6-1999

Ecosystem Restoration Program Plan Vol 2 - Ecological Management Zone Visions. Draft Programmatic EIS/EIR Technical Appendix

CalFed Bay-Delta Program

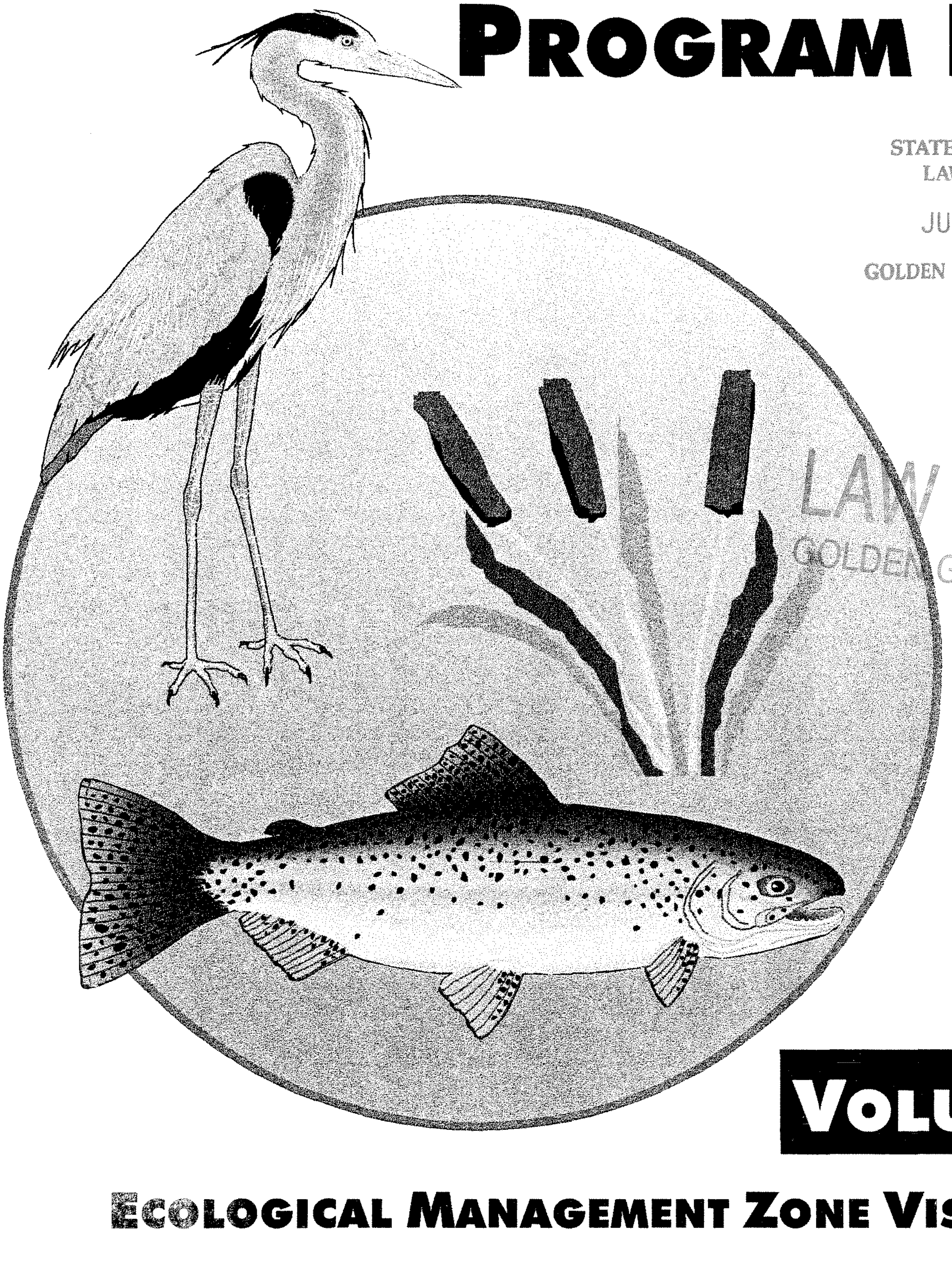
CALFED BAY-DELTA PROGRAM

Ecosystem Restoration Program Plan
Vol 2 - Ecological Management Zone Visions

Draft Programmatic EIS/EIR Technical Appendix

June 1999

ECOSYSTEM RESTORATION PROGRAM PLAN



VOLUME II

ECOLOGICAL MANAGEMENT ZONE VISIONS

CALFED
BAY-DELTA
PROGRAM

June 1999

CALFED BAY-DELTA PROGRAM
ECOSYSTEM RESTORATION PROGRAM PLAN
VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

SECTION **PAGE**

TABLE OF CONTENTS (continued)

SECTION **PAGE**

TABLE OF CONTENTS (continued)

SECTION **PAGE**

TABLE OF CONTENTS (continued)

SECTION **PAGE**

TABLE OF CONTENTS (continued)

SECTION | **PAGE**

List of Tables

Table

ENVIRONMENTAL DOCUMENTATION

The CALFED Bay-Delta Program (Program) is currently in what is referred to as Phase II, in which the CALFED agencies are developing a Preferred Program Alternative that will be subject to a comprehensive programmatic environmental review. This report describes both the long-term programmatic actions that are assessed in the June 1999 Draft Programmatic EIS/EIR, as well as certain more specific actions that may be carried out during implementation of the Program. The programmatic actions in a long-term program of this scope necessarily are described generally and without detailed site-specific information. More detailed information will be analyzed as the Program is refined in its next phase.

Implementation of Phase III is expected to begin in 2000, after the Programmatic EIS/EIR is finalized and adopted. Because of the size and complexity of the alternatives, the Program likely will be implemented over a period of 20-30 years. Program actions will be refined as implementation proceeds, initially focusing on the first 7 years (Stage I). Subsequent site-specific proposals that involve potentially significant environmental impacts will require site-specific environmental review that tiers off the Programmatic EIS/EIR. Some actions, such as recreation of shallow water habitats in the Delta and Suisun Marsh, also will be subject to permit approval from regulatory agencies.

◆ CALFED Bay-Delta Program
Ecosystem Restoration Program Plan

Overview

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. The Program addresses problems in four resource areas: ecosystem quality, water quality, levee system integrity, and water supply reliability. Programs to address problems in the four resource areas will be designed and integrated to fulfill the CALFED mission.

Ecosystem goals presented in the ***Strategic Plan for Ecosystem Restoration*** will guide the Ecosystem Restoration Program (ERP) during its implementation phase. Strategic Goals include the following:

1. Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

2. Rehabilitate natural processes in the Bay-Delta system to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native members of those communities.

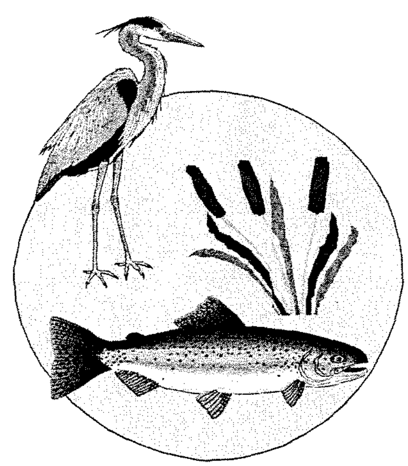
3. Maintain and enhance populations of selected species for sustainable commercial and recreational harvest, consistent with goals 1 and 2.

