish nursery habitat
- Predation Experiments – Isolated gravel pits, pre and post monitoring
- Spawning distribution – Level of problem; would improving spawning gravel reduce superimposition and egg loss
- Nursery Habitat – Costs and benefits to influence fry distribution

Flows and Channel/Gravel Restoration on the Tuolumne River

Population trend analyses based on escapement surveys and rotary screw trap sampling have been completed recently to evaluate the success of the early restoration projects and to evaluate potential limiting factors for adult production in the Tuolumne River. The preliminary results suggest that the number of smolt-sized Chinook salmon migrating from the river has not increased since 2002 in spite of several gravel augmentation projects near La Grange and two predator isolation projects at Special Run Pools 9 and 10. Instead, results show that the number of adult Tuolumne River salmon is highly correlated with the number of smolt-sized juveniles (> 70 mm fork length) that successfully out-migrated from the river in spring between 1998 and 2005; and spring flows in the Tuolumne River are highly correlated with both the abundance of smolt out-migrants and adult production. Conversely, neither the number of smolt out-migrants nor adult escapement is correlated with the number of fry produced in the Tuolumne River. This suggests that although the spawning habitat is highly degraded in the Tuolumne River, inadequate flows between February and mid-June and degraded rearing habitat in the Tuolumne River appear to be the primary limiting factors for the production of both smolt out-migrants and adult salmon.

A rigorous research program is needed to test key hypotheses regarding flow management and restoration priorities. As part of this research program, the effectiveness of new habitat restoration, focused on improving fry rearing habitat by increasing floodplain connectivity with the active channel and enhancing riparian forests, will be compared to the effectiveness of ongoing projects that have focused on adding and mobilizing gravel to enhance spawning habitat. Funding for a majority of this research program is expected to be provided by the ERP, City and County of San Francisco, and the Turlock and Modesto irrigation districts.

San Joaquin River Salmon Production as a Function of Spring Vernalis Flow

San Joaquin Basin salmon production continues to decline. Data seem to show that fish production cohorts improve with spring flows, therefore better protection measures are needed through flow management. The Vernalis Adaptive Management Program (VAMP) suggested a need for several successive high flow range tests to define/solidify the relationship of flow on Chinook production.

A model was developed to better link salmon production to flow magnitude and duration and to evaluate the current flow objectives in the Water Quality Plan. The model simulates salmon production over time and assumes that flow is the primary

driving factor for population numbers (not harvest, exports or adult stock density). When increased Vernalis flow magnitude, duration, and frequency were modeled, they all projected increased adult salmon production.

Effects of Managed Flow Fluctuations and Fish Flows

To determine why the salmon population failed to respond to a new flow schedule and habitat restoration projects, it will be necessary to more fully assess population trends, test the conceptual models used to select and design the restoration projects, and evaluate the effectiveness of the current flow management strategies. One of the Region's primary goals is to increase naturally occurring salmon populations and to improve escapement. Therefore, escapement and juvenile production should be key components of any monitoring program. However, escapement also is affected by Delta and ocean conditions, which somewhat confound the analyses assessing flow changes and restoration effectiveness (changes in escapement). A solution is to monitor juvenile production with calibrated screw traps as the primary means of assessing population trends relative to river actions. In order to study the effectiveness of restoration projects, how predator isolation projects directly affect predation rates and how gravel augmentation projects directly affect egg survival to emergence must be determined. The following four hypotheses about flow release strategies should be evaluated to determine the best use of the available water for fish flows:

- Periodically increasing flows between late-October and late-November, as needed, to extend the amount of spawning habitat with water temperatures below 52 degrees Fahrenheit would better distribute spawners and thereby reduce redd superimposition and improve juvenile production.

- Periodically increasing flows between April and September, as needed, to extend the amount of juvenile rearing habitat with water temperatures below 65 degrees Fahrenheit improves juvenile survival by improving growth rates and reducing the rates of disease and predation.

- In the absence of natural flood events, releasing sufficient flow to briefly inundate floodplain habitats between March and mid-June increases the amount of organic matter that enters the aquatic food chain and improves the survival of native riparian seedlings.

- Releasing pulse flows of 1,000 cfs during mid-October for 10 days significantly affects the ability of adult fall-run to migrate through the Delta and into the lower Tuolumne River.

Limiting Factor Analyses and Recommended Studies for Fall-Run Chinook Salmon and Rainbow Trout in the Tuolumne River

The survival of salmon smolts through the lower Tuolumne River and the Delta between early April and mid June is the most critical life history stage affecting adult recruitment.

A limiting factor report prepared by the AFRP, NMFS, and DFG provided evidence that there are two critical flow periods affecting adult recruitment: 1) winter flow affects the number of fry that survive to a smolt size in the Tuolumne River, and 2) spring flow affects the number of smolts that survive their migration through the Tuolumne River and the Delta. The report also supports the importance of winter flows for fry rearing and spring flows for smolt outmigration.

Salmon Population Prediction Model

The SJR fall-run Chinook salmon Population Prediction Model was developed by DFG in response to a request from the State Water Resources Control Board (SWRCB) to provide a recommendation for Vernalis flow objectives. Development of a quantitative model to assess the response of fall-run Chinook salmon production is a valuable step in the overall recovery strategy and management of the San Joaquin River water resources and fisheries. It has allowed assessment of several factors as they relate to potential impacts of increased flows on salmon and is one tool that may provide insight into long term flow recommendations.

Restoration Project Design

Projects are needed for increased streamflows, especially at critical times when juvenile salmonids are outmigrating. They should 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 critical 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, filling of instream dredger mining pits, and revegetation efforts.

During the next phase of restoration on the Merced River, juvenile habitat needs will be re-defined. That information will be applied to the design of the next phase of Merced River Salmon Habitat Enhancement Project, together with quantifiable objectives of project performance. AFRP staff developed a white paper documenting current research on the habitat needs of salmon fry, particularly with respect to floodplains. DWR staff is collecting papers and reports of current research and meeting with agency staff presently surveying nearby rivers for rearing habitat. USFWS Instream Flow staff completed a PHABSIM and 2-D modeling habitat study on the Robinson Reach, which 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.

Increase Rearing Habitat in Conjunction with Gravel Augmentation

Based on the documented decline in spawning habitat and the superimposition of redds, it would appear that gravel augmentation projects are one of the highest priorities for improving conditions for salmon and steelhead. However, there is be little quantitative information on the relative impact of various mortality factors for Chinook and steelhead in river systems. If an increase in the number of fry due to improved

spawning habitat is negated by stranding in the mining reaches, or predation in the gravel pits/special run pools, there will be little benefit from the coarse sediment transfusion until these other sources of mortality are addressed. Conversely, if there is insufficient spawning habitat in the system, any improvement in rearing habitat may be ineffective. Ultimately, a complete assessment of the factors controlling the productivity of the fish in freshwater will be required to accurately prioritize projects.

Monitoring as the Primary Vehicle for Learning and Putting Adaptive Management into Action

In most projects there is no description of how monitoring will coordinate with other projects within the same or other basin rivers. It may be difficult to attribute a measured change in condition to a specific project may be difficult, especially for biological responses. For example, how can any improvements in Chinook salmon performance be segregated among the various restoration projects planned for the river? If smolt output goes up is it due to the sediment augmentation, or the mining-reach restoration, or filling of "special-run-pools"? Will or can monitoring efforts be coordinated across all these projects? Without some careful coordination, interpretation of the observed changes in river condition will be difficult. The monitoring efforts for all restoration projects need to be coordinated in order to tease apart the specific responses to individual projects.

Chinook salmon and steelhead have a generation time of 3 to 7 years. For projects that propose to improve salmonids by increasing escapement, conclusions could not possibly be made until at least 3 or 4 years after project implementation. Any response in smolt output might take multiple generations to become apparent. The length of the monitoring effort should be appropriate for the factors being measured.

Provided there are no limiting variables such as inadequate flows or low DO, gravel augmentation projects appear to have a high probability of producing benefits. The biggest potential benefit is simply the improvement of habitat conditions for salmon and steelhead that may occur as a result of the coarse sediment transfusion. The Project Completion Reports could provide valuable information about the logistics involved in the engineering and construction phases of a project of this type and extent. The monitoring reports also have the potential to provide very valuable information, but monitoring reports produced for only two years following project implementation are not as useful, since many of the biological responses likely will not occur within that timeframe.

In order for monitoring products to be of value, a detailed plan should be produced as the conceptual models are developed. The plan should include details on any planned adaptive management experiments and how the effort will be coordinated with other restoration projects' monitoring and river-wide monitoring being conducted by CDFG. Given the fact that restoration projects will likely be replicated widely across the Central

Valley, the system response to the sediment transfusion and channel-floodplain should be thoroughly assessed.

Dissemination of Information

One of the most critical audiences for the information generated by restoration development, implementation, and monitoring is other restoration practitioners. Most project proposals make no mention of such a process nor do they indicate that other restoration teams are even considered a key audience for the products of this project. The Adaptive Management Forum suggested that a more formal process of communication be developed to ensure that information is shared among the various restoration efforts in the Central Valley.

Impediments to Implementation

Adequate Access for Monitoring

The scientific and economic value of projects, and the results of habitat restoration may not be fully known if adequate access is not available to continue effective monitoring on a more or less indefinite basis. Poor access can also substantially increase project costs for implementation and monitoring or limit the effectiveness of the placement of gravels and data collected by monitors.

Gravel Costs

For gravel augmentation projects, there is a competitive demand for material with other development activities like road and structure building resulting in higher project costs. Additionally, the material which is currently permitted for extraction near restoration projects is usually adjacent to the rivers which may lead to more channel failures and added future restoration costs. The funding agencies have suggested that alternative sources of material with a more beneficial reclamation potential should be researched.

Funding

The current system of limiting funding to relatively short terms greatly constrains the opportunity to design, implement and monitor large channel-floodplain projects properly. The Adaptive Management Forum suggested funding agencies to explore ways to ensure the necessary long term commitment of resources that will ensure success.

Status of Area Today

The San Joaquin Region has seen the greatest degree of hydrologic alteration in the Central Valley. All of its rivers are dammed, and most of the captured and stored water is diverted directly from the reservoirs for in-basin use - primarily agriculture. The basin's water resources are seriously over-allocated.

Flows in all of the rivers are insufficient to adequately support sustainable populations of Chinook salmon. Chinook salmon populations have declined and currently only provide 36% of the San Joaquin River basin population objectives. Individually, current salmon adult escapement abundance for the Stanislaus, Tuolumne, and Merced rivers, respectively, is only 39 percent, 26 percent, and 50 percent of targeted population goals. Salmon populations in these rivers are in poor condition. There are many factors, including water temperature levels and regimes that contribute to this status.