4. Protect or restore functional habitat types throughout the watershed for public values, such as recreation, scientific research, and aesthetics.

5. Prevent establishment of additional non-native species and reduce the negative biological and economic impacts of established non-native species.

6. Improve and maintain water and sediment quality to eliminate, to the extent possible, toxic impacts to organisms in the system, including humans.

The ERP addresses these goals by restoration of ecological processes associated with streamflow, stream channels, watersheds, and floodplains. These processes create and maintain habitats essential to the life history of species dependent on the Delta. In addition, the Program aims to reduce the effects of stressors that inhibit ecological processes, habitats, and species.



ORGANIZATION OF THE PLAN

The ERP is comprised of a Strategic Plan and the two volume restoration plan:

- Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed
- Volume II: Ecological Management Zone Visions.

STRATEGIC PLAN FOR ECOSYSTEM RESTORATION provides the ERP approach to adaptive management and contains the proposed plans for indicators of ecological health, a monitoring program to acquire and evaluate the data needed regarding indicators, a program of focused research to acquire additional data needed to evaluate program alternatives and options, and the approach to staging and implementation of the ERP over time.

VOLUME I: ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED presents the visions for ecological processes and functions, fish and wildlife habitats, species, and stressors that impair the health of the processes, habitats, and species (Figure 1). The visions presented in Volume I are the foundation of the ERP and display how the many ecosystem elements relate to one another and establish a basis for actions which are presented in Volume II.

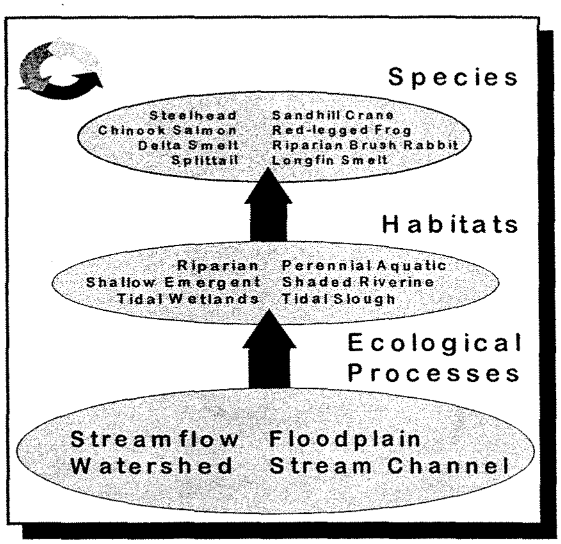


Figure 1. Relationship of ecological, processes, habitats, and species in the Ecosystem Restoration Program Plan.

VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS presents the visions for the 14 ecological management zones and their respective ecological management units. Each individual ecological management zone vision contains a brief description of the management zone and units, important ecological functions associated with the zone, important habitats, species which use the habitats, and stressors which impair the functioning or utilization of the processes and habitats. Volume II also contains strategic objectives, targets, and programmatic actions which describe the ERP approach to improving the ecological health of the zone and its contribution to the health of the Delta. Rationales are also contained in Volume II which clarify, justify, or support the targets and programmatic actions.

INTRODUCTION TO VOLUME II

Volume II, Ecological Management Zone Visions, integrates the landscape ecological concepts for processes, habitats, species, and stressors presented in Volume I: Visions for Ecosystem Elements. Volume II presents this information in population targets and actions for species and 14 visions for the Ecological Management Zones which comprise the ERPP Study Area (Table 1).

Each Ecological Management Zone (Zone) is further divided into component Ecological Management Units (Unit). For example, the East San Joaquin Zone is divided into three Units: Stanislaus River, Tuolumne River, and Merced River. The vision for each Ecological Management Zone provides introductory information, Zone and Unit descriptions which identify the status of ecological processes, habitats, and species, and describes how stressors adversely affect those ecosystem elements.

Table 1. Ecological Management Zones and Ecological Management Units within the ERPP Study Area.

Ecological Management Zone	Ecological Management Unit	
Sacramento-San Joaquin Delta	North Delta South Delta	East Delta Central and West Delta
Suisun Marsh/North San Francisco Bay	Suisun Bay and Marsh Sonoma Creek San Pablo Bay	Napa River Petaluma River
Sacramento River	Keswick to Red Bluff Chico Landing to Colusa Verona to Sacramento	Red Bluff to Chico Landing Colusa to Verona
North Sacramento Valley	Clear Creek Bear Creek	Cow Creek Battle Creek
Cottonwood Creek	Upper Cottonwood Creek	Lower Cottonwood Creek
Colusa Basin	Stony Creek Thomes Creek	Elder Creek Colusa Basin
Butte Basin	Paynes Creek Mill Creek Big Chico Creek Butte Sink	Antelope Creek Deer Creek Butte Creek
Feather River/Sutter Basin	Feather River Bear River Sutter Bypass	Yuba River Honcut Creek
American River Basin	American Basin	Lower American River
Yolo Basin	Cache Creek Solano	Putah Creek Willow Slough
Eastside Delta Tributaries	Cosumnes River Calaveras River	Mokelumne River
San Joaquin River	Vernalis to Merced Mendota Pool to Gravelly Ford	Merced to Mendota Pool Gravelly Ford to Friant
East San Joaquin	Stanislaus River Merced River	Tuolumne River
West San Joaquin		

Visions follow the introductory material for each Zone which presents the relevant ecological processes, habitats, species and stressors within the Zone and Unit. The visions are followed by sections on how restoration efforts in the Zone integrate with other programs and how the Zone is linked to other Zones. The final section of each vision provides implementation objectives, targets, and programmatic restoration actions.

PERSPECTIVE

The ecological hub of the Central Valley is the Sacramento-San Joaquin Delta and Bay. The ERP signals a fundamental shift in the way ecological resources of the Central Valley are managed. For many decades, government entities, non-profit organizations, and the private sector have engaged in managing, protecting, regulating, and in some cases breeding fish and wildlife species of the Bay and Delta - yet many populations have not recovered sufficiently and remain in decline. In spite of constant human intervention to repopulate fish and wildlife that have commercial, recreational, and biological importance to society (e.g., hatchery programs and expensive re-engineered water diversions), populations have not been sustained at stable, healthy levels that support historic utilization of those resources.

Historic efforts at individual species regulation and management will be replaced by an integrated systems approach that aims to reverse the fundamental causes of decline in fish and wildlife populations. A systems approach will recognize the natural forces that created historic habitats and use these forces to help regenerate habitats. The Bay-Delta ecosystem is not simply a list of species. Rather, it is a complex living system sustained by innumerable interactions that are physical, climatic, chemical, and biological in nature, both within and outside of the geographic boundaries of the Delta.

The central theme of the ERPP is the recognition that truly durable and resilient populations of all fish and wildlife inhabiting the Bay and Delta require, above all else, the rehabilitation of ecological processes throughout the Central Valley river and estuary systems and watersheds.

The ERP is fundamentally different from many past efforts in another way as well. It is not designed as mitigation for projects to improve water supply reliability or to bolster the integrity of Delta levees; improving ecological processes and increasing the amount and quality of habitat are co-equal with other program goals related to water supply reliability, water quality, and levee system integrity. Solving serious and long-standing problems in each of these resource areas will require an ambitious, integrated, long-term program. We do not know the balance needed between restoration efforts in the Delta and Bay and restoration efforts upstream. However, aquatic species cannot be the sole driving force for ecosystem restoration. Ecosystem restoration must involve the integration of the needs of terrestrial and aquatic species and plant communities.