Several reaches of the mainstem San Joaquin River and all of the smaller tributaries run dry seasonally. Several hydroelectric licenses are coming up for renewal. The USBR initiated early review toward a New Melones Revised Plan of Operation. The State Water Resources Control Board triennial review is also underway with the resource agencies participating and examining the continual decline in salmonids, flows, temperatures, and conservation solutions. DFG submitted a proposal to the Central Valley Regional Water Quality Control Board to consider placing the above rivers on the Clean Water Act Section 303(d) list of impaired waters because temperature and water quality standards are not met.

Elevated water temperatures appear to be a significant factor in the continued decline in adult salmon escapement abundance in the San Joaquin, Stanislaus, Tuolumne, and Merced rivers by: 1) inducing adult mortality as adults migrate into the San Joaquin River and tributaries to spawn (i.e. pre-spawn mortality); 2) reducing viability of eggs deposited in stream gravels, 3) increasing stress levels and therefore reducing survival of juveniles within the tributary nursery habitats, and/or 4) reducing salmon smolt out-migration survival as smolts leave the nursery habitats within tributaries to migrate down the San Joaquin River to Vernalis and through the south Delta. For rainbow trout, potentially including anadromous steelhead, excessively warm water temperatures have the potential to limit trout population abundance by restricting suitable habitat for juveniles and adults to very short stream reaches. Too few miles of suitable habitat may exist to sustain healthy population levels. Temperature and salmonid production models are new tools being evaluated.

Future Vision

Priority 1. Develop and Implement habitat restoration actions including channel-floodplain reconstruction projects and habitat restoration studies in collaboration with local groups.

- *Channel-floodplain reconstruction projects.* Physical processes in the San Joaquin Region related to fluvial geomorphology and hydrology are extremely important in restoration efforts in this region.

  Individual projects need to be designed and implemented from both a tributary-scale and ecosystem perspective. Proposed channel-floodplain reconstruction

projects should clearly articulate a conceptual model explaining how the projects will restore ecosystem function within the context of the regulated flow regime, existing habitat, sediment routing, and companion restoration strategies, such as gravel augmentation.

Major projects, such as gravel augmentation, channel and floodplain re-construction in the gravel reach, and filling in gravel pits, should provide an overall assessment of the project's effect on the primary objectives of the restoration plans. These include the creation and maintenance of fall-run Chinook salmon habitat; riparian improvement; and a self-sustaining, dynamic, native woody riparian corridor.

Projects need to have a strong commitment to evaluating the outcome of the restoration built in. Monitoring is the primary vehicle for learning and putting adaptive management into action. Additional information could be obtained through experiments that address:

- influence of low flow levels on Chinook salmon survival
- success and understanding of riparian habitat restoration
- effects of predation associated with isolated gravel pits, including pre- and post-project monitoring
- magnitude of spawning distribution problems and effectiveness of improving spawning gravel quality to reduce superimposition or redds and egg loss
- costs and benefits of manipulating nursery habitat to influence fry distribution
- value of riparian vegetation as fish nursery habitat

(Strategic Goal 1, At risk Species; Strategic Goal 2, Channel Dynamics and Sediment Transport; and Strategic Goal 4, Riparian Habitat).

- *Gravel augmentation projects.* Projects are needed to replenish spawning gravel and maintain gravel recruitment in all regional rivers. Carefully planned gravel augmentation projects appear to have a high probability of producing benefits. The biggest potential benefit is simply the change in habitat conditions for salmon and steelhead that may occur as a result of the coarse sediment transfusion. Monitoring the movement of replenished gravels is necessary, as is developing and implementing techniques to assess fish use of replenished gravel. Monitoring reports produced for only two years following project implementation are not that valuable, because many of the effects of the project are unlikely to occur within that timeframe, especially any biological responses.

  Results of the CALFED-funded physical modeling experiment, *Physical Modeling Experiments to Guide River Restoration Projects* (**ERP-02D-P55**), conducted by

Stillwater Sciences at the hydraulic modeling facilities at the University of California's Richmond Field Station to guide river restoration projects and implications for restoring dam-impacted rivers need to be used.

The increased cost of gravel is resulting in higher project costs. Securing a long term source of gravel is needed. Secured gravel sources should be used to develop actions/projects that afford the ability to process and utilize gravel for restoration purposes. (Strategic Goal 2, Channel Dynamics and Sediment Transport) .

- *Non-native invasive species.* Projects are needed to implement an eradication program for purple loosestrife (*Lythrum salicaria*) along the Tuolumne River. Continued funding of treatments done to date, which have significantly reduced plant numbers/densities, will continue to shrink populations and exhaust the seed bank. With additional funding, purple loosestrife can be prevented from taking over California's Bay-Delta waterways, thereby likely avoiding the establishment and integration of purple loosestrife into the natural environment, as has happened in the northeastern United States.

- *Riparian and riverine aquatic habitat restoration and research.* Efforts should be designed to provide multiple ecosystem benefits, including habitat for at-risk species, such as riparian brush rabbit, riparian woodrat, and migratory songbirds in the riparian zone. New research should be implemented that leads to an ecological model that can be used to predict effect of alternative restoration strategies, making it possible to optimize restoration activities in terms of cost and ecological benefits. This model should have a predictive ability about when and where seedling recruitment will be successful given certain assumptions about flow. (Strategic Goal 1, At risk Species and Strategic Goal 4, Riparian Habitat).