The ERP, like all components of Bay-Delta solution alternatives, is being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will necessarily be composed of many different programs, projects, and actions that will be implemented over time. During the current phase of the Program, solution alternatives have been evaluated as sets of programs and projects and broad benefits and impacts have been identified. In the implementation phase of the Program, more focused analysis, environmental documentation, and implementation of specific programs and actions will occur.

The CALFED goal for ecosystem quality will be achieved by further developing and adhering to the *Strategic Plan for Ecosystem Restoration*. A major effort toward reaching target levels will be emphasized during the first 7 years of the implementation program. Special effort will be directed to actions that can be implemented to restore ecological processes. The restoration of these processes is intended to restore and maintain habitats, and to provide for the needs of the species dependent on a healthy Bay-Delta system. For example, restoring stream channels contributes to sediments, nutrients, and a variety of habitats. The strategy recognizes that not all processes can or should be completely restored and that intervention, manipulation, and management will be required. For example, streambed gravel may have to be introduced, habitats may have to be constructed, and vegetation planted. Still, an important part of the approach is to recommend measures that in the long-term will limit the need for continued human intervention.

Implementation of the ERP is further guided by the recognition that all landscape units and physical and biological components of the ecosystem are interdependent and dynamic. Interdependence means that actions and stressors in one part of the system can and do affect populations and conditions that may be separated by hundreds of miles (e.g., in watersheds and spawning tributaries), or affect the food web in ways that may not be felt for several years.

Natural systems are dynamic; i.e., they are characterized by response to cycles of change and episodic catastrophes that are driven by natural or human factors. Most habitats undergo expansions and contractions, or shifts in space and time. The dynamic nature of healthy habitats is the cause of much biological diversity, and complex habitats tend to make species populations more resilient to change. If the mosaic of habitats distributed across a broad landscape is complex, and if large areas of habitat are connected by smaller patches and corridors such as those associated with riparian systems, then healthy areas of the ecosystem can be relied upon to sustain species during temporary setbacks in other areas.

GEOGRAPHIC SCOPE

The geographic (spatial) scope of the ERP is defined by the interdependence and linkage of the ecological zones which encompass the Central Valley. These ecological zones include the upland river-riparian systems, alluvial river-riparian systems, the Delta, and Greater San Francisco Bay (Note: These ecological zones are more fully described in the Volume I section on Key Ecological Attributes of the San Francisco-Bay Delta Watershed.) The geographic scope defines the locations where actions might be implemented to maintain, protect, restore, or enhance important ecological processes, habitats, and species. Some rivers or watersheds have ecological attributes which are valued higher than the attributes of others areas. These ecological values include the condition of important ecological processes and how well they support a diversity of habitats. The values also include the fish, wildlife, and plants which occupy or utilize the habitats within these local areas.

CALFED is developing a Multi-Species Conservation Strategy to serve as the platform for compliance with the Federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), and the State's Natural Community Conservation Planning Act (NCCPA). The Conservation Strategy has identified a subset of species which are federally and State listed, proposed, or candidate species, other species identified by CALFED that may be affected by and for which the CALFED Program and the ERP have responsibility related to (1) recover the species, (2) contributing to their recovery, or (3) maintaining existing populations. The "recover species" depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, for example, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

Secondarily, the ERP addresses, at a broader, programmatic level, Central and South San Francisco Bay and their local watersheds (Note: The primary geographic focus area for the ERP can be divided into 14 management zones, each characterized by a predominant physical habitat type and species assemblage.) These 14 ecological management zones constitute the geographic areas in which the majority of restoration actions will occur. The upper watersheds surrounding the primary focus area are important and addressed through general actions that focus on watershed processes and watershed planning, management and restoration. The CALFED Coordinated Watershed Management Program addresses the coordination of planning and restoration actions in the upper watershed regions.

IMPLEMENTATION STRATEGY

A large and diverse ecosystem like the Bay-Delta is extremely complex. There are many processes and relationships at work in the ecosystem that are not fully understood. Thus, there are many difficulties and uncertainties associated with a program to improve ecosystem health. In some cases, problems are well understood and the steps to improvement are clear. In other cases, there is some understanding of the reasons for decline but this understanding is not sufficient to warrant full-scale implementation of remedial measures. In still other cases, additional research is needed before solutions can be identified with certainty.

The difficulties and uncertainties of ecosystem restoration call for an implementation strategy that is flexible and can accommodate and respond to new information. The foundation of the ERP implementation strategy is adaptive management. Adaptive management is a process of testing alternative ways of meeting objectives, and adapting future management actions according to what is learned. Adaptive management relies upon the identification of indicators of ecosystem health, comprehensive monitoring of indicators to measure improvement over time, focused research, and phasing of actions.

INDICATORS are features or attributes of the ecosystem that are expected to change over time in response to implementation of the ERP. Indicators are selected to provide measurable evaluations of important ecological processes, habitats, and species whose status individually and cumulatively provide an assessment of ecological health. Indicators of ecosystem health are the gauges we will use to measure progress toward the goal. Some indicators are very broad in scale while others are very specific. For example, a very broad or landscape level indicator of ecosystem health might be a comparison of the total area of riparian forest to historic coverage or an evaluation of the average distance between patches of such forest with closer patches indicating better health than more distant patches. A more specific indicator might be the concentration of toxic substances in the flesh of adult striped bass.

COMPREHENSIVE MONITORING is the process of measuring the abundance, distribution, change or status of indicators. For example, contaminant concentrations in fish tissues can be measured at various locations and times in the system to determine if contaminant levels are changing. This will allow progress to be measured, allow actions to be modified if necessary, and provide assurances that the restoration objectives are being achieved. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

DIRECTED RESEARCH will help answer questions about the system and its components and increase the certainty surrounding the relationships of ecological processes, habitats, and species. For example, the relationships among streamflow, storm events, flow-related shaping of river channels to modify habitat, and the physical and chemical signals that flow provides for aquatic species all need to be better understood for effective management of the system. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

STAGED IMPLEMENTATION is the logical sequence of implementing restoration actions to achieve CALFED goals as effectively as possible. Phasing will consider all targets and programmatic actions and will be used to prioritize actions. For example, actions directed at recovering endangered species and which are consistent with the long-term restoration program and contribute to ecological resilience have a high priority.

Stage I implementation is defined as the first 7 year phase of the program and will include restoration of ecological processes and habitats that are most important for endangered species recovery, reduction of stressors that affect threatened and endangered species, and other actions that may reduce conflicts between beneficial uses in the system. Later implementation phases will be shaped through adaptive management by the results of restoration actions in the first 7 years of the program.

The ERP will be refined and implemented according to the steps listed below.

1. **REFINE THE ERP** based on broad public participation, and using the best scientific knowledge currently available in the short term.

2. **CREATE AN ECOSYSTEM SCIENCE PROGRAM** to provide ongoing scientific evaluation of the ERP. The Science Program will be a collaborative effort among local and national, independent stakeholder and agency scientists and technical experts convened to address outstanding scientific issues and review the ERP.