Priority 2. Restore geomorphic processes in stream and riparian corridors

Success in restoring riparian communities will depend on how well the physical processes that maintain dynamic stream channels are understood and utilized. Implement new knowledge gained during Stage 1 projects evaluating the physical processes to maintain dynamic stream channels and the basis for potential restoration actions.

- *Hydrologic and sediment transport models as restoration tools for the main stem San Joaquin River and its tributaries below Friant Dam*. In 2006, a historic agreement was announced to restore water flows for salmon in the San Joaquin River below Friant Dam near Fresno. The USBR, USFWS, and DFG have implemented several studies on the San Joaquin River to provide information to support the San Joaquin River Restoration Program (SJRRP) which is now

The lower San Joaquin River is integral to the success of restoration efforts in the upper San Joaquin River. Beside the obvious hydrologic connectivity, the two river sections also share flood control system components, similar urban and agricultural land uses, and water quality issues. Solving many of the downstream issues could have multiple benefits for different interests. For example, existing water quality conditions in the lower San Joaquin River may pose a critical constraint to the restoration of anadromous salmonids in the upper San Joaquin River. Providing increased flows to the San Joaquin River may allow improvements to water quality and result in benefits that extend well beyond anadromous salmonid survival.

- *San Joaquin Floodplain evaluation*. Restoration efforts along the San Joaquin River should continue, including constructing setback levees within the floodplain easements in order to allow natural floodwater to inundate these areas, improving floodplain conditions and returning the area to a more natural setting. Coordinate with the CALFED Levee Program to implement levee setbacks along the San Joaquin River. Seek out land acquisitions along the lower San Joaquin River floodplains to provide protection and enhancement of the flood protection corridor.

- *Biological Value of Floodplain Habitats*. Specific studies are needed to provide additional information and better understanding of the role of natural and managed floodplains in the food web and the survival and growth of young fish. Floodplain inundation is surmised to be linked with reduced predation rates, increased habitat availability, and better food supply for fish populations (Bennett and Moyle 1996). Potential benefits that could be provided by restoring highly productive floodplains that become inundated on an annual basis, such as increased food resources and refuge from predators, should be evaluated. Other benefits, such as reduced water temperatures and contaminant dilution that would probably occur during high flows, should be looked at.

Priority 3. Improve rearing and spawning habitat and downstream fish passage on tributary streams and the main stem San Joaquin River, particularly for Chinook salmon, steelhead trout, and Sacramento splittail.

The San Joaquin River and its tributaries are the southernmost spawning populations of Chinook salmon in the Central Valley and have been the focus of restoration for decades. A variety of stressors have been identified in the San Joaquin that are detrimental to the survival of juvenile and adult fish. Efforts to improve our understanding of these stressors and actions to abate the problems are needed.

- *Facilities improvements and fish passage programs*. Projects should improve fish passage by improving existing facilities or constructing new fish passage and protection facilities, repairing weirs, and removing physical barriers to upstream and downstream migration. (Strategic Goal 1, At Risk Species Assessments).

- *Fish Screens.* Ongoing fish screen construction projects currently funded by ERP, CVPIA, or others, should be completed and supported.

- *Evaluate Biological Performance.* Project level biological performance measures are generally aspects of physical habitat (flow velocity, temperature, etc.), and the assessment of habitat conditions are used to infer biological response. There should be specific biological measurements taken at the reach scale that would enable project-level biological responses to be associated with fish monitoring being done on the broader scale.

Priority 4. Implement actions to improve understanding of at-risk species in the region.

Additional actions and information are needed for numerous at-risk species in the region.

- *Resource Assessment and Monitoring Programs and Salmonid-life History Studies.* Adult anadromous salmonid returns to each watershed should be monitored using existing, expanded, and new monitoring programs. Efforts are also needed to standardize monitoring techniques, data compilation and analysis, and reporting among researchers and watersheds. Water quality stressors of salmonids and other aquatic life need to be evaluated; as well as the benefits achieved from habitat restoration actions. Ecological models should be developed to predict the effects of alternative restoration strategies, in order to optimize the cost and ecological benefits of restoration activities.

- *Protect and better understand at risk species in the region.* Preserve grassland, alkali sink, and alkali scrub habitat in the Central Valley, especially in the Tulare Basin, to protect and restore habitat and habitat linkages for San Joaquin kit fox

- *Other at-risk species life history studies.* Continue recovery efforts, preserve existing habitat, and restore additional habitat to benefit riparian brush rabbit, riparian wood rat, valley elderberry longhorn beetle, giant garter snake, and vernal pool species. Study the threat to these species as well as their distribution, abundance, and potential opportunities for restoration.

Priority 5. Develop understanding and technologies to reduce the impacts of irrigation drainage on the San Joaquin River and reduce transport of contaminant (selenium) loads carried by the San Joaquin to the Delta and Bay.