3. **PREPARE CONCEPTUAL MODELS** to describe the Bay-Delta ecosystem and the proposed actions of the ERP. Restoration or rehabilitation programs for complex ecosystems must be based on clear concepts about how the system is believed to function, how it has been altered or degraded, and how various actions might improve conditions in the system. Conceptual models can provide a basis for quantitative modeling or identify critical information needs for research or monitoring. In ecosystem restoration, they can be used to link human activities or management actions to outcomes important to society. In adaptive management, the most important uses of conceptual models are for: linking human activities to valued outcomes, highlighting key uncertainties where research or adaptive probing might be necessary, and identifying monitoring needs.

4. **DEVELOP TESTABLE HYPOTHESES** for proposed ERP actions. The hypotheses underlying the ERP will be tested through experiments using the conceptual models and on-the-ground research. The results from these experiments will feed back into the adaptive management process and will support proposed actions, suggest revisions to actions, and identify needs for further research.

5. **CONDUCT IMMEDIATE DIRECTED RESEARCH** to improve understanding of the ecosystem and the causes of problems identified in the conceptual models and testable hypotheses. Use results from short-term studies to adjust the way that objectives are achieved, making refinements to the final ERP targets, actions, and implementation schedule.

6. **DEVELOP AND BEGIN A STAGED IMPLEMENTATION PROGRAM** that entails:

- short-term implementation of ecosystem restoration demonstration projects (e.g., through Restoration Coordination and related programs), including stressor reduction measures, to help threatened populations begin recovering and to test the viability and effectiveness of targets and actions,
- coordinated monitoring, evaluation, and reporting of the results of recovery efforts, and the status of ecological indicators in the Bay-Delta and other zones, and
- adaptive management of each successive phase of ERP implementation, including pragmatic adjustments to ecosystem targets, funding priorities, and restoration techniques to ensure that public and private resources are well spent and complement other related efforts.

During refinement and implementation of the ERP, public accountability and program effectiveness will be assured through continuing public involvement as well as environmental impact analysis and documentation.

COMPREHENSIVE MONITORING, ASSESSMENT, AND RESEARCH PROGRAM

Many institutions, both within and outside of the CALFED partnership, are involved in monitoring and applied research that can contribute to the design and assessment of environmental rehabilitation programs. The scope, coverage, and coordination of existing monitoring and applied research, however, are admittedly fragmentary. When viewed together, these programs do not provide a coherent, overall picture of what is being monitored, how the environment is changing over large spatial scales, or a clear sense of how the monitoring data might be used by resource managers and decision makers. The ability to provide coordinated and complete monitoring coverage is especially difficult because of the complex system structure, and the complexities of the associated physical and ecological processes. These programs, however, provide information essential to our understanding and management of the system. These existing programs will figure prominently in the development of a Comprehensive Monitoring, Assessment and Research Program (CMARP) (CMARP Steering Committee 1998).

Monitoring, assessment, and research are important steps in an iterative process to understand and manage a natural resource system. Monitoring involves measuring and sampling physical, chemical, and biological attributes of the resources and can include social and economic attributes of associated human activities. Assessment involves developing correlations among monitored data, for example correlations between the abundance of a fish species and a factor such as river flow that might affect abundance. Research involves analysis or experiments to establish mechanisms that explain observed correlations, such as documenting fish distributions and mortalities for different flows. The information generated from monitoring, assessment, and research provides resource managers with understanding needed to design actions and to detect responses to their actions.

CALFED needs a monitoring and research program for at least four reasons. First, CALFED needs monitoring data and information to implement the preferred program alternative and to carry out its related programs, and this need is increased by CALFED's adoption of an adaptive management strategy. Second, CALFED needs to satisfy the Congressional mandate for indicators and performance measures with which to judge the success of restoration efforts. Third, CALFED needs data and information with which to assure stakeholders that the actions being taken are having desired results. Finally, CALFED needs to reduce the scientific uncertainty regarding the management and protection of valued natural resources.

Thus, the purpose of CMARP is to provide those new facts and scientific interpretations necessary for CALFED to implement fully its preferred program alternative and related programs and for the public and government to evaluate the success of CALFED actions.

TERMS USED IN THE ERPP

The following terms are used in the ERP:

ECOSYSTEM-BASED MANAGEMENT: Ecosystem-based management is a resource management concept of achieving species management objectives by sustaining and enhancing the fundamental ecological structures and processes that contribute to the well being of the species. A basic tenant of CALFED's implementation of ecosystem-based management is, to the extent feasible, to restore or rehabilitate the natural processes that create and maintain the important elements of ecosystem structure. Ecosystem-based management differs fundamentally from the more traditional approach of species-based management, which seeks to manipulate specific environmental factors (e.g., direct removal of predators from the environment to reduce predation levels on the target species) thought to be limiting target species populations at levels below management objectives.

ECOSYSTEM ELEMENT: An ecosystem element is a basic component or function which, when combined with other ecosystem elements, make up an ecosystem. An ecosystem element can be categorized as a process, habitat, species, species community or stressor.

ECOSYSTEM REHABILITATION: Within CALFED's concept of ecosystem restoration, the ERP will largely focus on ecosystem rehabilitation. In the context of CALFED, ecosystem rehabilitation is defined as the process by which resource managers reestablish or refurbish key elements of ecological structure and function within the Bay-Delta ecosystem to a level necessary to achieve ERP goals and objectives.

ECOSYSTEM RESTORATION: Ecosystem restoration is a term sometimes used to imply the process of recreating the structural and functional configurations of an ecosystem to that present at some agreed to time in the past. Because the structure and function of many elements of the Bay-Delta ecosystem have been severely disrupted and cannot be feasiblely restored to a specified historic condition, within the context of CALFED, ecosystem restoration is more realistically defined as the process by which resource managers ensure that the capacity of the ecosystem to provide ecological outcomes valued by society is maintained, enhanced, or restored.

ECOLOGICAL PROCESS: Ecological processes act directly, indirectly, or in combination, to shape and form the ecosystem. These include streamflow, watershed, stream channel, and floodplain processes. Watershed processes are closely linked to streamflow and include fire and erosion. Stream channel processes include stream meander, gravel recruitment and transport, water temperature, and hydraulic conditions. Floodplain processes include overbank flooding and sediment retention and deposition.

HABITATS: Habitats are areas that provide specific conditions necessary to support plant, fish, and wildlife communities. Some important habitats include gravel bars and riffles for salmon spawning beds, winter seasonal floodplains that support juvenile fish and waterbirds, and shallow near-shore aquatic habitat shaded by overhanging tule marsh and riparian forest.

LONG- AND SHORT-TERM OBJECTIVES: Objectives can be both short-term and long-term. Short-term objectives should be clearly feasible, relatively easy to measure, and achievable in reasonable length of time (usually <25 years). The time period is not the same as Stage I of the CALFED process. Long-term objectives may be more difficult to determine and require additional resources and knowledge to achieve.

PROGRAMMATIC ACTION: A programmatic action represents a physical, operational, legal, institutional change or alternative means to achieve a target. The number of actions and their level of implementation is subject to adjustment by adaptive management. For example, the number of diversions screened may be adjusted up or down depending on the overall response of fish populations to screening and other restoration actions.

An example of a programmatic action is to develop a cooperative program to acquire and restore 1,500 acres of shallow-water habitat in the Suisun Bay and Marsh Ecological Management Unit.

STRATEGIC OBJECTIVES: Strategic objectives are a more detailed delineation of the Strategic Goal components and provide a framework to develop and organize targets and programmatic actions. A strategic objective is the most specific and detailed description of what the ERP strives to maintain or achieve for an ecosystem element. The objectives are stated primarily in terms of management actions designed to have a favorable impact on the Bay-Delta system, however, some are also stated in terms of studies that will teach us how the ecosystem behaves so that principles of adaptive management can be better employed.

SPECIES AND SPECIES GROUPS: Certain species or groups of species are given particular attention in the ERP. This focus is based on three criteria that might be met by a species (including fish, wildlife, and plants): 1) is it a formally listed threatened or endangered species (e.g., winter-run chinook salmon, delta smelt), or is it a species proposed for listing; 2) it is economically important, supporting a sport or commercial fishery (e.g., striped bass, signal crayfish); 3) is it a native species or species community that is presently not listed by which could be if population abundance or distribution declines, or 4) it is an important prey species (e.g., Pacific herring).

STAGE 1 EXPECTATIONS: Stage 1 expectations are meant to be measures of the progress towards meeting short-term objectives in the first 7 years of implementation program. These expectations have two basic components: improvements in information to allow better management of the ecosystem and improvements in physical and biological properties of the Bay-Delta ecosystem and watershed.

STRATEGIC GOAL: Strategic goals are the broad statements that define the scope and purposes of the ERP. Strategic goals provide guidance in the development and evaluation of proposed restoration actions.

STRESSORS: Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Environmental stressors include water diversions, water contaminants, levee confinement, stream channelization and bank armoring, mining and dredging in streams and estuaries, excessive harvest of fish and wildlife, introduced predator and competitor species, and invasive plants in aquatic and riparian zones. Some major stressors affecting the ecosystem are permanent features on the landscape, such as large dams and reservoirs that block transport of the natural supply of woody debris and sediment in rivers or alter unimpaired flows.

TARGET: A target is a qualitative or quantitative statement of an implementation objective. Targets are something to strive for but may change over the life of the program with new information and progress, or may vary according to the configuration of storage and conveyance in all alternatives. Targets may include a range of values or a narrative description of the proposed future value of an ecosystem element. Targets are to be set based upon realistic expectations, must be balanced against other resource needs and must be reasonable, affordable, cost effective, and practicably achievable.

The intent of the ERP is to achieve ecosystem health; targets are flexible tools to guide the effort. The level of implementation for each target will be determined or adjusted through adaptive management. Targets are categorized according to the three levels of certainty described above: (1) targets that have sufficient certainty of success to justify full implementation in accordance with program priorities and staged implementation; (2) targets which will be implemented in stages with the appropriate monitoring and evaluation to judge benefits and successes; and (3) targets for which additional research, demonstration and evaluations are needed to determine feasibility or ecosystem response.

Examples of targets for tidal perennial aquatic habitat are to restore 1,500 acres of shallow-water habitat in the Suisun Marsh/North San Francisco Bay Ecological Management Zone and restore 2,000 acres of shallow-water habitat in the South Delta Ecological Management Unit.

VISION: A vision is what the ERP will accomplish with the stated objectives, targets, and programmatic actions for an ecological process, habitat, species or species group, stressor, or geographical unit. The vision statements included in the ERP provide technical background to increase understanding of the ecosystem and its elements. Two types of vision statements are included in the ERP: visions for ecosystem elements and visions for ecological zone. A resource vision addresses an individual ecological processes, habitat, species or species group, or stressor, while an ecological zone vision addresses the integration of ecological processes, habitats, species, and stressors within a clearly delineated geographical area. Cumulatively, the visions also provide detailed descriptions of the ecosystem and its elements as they will look and function after restoration is accomplished.

REFERENCES

CMARP Steering Committee. 1998. A proposal for the development of a comprehensive monitoring assessment and research program. Developed for CALFED by the CMARP Steering Committee. Final Report. April 24, 1998. 50 pp.

Costanza, R. and H. Daly. 1992. Natural capital and sustainable development. Conservation biology 1:31-45.

Ecological Society of America. 1995. The scientific basis for ecosystem management. Ad Hoc Committee on Ecosystem Management. Washington, D.C.

Healey, M. 1998. Paradigms, policies and prognostication about watershed ecosystems and their management. To appear in R. J. Naiman and R. E. Bilby (eds.), Ecology and management of streams and rives in the

Pacific Northwest Coastal Ecoregion. Springer-Verlag. New York, NY.

Hennessey, T.M. 1997. Ecosystem management: the governance dimension. Western Social Sciences Association Symposium. Albuquerque, April 23-16, 1997.

Richardson, J.S., and M. Healey. 1996. A healthy Fraser River? How will we know when we achieve this state? Journal of Aquatic Ecosystem Health 5:107-115.

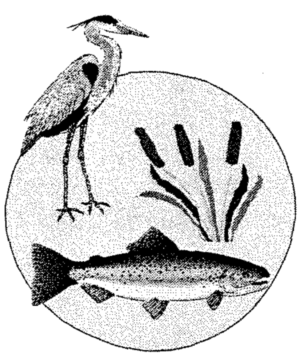
Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

World Commission on Environment and Development. 1987. Our common future. Report of the World Commission on Environment and Development. Oxford University Press. Oxford England.

◆ Population Targets and Programmatic Actions for Species and Species Groups

Introduction

This section presents the approach for describing population targets and programmatic actions for species and species groups. Many of these population targets are linked to formal recovery plans for State- or federally listed threatened or endangered species and, therefore, constitute an exceedingly important component of the overall ecosystem restoration program.



Broad species and species group population targets are presented here, prior to our discussion of individual ecological management zones, to avoid redundancy. Where necessary, we provide additional targets and actions within the ecological management zone descriptions if they differ or are in addition to the initial presentation of species population targets and programmatic actions.

Little recent information regarding abundance, distribution, or life history requirements are available for some species. This limits our ability to develop species targets and programmatic actions. Instead, some targets are presented as information needs, such as a target for lamprey would be to conduct distributional and abundance surveys to enable the development of lamprey targets and programmatic actions. These information-directed targets are linked to the Comprehensive Monitoring, Assessment, and Research Program (CMARP) which is developing the CALFED monitoring and research program.

Consistent with the Strategic Plan, this section is divided into five segments that correspond with the classification system used for Strategic Objectives. Four of the segments fall under Strategic Goal 1 (at-risk species) and the remaining segment is linked to Goals 3 (harvested species).

Strategic Goals

1. Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

3. Maintain and enhance populations of selected species for sustainable commercial and recreational harvest, consistent with goals 1 and 2.

The divisions follow:

- **High Priority At-risk Species** (Priority Group I): These are at-risk native species dependent on the Bay-Delta system, most of them listed under the Endangered Species Act (ESA) or proposed for listing, whose management for restoration implies substantial manipulations of the ecosystem (e.g., requiring large amounts of fresh water at certain times of the year).

- **AT-RISK NATIVE SPECIES** (Priority Group II): These are at-risk native species dependent on the Bay-Delta system whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed (e.g., brackish water plants).

- **AT-RISK UPSTREAM NATIVE SPECIES** (Priority Group III): These are at-risk species that primarily live upstream of the estuary or in local watersheds of San Francisco Bay.

- **DECLINING NATIVE SPECIES** (Priority Group IV): These are native species in the estuary and watershed not yet at risk of extinction that have the potential to achieve that status if steps are not taken to reverse their declines or keep populations at present levels. Their rehabilitation either does not depend on conditions in the Bay-Delta system or depends on unknown factors.