- *Dissolved Oxygen (DO).* The CALFED ROD specifically identifies the issue of improving DO conditions in the San Joaquin River near Stockton. Additionally, the Safe Drinking Water, Clean Water, Watershed Protection, and Flood Protection Act of 1999 (Proposition 13) authorizes CALFED to fund construction of facilities to control waste discharges that contribute to low DO in the lower San Joaquin River and the south Delta. An important contributing factor to DO deficits at the Stockton Deep Water Ship Channel could be the production of oxygen consuming substances. These include carbonaceous and nitrogenous biological oxygen demand (BOD), algae, and algal nutrients that develop into algae as they are transported from their source to the San Joaquin Deep Water Ship Channel. Management techniques need to be developed, and assessment their efficacy and cost-effectiveness assessed, for the reduction and control of oxygen demanding substances in the San Joaquin River Deep Water Ship Channel.

- *Reduce the impacts of irrigation drainage on San Joaquin River habitats and reduce transport of contamination (selenium) loads carried by the San Joaquin River to the Delta and Bay.* Although selenium contamination is well known in San Francisco Bay, and studies of selenium in the Delta are beginning, there have only been scattered studies of the selenium problem at its source. A program of study in the San Joaquin River, itself, is needed. This work should be conducted in collaboration with, and as a complement to, the studies and monitoring of the Bureau of Reclamation and the Fish and Wildlife Service. Specific tasks needed are:

    - Collect data and develop mass balance models at appropriate time and spatial scales to understand and monitor inputs from all sources of selenium, and the fate of selenium in the San Joaquin River.

- Determine selenium dynamics and concentrations on suspended particulates, since this is a primary source of bioavailable selenium.
- Determine biogeochemical transformation of selenium in the river, sloughs and wetlands both near and far from the drainage inputs.
- Conduct field studies to collect information for conceptual models of ecosystem processes, stressors and food webs of the river, sloughs and wetlands.
- Develop bioindicator performance measures, and begin long-term monitoring to track the progress of selenium clean-up in the river.
- Describe and develop models of selenium dynamics within species and within the food webs.
- Develop technologies for removing selenium from drainage and strategies for employing such technologies so that significant improvements in releases to the ecosystems can be made.

(Strategic Goal 6, water and sediment quality)

- *Pesticides and other contaminants.* High genetic damage, possibly from pesticides, has been reported in the California sucker in the San Joaquin River (Anderson, 2000). Better understanding is needed of dynamics, inputs, fate and biological effects of pesticide and other contaminant in the system (Strategic Goal 6, water and sediment quality).

- *New technologies to prevent pollutant inputs.* Develop research and pilot/demonstration projects to test and evaluate new solutions and/or BMPs to reduce "pollutant" (especially oxygen-depleting substances, pesticides, selenium, fine sediment, and nutrients) discharges from agricultural lands (Strategic Goal 6, water and sediment quality).

- *Real-time Monitoring.* Expand the San Joaquin River water quality real-time monitoring program.

- *Improved and expand other Water Quality monitoring programs.* Better assessment of the type and toxicity of contaminants coming into Delta waters is essential to safeguard public health; develop a baseline for ecosystem conditions; and track changes in the amount and types of pollutants entering the Delta, including those not currently regulated by the state and federal governments.

Priority 6. Conduct adaptive management experiments with natural and modified flow regimes to promote ecosystem functions or otherwise support restoration actions.

Natural and modified flow regimes in the San Joaquin River basin need to be addressed in order to promote ecosystem functions and favorable biological responses. In particular, research is needed that augment or improve the scientific basis for flow-related actions and which improve our ability to effectively manipulate and supplement flows.

- *Mechanistic models as restoration tools*. Projects are needed to develop methods, including a combination of simulation models and physical measurements, to evaluate flow, sediment transport and other fluvial processes. Models could help in the development of ecologically based plans by improving our understanding of ecological processes. This would aid restoration of conditions in rivers, sloughs, and floodplains (including bypasses) that could support restoration targets for Chinook salmon, steelhead, sturgeon, and splittail (Strategic Goal 2, natural flow regimes).

- *Instream flow programs.* Instream flow studies are needed 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. In particular, flow recommendations should be developed and tested for San Joaquin fall-run Chinook salmon in the regional tributaries. (Strategic Goal 2, natural flow regimes).

- *Streamflow management plans.* Projects should design and implement ecologically-based streamflow and temperature management plans, including geomorphic and biological criteria for water acquisitions on the San Joaquin, Stanislaus, Merced, and Tuolumne Rivers (Strategic Goal 2, natural flow regimes).

- *Effects of managed flow fluctuations.* The effects of managed flow fluctuations on ecosystem processes and habitat conditions need to be evaluated, especially the effects of flow fluctuations on anadromous fish habitat below dams. It is critical that the monitoring program, during the remaining years of hydroelectric license, focus on the key factors which are the likeliest to recover significant fall-run Chinook salmon and rainbow trout production that has been lost due to project operations (Strategic Goal 2, natural flow regimes).

- *Environmental water acquisitions.* Projects should develop ecological and hydrodynamic modeling tools and conceptual models that describe ecological attributes, processes, habitats, and the relationships between outflow and fish population. Ecological and biological criteria should then be developed for water

Priority 7. Develop Models to support restoration of river, stream, and riparian habitat, and improve scientific understanding of the ecosystem.

To develop a regional measure of restoration success, more monitoring and a better understanding of historical data are needed, as well as greater knowledge of basic processes, populations and communities, stressors, and ecological implications of restoration actions.

- *Compare conceptual models and develop restoration performance measures for tributary streams and rivers.* An important need exists for systematic knowledge of restoration activities and accomplishments across Stanislaus, Tuolumne and Merced rivers. An important initial need is to develop integrated interdisciplinary conceptual models describing the existing and restored ecosystems in each of these streams (including fish communities, benthic and water column communities, and stream usage by key species and groups of species). These models should include the processes that support the communities and related ecosystem functions in each (e.g. flow, temperature, sediment transport, channel morphology, distribution and quality of in-channel and floodplain habitat, biological interactions, chemical quality, and human disturbance and management of these process). Conceptual models of salmonid stressors and their effects on rivers are also needed.

- *Development of ecosystem and water system operations models.* Section 3406 (g) of the CVPIA provides for the development of ecosystem and water system operations models. The models produce data that are broadly available and readily usable to evaluate existing and alternative water management strategies, and to improve the scientific understanding of the ecosystem. The CVPIA does not propose any specific goals, but suggests the need to develop models in nine topical areas related to potential ecologic and hydrologic effects of water management alternatives in the Sacramento, San Joaquin, and Trinity River watersheds. The following analyses are needed:

    - Comprehensive water budget of surface and groundwater supplies, considering all sources of inflow and outflow available over extended periods of time.
    - Water quality conditions and improvement alternatives, including better temperature prediction capabilities related to water storage.
    - Surface-ground and stream-wetland interactions.
    - Measures needed to restore anadromous fisheries to optimum and sustainable levels that can be supported by the restored carrying capacities of Central Valley rivers, streams, and riparian habitats.

- Development and use of base flows and channel maintenance flows to protect and restore natural channel and riparian habitat values.
- Operational regimes at State and Federal facilities that will increase springtime flow releases, retain additional floodwaters, and assist in restoring both upriver and downriver riparian habitats.
- Measures designed to reach sustainable levels of resident and anadromous fish harvest, including the development and use of tradeable harvest rights systems.
- Opportunities to protect and restore wetland and upland habitats throughout the Central Valley.
- Measures to enhance the firm yield of existing Central Valley Project facilities, including improved management and operations, conjunctive use opportunities, development of off-stream storage, levee setbacks, and riparian restoration.

Future Ecological Risks

Continued ecological degradation of the San Joaquin River and its drainages could lead to the extirpation of anadromous fish throughout the entire basin. Increasing water temperatures and decreasing levels of dissolved oxygen lead to expansion of invasive and non-native species populations, which further degrades the health of the system.

Several of the major streams in the San Joaquin Valley Region are being evaluated to determine if they qualify for an "impaired" status by the Regional Water Quality Control Board. Several water quality parameters, including water temperature, salinity, and dissolved oxygen, are of particular concern, due to their direct and potentially lethal effects on juvenile salmon and steelhead migrating through the Delta, as well as other native fish species. If water quality in the lower San Joaquin River and Delta does not substantially improve, impaired water quality conditions will continue to constrain juvenile and adult anadromous salmonid migrations.

Future Institutional Barriers

Removing institutional barriers to water markets would significantly improve options and opportunities to restore the San Joaquin Regional ecosystem. Transfers are more difficult in California than in other jurisdictions due to a number of unique circumstances. The developed water system in California is dominated by two large public projects; CVP and SWP. The water stored by these projects is distributed largely though local water district contractors. Surface applications of this project water constitute the largest source of groundwater recharge in many parts of the project service areas and, in California, this groundwater comprises a larger fraction of irrigator supply than in any other western reclamation state. Water transfers often require

approval at three levels: the local district, the Bureau of Reclamation or the Department of Water Resources, and the State Water Resources Control Board.

Key reforms necessary to facilitate water transfers include creating incentives for water and irrigation districts to facilitate water transfers.

References

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2. REGIONAL OVERVIEWS

2.4. Multi-Region Project Overview

Program-wide Description

Many of the projects selected for funding through the ERP encompassed more than one region or ecological management zone. Some projects apply to all the regions while others were linked to at least two areas. This section covers those broad activities that span a larger ERP geographic scope. For example, studies and education programs often have results that apply to multiple EMZs or regions. Actions that are specific to a region or ecological management zone are covered in the regional/EMZ sections.

Summary of ERP Investment and Program-wide Highlights

A total of 118 projects were assigned to this category with a total expenditure of nearly $98 million (Table 1). ERP project implementation was supported by numerous sources of funding including state and federal funds and water agency funding.

Table 1. Program-wide ERP Investment by Fund Source

Program Region	Number of Projects[1/]	Sum Of Total Amount ($)[1/]	Fund Source
Program-wide	1	287,353	Clean Water Act, Section 104(b)(3)
	4	2,205,086	CUWA: Category III
	1	105,466	CVPIA: Anadromous Fish Restoration Program
	23	12,513,680	Federal Bay Delta Act Funds - (water and related resources)
	3	1,460,121	Proposition 13: Mine Remediation
	21	11,256,392	Proposition 204: Category III
	48.8	46,544,409	Proposition 204: Chapter 7
	16.1	22,189,967	Proposition 50
	0.1	1,252,295	Proposition 84
	118	**97,814,770**	**All Funding Sources**

[1/] Does not include projects that are approved for funding but have not been executed.

Program-wide projects fell into 15 topical subjects and 2 administrative support functions (Table 2 and Figure 1). The latter 2 projects provided administrative, program, and technical support for the ERP.