- **HARVESTED SPECIES:** These are species that support recreational and commercial harvest not already covered by the previous classes.

LINKAGE TO CONSERVATION STRATEGY

The Multi-species Conservation Strategy (MSCS) addresses all federally and State listed, proposed, and candidate species that may be affected by the CALFED Program; other species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the MSCS. The term "evaluated species" is used to refer to all of the species addressed by the Conservation Strategy. Please refer to the MSCS appendix (bound separately) for more information and for a complete list of evaluated species.

RECOVERY "R": For those species designated "R" the CALFED Program has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of "Recovery" was generally assigned to those species whose range is entirely or nearly entirely within the area affected by the CALFED Program and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recovery the species. The term "recover" generally means the decline of a species is arrested or reversed, threats to the species are neutralized, and thus, the species' long-term survival in nature is assured. In the case of most species listed under the Federal ESA, recovery is equivalent, at a minimum, to the requirements of delisting. For certain species, such as anadromous fish, with threats outside the geographic scope or purview of the CALFED Program, CALFED may not be capable of completely recovering the species, but will implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED may choose a goal that aims to achieve more than would be required for delisting (e.g., restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "Recovery" may be highly variable between species. In sum, a goal of "Recovery" implies that CALFED will undertake all actions within the ERP Ecological Management Zones and program scope necessary to recover the species.

CONTRIBUTE TO RECOVERY ("r"): For those species designated "r," the CALFED Program will make specific contributions toward the recovery of the species. The goal "Contribute to Recovery" was generally assigned to those species for which CALFED Program actions affect only a limited portion of the species range and/or CALFED Program actions have limited effects on the species. In the case of a species with a recovery plan, this may mean implementing some of the measures identified in the plan. For species without a recovery plan, this would mean implementing specific measures that would benefit the species. In sum, a goal of contributing to a species' recovery implies that CALFED will undertake some of the actions within its geographic scope necessary to recovery the species.

MAINTAIN ("M"): For those species designated "m," the CALFED Program will undertake actions to maintain the species (this category is less rigorous than Contribute to Recovery). The goal "Maintain" was generally assigned to species expected to be minimally affected by CALFED actions. For this category, CALFED will ensure that any adverse effects to the species are addressed commensurate with the level of effect on the species; thus, actions may not actually contribute to the recovery of the species, but would be expected, at a minimum, to not contribute to the need to list an unlisted species or degrade the status of an already listed species. CALFED will also maximize beneficial effects on these species to the extent practicable.

SPECIES POPULATION TARGETS AND PROGRAMMATIC ACTIONS

Targets developed for the species and species groups can be classified by their reliability in contributing to attainment of the Strategic Objectives. The target classification system used in the following section is as follows:

Class	Description
◆	Target for which additional research, demonstration, and evaluation is needed to determine feasibility or ecosystem response.
◆◆	Target which will be implemented in stages with the appropriate monitoring to judge benefit and success.
◆◆◆	Target that has sufficient certainty of success to justify full implementation in accordance with adaptive management, program priority setting, and phased implementation.

Strategic Plan Priority Group I. At-risk native species dependent on the Bay-Delta system, most of them listed under the Endangered Species Act (ESA) or proposed for listing, whose management for restoration implies substantial manipulations of the ecosystem (e.g., requiring large amounts of fresh water at certain times of year).

DELTA SMELT (R)[1]

POPULATION TARGET: Meet Delta Native Fishes Recovery Plan goals which include recovery goals tied to the fall midwater trawl survey and distribution of catch in various trawl survey zones (◆◆).

PROGRAMMATIC ACTION: Restoring delta smelt will come indirectly from increasing March to May Delta inflow and outflow; Delta channel hydraulics, the Delta aquatic foodweb, and aquatic wetland and riparian habitats; and reducing stressors including effects of water diversions and contaminants.

RATIONALE: *The recovery objective for delta smelt is to remove delta smelt from the Federal list of threatened species through restoration of it abundance and distribution. Recovery of delta smelt should not be at the expense of other native fishes. The basic strategy for recovery is to manage the estuary in such a way that it is a better habitat for native fish in general and delta smelt in particular. Improved habitat will allow delta smelt to be widely distributed throughout the Delta and Suisun Bay, recognizing that areas of abundance change with season.*

Recovery of delta smelt will consist of two phases, restoration and delisting. Separate restoration

1. Note: Letter in parentheses refers to Conservation Strategy goal for the species. (e.g., "R" is recovery of the species, "r" is contribute to recovery, "m" is maintain species, and "nc" is not covered.

and delisting periods were selected because it is possible that restoration criteria could be met quicky in the absence of consecutive extreme outflow years (i.e., extremely wet or dry years). However, without the population being tested by extreme outflows there is no assurance of long-term survival for the species.

Thus restoration is defined as a return of the population to pre-decline levels, but delisting is not recommended until the population has been tested by extreme outflows. Delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period. This period was chosen because it includes the earliest continuous data on delta smelt abundances and was a period in which populations stayed reasonably high in most years. The species will be considered recovered and qualify for delisting when it experiences a five-year period that includes two sequential years of extreme outflows, one of which must be dry or critically dry. Delta smelt will be considered for delisting when the species meets recovery criteria under stressor conditions comparable to those that led to listing and mechanisms are in place that insure the species' continued existence.

Restoration of delta smelt should be assessed when the species satisfies distributional and abundance criteria. Distributional criteria include: (1) catches of delta smelt in all zones 2 of 5 consecutive years, (2) in at least two zones in 1 of the remaining 3 years, and (3) in at least one zone for the remaining 2 years. Abundance criteria are: delta smelt numbers of total catch must equal or exceed 239 for 2 out of 5 years and not fall below 84 for more that two years in a row. Distributional and abundance criteria can be met in different years. If distributional and abundance criteria are met for a five-year period the species will be considered restored. Delta smelt will meet the remaining recovery criteria and be considered for delisting when abundance and distributional criteria are met for a five-year period that includes two successive extreme outflow years, with one year dry or critical. Both criteria depend on data collected by the California Department of Fish and Game during the fall midwater trawl, during September and October (U.S. Fish and Wildlife Service 1996).

Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young delta smelt survival, and by providing transport flow to larval delta smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult delta smelt.

LONGFIN SMELT (R)

TARGET: Meet the goals of the Delta Native Fishes Recovery Plan which include recovery goals tied to the fall midwater trawl survey and the distribution of catch in various zones of the trawl survey, and catch goals in the Suisun Marsh trawl survey (◆◆).

PROGRAMMATIC ACTION: Restoration of longfin smelt will come indirectly from: increasing March to may Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; improving aquatic wetland and riparian habitats, and reducing stressors including the effects of water diversions, contaminants, and the stocking of striped bass and chinook salmon in longfin smelt nursery areas of North San Francisco Bay.

***RATIONALE**: General restoration objectives are the same as those described for delta smelt. Longfin smelt will be considered restored when its population dynamics and distribution patterns within the estuary are similar to those that existed in the 1967-1984 period. This period was chosen because it includes the earliest continuous data on* *longfin smelt abundances and was a period in which populations stayed reasonably high in most years.*

Restoration of longfin smelt will be achieved when the species satisfies distributional and abundance criteria. Distributional criteria are: (1) longfin smelt must be captured in all zone 5 of 10 years, (2) in two zones for an additional year, and (3) at least one zone for 3 of the 4 remaining years, with no failure to meet site criteria in consecutive years. Abundance must be equal to or greater than predicted abundance for 5 of 10 years. Distributional and abundance criteria can be met in different years. If abundance and distributional criteria are met for a ten-year period, the species will be considered restored. Both criteria depend on data collected by the California Department of Fish and Game with the fall midwater trawl, during September and October (U.S. Fish and Wildlife Service 1996).

Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the longfin smelt population. Without such an increase in the population, there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young longfin smelt survival, and by providing transport flow to larval longfin smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay.

Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult longfin smelt. Reevaluation of stocking striped bass and chinook salmon into prime nursery habitats of longfin smelt in San Pablo Bay and Suisun Bay would reduce predation on young longfin smelt. Alternative locations and time of stocking may limit predation on longfin smelt.

GREEN STURGEON (R)

POPULATION TARGET: Meet goals of the Delta Native Fishes Recovery Plan which includes 1,000 green sturgeon greater than 100 centimeters long as measured in the DFG mark-recapture program for estimating sturgeon abundance (◆◆).

PROGRAMMATIC ACTION: Restoration of green sturgeon will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics, improving the Delta aquatic foodweb, and reducing stressors including effects of water diversions and contaminants.

TARGET: Restore access to habitat below Keswick Dam and increase the average annual abundance of adult green sturgeon to levels that will ensure the continued existence of this species (◆◆).

PROGRAMMATIC ACTION: Actions in the Sacramento River and San Joaquin River Ecological Management Zones have been designed specifically to restore green sturgeon, access to habitat below Keswick Dam, and habitat quality. This species will directly benefit from previously described actions in this zone to increase and improve streamflows, natural sediment supply, stream channel meander, and the area and distribution of riverine aquatic habitat.

These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- stream channel meander,
- riparian and riverine aquatic habitat,
- contaminants,
- water diversions, and
- dams, reservoirs, weirs, and other human-made structures.

Additional programmatic actions have been proposed in the Feather River/Sutter Basin, Sacramento-San Joaquin Delta, and Suisun

Marsh/North San Francisco Bay Ecological Management Zones that will contribute to restoring green sturgeon.

RATIONALE: *The primary objective is to maintain a minimum population of 1,000 fish over 1 meter (39 inches) total length each year, including 500 females over 1.3 meters (51 inches) total length (minimum size at maturity), during the period (presumably March-July) when spawners are present in the estuary and the Sacramento River. The restoration of green sturgeon should not be at the expense of other native fishes, including white sturgeon. The 1,000 number was determined as being near the median number of green sturgeon estimated to be in the Estuary during the 1980s. The total size of the adult green sturgeon population that uses the estuary may be larger than 1,000 because non-spawning adults may be in the ocean.*

Green sturgeon will be considered restored in the Sacramento-San Joaquin estuary once the median population of mature individuals (over 1 meter total length) has reached 1,000 individuals (including 500 females over 1.3 meters total length) over a 50 year period or for five generations (10 years is the minimum age of sexual maturity). If population estimates are fewer that 1,000 fish for more than three years in a row, the restoration period will be restarted. (Note: This definition is subject to revision as more information becomes available.) Restoration will be measured by determining population sizes from tagging programs or other suitable means. The present sturgeon tagging programs, which focus on white sturgeon, are inadequate for determining accurately the abundance of green sturgeon. Therefore, a median population goal of 1,000 fish over 1 meter total length (including 500 females over 1.3 meters total length) is achievable with numbers determined through a monitoring program that focuses specifically on green sturgeon. Thus, the first restoration criterion will be establishment of an adequate population determination through a monitoring program. Once that program is in place, the minimum population goals can be re-evaluated and a realistic, presumably higher, goal established. It may be desirable to have the numbers high enough to support the removal of a minimum of 50 fish over 1 meter total length per year by a fishery (assuming an exploitation rate of 5 percent is sustainable) (U.S. Fish and Wildlife Service 1996).

Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young sturgeon survival, and by providing transport flow to larval sturgeon to move them from the rivers into prime nursery habitat in the Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult sturgeon.

SPLITTAIL (R)

POPULATION TARGET: Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include recovery goals tied to the fall midwater trawl survey and distribution of catch in various zones of the trawl survey (♦♦).

PROGRAMMATIC ACTION: Restoration of splittail will come indirectly from increasing March to May Delta inflow which will increase spawning area availability, improving Delta water temperature, improving Delta channel hydraulics, improving the Delta aquatic foodweb, improving aquatic wetland, and riparian habitats, and reducing stressors including effects of water diversions and contaminants.

TARGET: Increase the average annual abundance and distribution of adult fish to levels that existed from 1967 to 1983 (♦♦).

PROGRAMMATIC ACTION: Actions in the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones have been designed specifically to restore splittail or their habitat. This species will directly benefit from actions in this zone to increase the area and distribution of riparian and riverine aquatic habitats and natural flood and floodplain processes. These programmatic actions address:

- riparian and riverine aquatic habitat, and
- natural flood and floodplain processes.

Additional restoration actions that will benefit splittail are proposed for the American River Basin, Yolo Basin, Feather River/Sutter Basin, Eastside Delta Tributaries, and San Joaquin River Ecological Management Zones.

***RATIONALE**: Splittail will be considered restored when they meet two out of three possible restoration criteria, developed from three independent surveys. The three possible criteria are: (1) fall midwater trawl numbers must be 19 or greater for 7 of 15 years; (2) Suisun Marsh catch per trawl must be 3.8 or greater and catch of young-of-year must exceed 3.1 per trawl for 3 of 15 years; and (3) Bay Study otter trawl numbers must be 18 or greater and catch of young-of-year must exceed 14 for 3 out of 15 years. Within each survey, if target criteria are not met at least once in 5 consecutive years, the restoration period for the failed survey will be re-started. Criteria depend on data collected by three independent surveys, two conducted by the California Department of Fish and Game and on conducted by the University of California Davis. These studies were chosen because they sample most of the splittail range and contain the earliest continuous data on splittail abundance.*

When any two out of three criteria are reached, splittail will be considered restored.

- *Splittail will be considered restored when the fall midwater trawl exceeds 19 for 7 out of 15 years. If splittail fail to meet this restoration criterion for five consecutive years, the restoration period will start over.*

- *Splittail will be considered restored when Suisun Marsh catch per trawl exceed 3.8 for 7 out of 15 years and when splittail young abundance exceeds 3.1 per trawl for at least 3 out of 15 years. Splittail young abundance can be used to make up total abundance. If these target criteria (both young and overall) are not met for 5 consecutive years, the restoration period will begin again.*

- *Splittail will be considered restored when Bay Study otter trawl numbers exceed 18 for 7 out of 15 years and when splittail young numbers exceed 14 for 3 out of 15 years. Young-of-year numbers can be applied to meet overall criterion. If these targets, including both young-of-year and overall criteria, are not met for five consecutive years, the restoration period will be re-started (U.S. Fish and Wildlife Service 1996).*

Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving upstream into the Delta and rivers to spawn, by increasing flooding of riparian vegetation and flood plain processes which provide important spawning habitat of splittail, by stimulating aquatic foodweb production to help ensure young splittail survival. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Improving shallow water, slough, and wetland habitats should increase the spawning and rearing habitat of splittail. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult splittail.