The topic areas (excluding administrative support projects), ranked by number of projects, included:

- Non-Native Invasive Species (21 projects)
- Ecosystem Water and Sediment Quality (20 projects)
- Environmental Education (18 projects)
- At-Risk Species Assessment (13 projects)
- Harvestable Species Assessment (6 projects)
- Local Watershed Stewardship (5 projects)
- Hydrodynamics, Sediment Transport, and Flow Regimes (4 projects)
- Environmental Water Management (2 projects)
- Estuary Foodweb Productivity (2 projects)
- Mine Remediation (2 projects)
- Shallow Water and Marsh Habitat (2 projects)
- Fish Screens (2 projects)
- Lowland Floodplains and Bypasses (1 project)
- Riparian Habitat (1 project)
- X2 Relationships (Freshwater-Seawater Interface) (1 project)

Table 2. Program-wide ERP Investment by Topic Area

Topic Area	Expenditures ($)[1/]	Number of Projects[1/]	Percent of Total Expenditures (%)
Administrative or Program Support	20,998,330	16	21.47
At-Risk Species Assessment	8,497,194	13	8.69
Ecosystem Water and Sediment Quality	30,651,645	20	31.34
Environmental Education	5,628,474	18	5.75
Environmental Water Management	704,828	2	0.72
Estuary Foodweb Productivity	1,239,240	2	1.27
Fish Screens	1,118,750	2	1.14
Harvestable Species Assessment	8,379,731	6	8.57
Hydrodynamics, Sediment Transport, and Flow Regimes	5,355,134	4	5.47
Local Watershed Stewardship	2,291,394	5	2.34
Lowland Floodplains and Bypasses	947,226	1	0.97
Mine Remediation	247,000	2	0.25
Non-Native Invasive Species	7,963,007	21	8.14
Riparian Habitat	356,876	1	0.36
Shallow Water and Marsh Habitat	2,416,605	2	2.47
Technical Support	510,115	2	0.52
X2 Relationships (Freshwater-Seawater Interface)	509,222	1	0.52
Totals	**97,814,771**	**118**	**100.00**

[1/] Does not include projects that are approved for funding but have not been executed.

Other Programs Contributions to ERP Vision

Virtually every State or federal resource agency and numerous environmental organizations have supported the implementation of the ERP. Key agencies include the California Department of Fish and Game, Wildlife Conservation Board, California Department of Conservation, California Department of Water Resources, Regional Water Quality Control Boards, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, National Marine Fisheries Service, U.S. Geological Survey, Natural Resources Conservation Service, and the Sacramento River Conservation Area Forum.

Other contributors include the Nature Conservancy, Central Valley Habitat Joint Venture, San Francisco Estuary Project, Ducks Unlimited, and California Waterfowl Association.

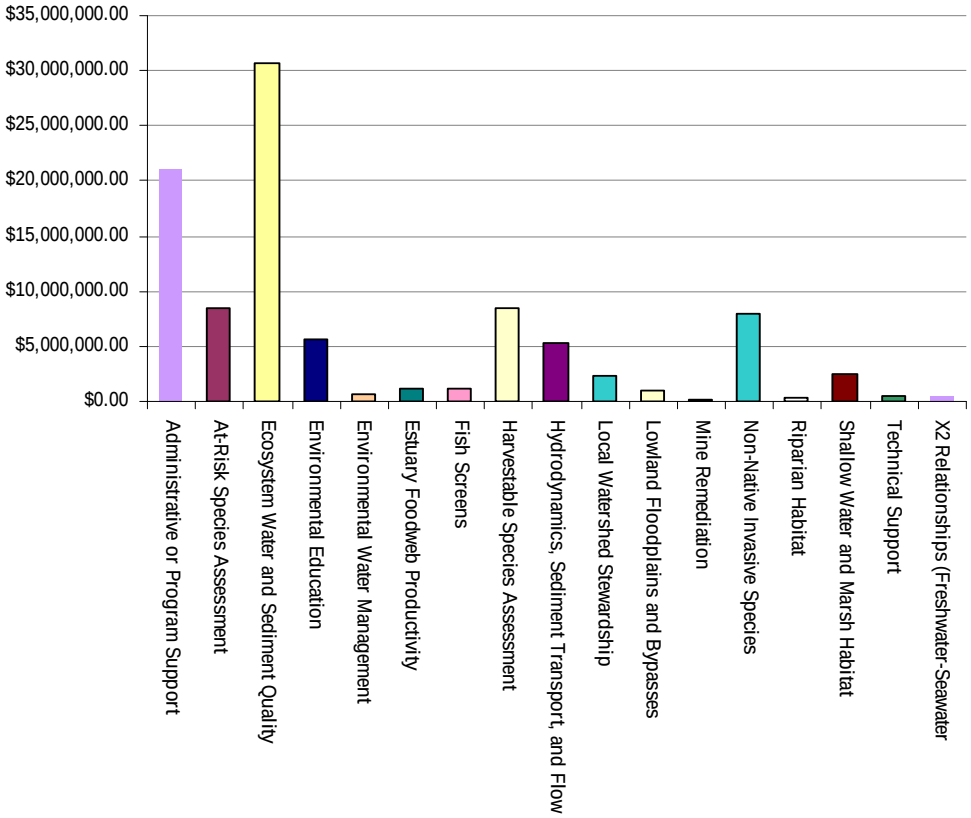

Figure 2.4.1. Program-wide ERP Investment by Topic Area

The following State programs were conducted during Stage 1 of ERP and contributed to meeting goals of the program:

- Department of Water Resources - water supplies and deliveries for the State Water Project, flood protection facilities, water quality monitoring, and multipurpose management of California water resources.
- State Water Resources Control Board - water rights for storage and diversions, including decisions about required instream flows for fish, water quality, and public trust resource protection.
- California Department of Conservation Reclamation – planning assistance programs initiated under the Surface Mining and Reclamation Act.
- Department of Fish and Game - Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 (DFG is required under State legislation to restore numbers of anadromous fish in the Central Valley); assessment of needs and development of recommendations for stream flows and water temperatures for the protection of aquatic resources in streams and at hatcheries; and management of the Sacramento River Wildlife Management Area.
- Wildlife Conservation Board - Inland Wetlands Conservation Program.

- The California Department of Food and Agriculture (Integrated Pest Control Branch) - tracks and controls federally listed noxious weeds throughout the State.
- San Francisco Bay Regional Water Quality Control Board, and San Francisco Bay Conservation and Development Commission - Regional Wetlands Management Plan.
- The Sacramento River Conservation Area Forum - preserve remaining riparian habitat and reestablish a continuous riparian ecosystem along the Sacramento River between Redding and Colusa.
- San Francisco Bay Regional Water Quality Control Board, and San Francisco Bay Conservation and Development Commission - Regional Wetlands Management Plan. These bulleted points need be put in the same grammatical form.

The following Federal programs were conducted during Stage 1 of ERP and contributed to meeting goals of the program:

- U.S. Army Corps of Engineers - flood control operations of reservoirs and management of flood control facilities (e.g. levees, overflow channels and bypass weirs).
- U. S. Bureau of Reclamation - operation of the Central Valley Project (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. Central Valley Project Improvement Act).
- Federal Energy Regulatory Commission - regulation of minimum flows below hydropower projects.
- U.S. Fish and Wildlife Service and National Marine Fisheries Service - 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.
- U.S. Geological Survey (water resources division) - measure streamflow and water quality, providing the information necessary for adaptive management of streamflows.
- U.S. Fish and Wildlife Service - administration of the Central Valley Project Improvement Act (PL 102-575) calling for the doubling of the anadromous fish populations (including striped bass, salmon, steelhead, sturgeon, and American shad) by 2002.
- Anadromous Fish Restoration Program - gravel replenishment program (CVPIA Subsection 3406 b 13).
- Natural Resources Conservation Service - Wetland Reserve Program.
- U.S. Fish and Wildlife Service - administration of the Recovery Plan for Upland Species of the San Joaquin Valley, California (contains specific measures for the riparian brush rabbit).
- U.S. Fish and Wildlife Service - expansion plans for the Sacramento River National Wildlife Refuge.

- U.S. Army Corps of Engineers - Sacramento River Flood Control and Bank Protection Projects.
- San Joaquin River Riparian Habitat Restoration Program - develop and implement a plan for restoration of a continuous riparian corridor.
- San Francisco Bay Area Wetlands Ecosystem Goals Project.

In addition to State and federal program support; local agencies, joint ventures, and non-profit organizations such as the following also contributed to meeting Stage 1 goals:

- The Nature Conservancy - ongoing Sacramento Valley conservation planning.
- The Cosumnes River Preserve - a joint project of The Nature Conservancy, Department of Interior, Department of Water Resources, Department of Fish and Game, Wildlife Conservation Board, and others.
- San Joaquin River Parkway - plans being put into effect for all county-sponsored instream mining and reclamation ordinances and river and stream management plans.
- Ducks Unlimited and the California Waterfowl Association – various restoration programs.
- The Riparian Habitat Joint Venture - promotes the coordinated development of riparian restoration plans with the primary purpose of conserving migrant land birds.
- The San Francisco Bay Joint Venture - public/private partnership working to protect, restore, enhance and increase wetlands of all types throughout the San Francisco Bay region to benefit fish and wildlife using a non-regulatory approach.
- Central Valley Habitat Joint Venture and North American Waterfowl Management Plan.

Future Vision

Experience gained during implementation of Stage 1 ERP should help guide both the administration of Stage 2 as well as restoration priorities. The following recommendations should be addressed in development of the ERP Stage 2 program:

- Provide centralized guidance to the development, implementation, and evaluation of ecosystem restoration projects. Stage 2 implementation needs to be tightly orchestrated to most effectively allocate any available funding.
- Link projects and programs for Stage 2 implementation to established conceptual models.
- Implement recommendations from the Adaptive Management Workshop by conducting adaptive management experiments to promote ecosystem functions or other restoration actions.
- Evaluate the effectiveness of major fish screen projects and conduct studies to improve knowledge of potential population-level effects.
- Coordinate with other planning efforts.
- Provide for regional planning and implementation support. Fund permanent staff positions assigned to prepare and maintain regional ERP implementation plans and to support ongoing implementation activities. These staff will help to develop conservation strategies for regional HCP/NCCPs and help develop comprehensive monitoring plans, indicators, and performance measures through conceptual models.
- Provide for project tracking for the Ecosystem Restoration Program. Fund permanent staff positions assigned to prepare and maintain ERP grant contracts and to oversee grant implementation activities.
- Non-native Invasive Species. DFG will work with the USFWS NIS Agency and Stakeholder Teams to implement and administer the NIS program, as developed and documented in the NIS Strategic and Implementation Plans.