SACRAMENTO WINTER-RUN CHINOOK SALMON (R)

POPULATION TARGET: Meet the goals of the Winter-Run Chinook Salmon Recovery Plan and the Anadromous Fish Restoration Program (◆◆).

PROGRAMMATIC ACTION: Restoring chinook salmon populations will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants.

TARGET: Restore the winter-run chinook salmon spawning population to levels that ensure its continued existence and allow for sport and commercial harvest (◆◆).

PROGRAMMATIC ACTION: Actions in the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zone have been designed specifically to restore winter-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and winter-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the recovery of winter-run chinook salmon are proposed for the Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones. Programmatic actions proposed for Battle Creek in the North Sacramento Valley Ecological Management Zone have the potential to allow the future establishment of an addition population of winter-run chinook salmon.

***RATIONALE**: The goal of the Sacramento River winter-run chinook salmon is to establish a framework for the recovery of the population through a logical program of improving the habitat and environment of the species. Specifically, the recovery of this species requires actions which increase their abundance and improve their habitat to the point that the probability of subsequent extinction will be very low. When the underlying causes of the species' decline are no longer in effect and the species has rebounded to relatively healthy levels, winter-run chinook can be removed from the list of threatened and endangered species; that is, it can be "delisted."*

An extinction model was used to develop the delisting criteria to ensure a low probability of extinction once the criteria have been reached. The risk level chosen was a probability of less than 0.1 within the 50 years following delisting. Assurance of the probability of extinction required specification of the population growth rate in addition to population abundance. The delisting criteria for winter-run chinook follow:

Population Criteria: the mean annual spawning abundance over any 13 consecutive years shall be 10,000 females (or a total spawning run of more than twice the female spawning abundance). The geometric mean of the Cohort Replacement Rate over those same 13 years shall be greater than 1.0. Estimates of these criteria shall be based on natural production alone and shall not include hatchery-produced fish. The variability in Cohort Replacement Rate is assumed to be the same as or less than the current variability. In addition, there must be a system in place for estimating spawning run abundance with a standard error less than 25% of the estimate, on which to base the calculation of the population criteria. If this level of precision cannot be achieved, then the sampling period over which the geometric mean of the Cohort Replacement Rate is estimated must be *increased by one additional year for each 10% of additional error above 25% (National Marine Fisheries Service 1997).*

Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young survival, and by providing transport flow to juvenile salmon to move them from the rivers into prime nursery habitat in the Delta and Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult salmon.

SACRAMENTO SPRING-RUN CHINOOK SALMON (R)

POPULATION TARGET: Maintain the average cohort replacement rate of Sacramento spring-run chinook salmon above 1.0 while the stock is rebuilding. Then maintain a replacement rate equal to or greater than 1.0 when the stock reaches restoration goal levels set by the regulatory agencies (◆◆).

PROGRAMMATIC ACTION: Actions in the Sacramento River, North Sacramento Valley, Cottonwood Creek, Butte Basin, Feather River/Sutter Basin, and Sacramento-San Joaquin Delta Ecological Management Zones have been designed to achieve the recovery spring-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and spring-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

RATIONALE: *Spring-run chinook salmon are listed as a threatened species under the California Endangered Species Act and proposed for listing under the ESA. Because of their life history patterns, spring-run chinook enter the Sacramento River early in the year and ascend to tributaries where they oversummer to spawn during the following fall. Young fish may rear for a year or longer in the tributaries before entering the Sacramento River during their seaward migration.*

The status of a spring-run chinook salmon in the mainstem Sacramento River is uncertain, however, evidence suggests that there may be a significant introgression with fall-run chinook. The role of the Sacramento River in sustaining spring-run chinook salmon is primarily to provide adult fish passage to the tributary streams and to provide rearing and emigration habitat for juveniles during their seaward migration.

Natural populations and their essential habitat must be sufficiently abundant to ensure Sacramento River spring-run chinook salmon's long-term survival. In order to achieve recovery, the remaining natural, non-introgressed populations of spring run and any re-established natural populations must be protected, monitored, and proven to be self-sustaining to the satisfaction of the Department of Fish and Game and the Fish and Game Commission. Recovery goals must ensure that the individual populations, as well as the collective metapopulation, are sufficiently abundant to avoid genetic risks of small population size. Thus, recovery goals need to address abundance levels (adult spawning escapements), population stability criteria, population distribution, and length of time for determining sustainability.

The California Department of Fish and Game's recovery objectives for Sacramento River spring-run chinook salmon are (1) the protection and enhancement of the existing natural populations; (2) the re-establishment of additional, viable native populations; and (3) the restoration and protection of natal, rearing, and migratory streams within the Sacramento River basin (California Department of Fish and Game 1998).

The U.S. Fish and Wildlife Service (1996) has recommended restoration objectives and criteria for Sacramento River spring-run chinook salmon based on the objective of establishing self-sustaining populations which will persist indefinitely for each species addressed. Additionally, the population goals for chinook salmon runs include extra adult production for allowing sustained limited harvests of each run. The plan states that restoration will be measured by three interacting criteria: (1) presence of self-sustaining spawning populations in Mill and Deer creeks; (2) total number of spawners in Mill, Deer, Antelope, Butte, Big Chico, Beegum, South Fork Cottonwood, and Clear creeks (if the Yuba River proves to still have a natural run of spring-run chinook, the population goal should be raised by whatever number of spawners the stream can support); and (3) smolt survival through the Delta.

Spring-run chinook salmon populations will be considered healthy when the average number of spawners in tributary streams to the Sacramento River exceeds 5,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry. The average number of natural, wild spawners over the 15-year period must not be fewer than 8,000 fish (USFWS 1996).

SACRAMENTO LATE-FALL-RUN CHINOOK SALMON (R)

POPULATION TARGET: Maintain the average cohort replacement rate of late-fall-run chinook salmon above 1.0 while the stock is rebuilding. Then maintain a replacement rate equal to or greater than 1.0 when the stock reaches restoration goal levels set by the regulatory agencies (◆◆).

PROGRAMMATIC ACTION: Actions in the Sacramento River, North Sacramento Valley, and Sacramento-San Joaquin Delta Ecological Management Zones have been designed specifically to restore late-fall-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and late-fall-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the recovery of late-fall-run chinook salmon are proposed for the Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones.

RATIONALE: *Presently, late-fall-run chinook salmon have no special protection. The great majority of late-fall-run chinook appear to spawn in the mainstem Sacramento River during January, February, and March. Late-fall-run chinook abundance has declined due to passage problems at Red Bluff Diversion Dam, loss of habitat, poor survival of emigrating smolts, sport and commercial harvest, and other factors, such as disease and pollutants.*

Sacramento River late-fall-run chinook salmon populations will be regarded as healthy when the average number of spawners in the Sacramento River basin exceeds 15,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry (U.S. Fish and Wildlife Service 1996).

FALL-RUN CHINOOK SALMON (R)

POPULATION TARGET: Maintain the average cohort replacement rate of Sacramento fall-run chinook salmon above 1.0 while the stock is rebuilding. Then maintain a replacement rate equal to or greater than 1.0 when the stock reaches restoration goal levels set by the regulatory agencies (◆◆).

PROGRAMMATIC ACTION: Actions in many of the Ecological Management Zones have been designed specifically to restore fall-run chinook and its habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and fall-run chinook salmon directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the restoration of fall-run chinook salmon are proposed for the North Sacramento Valley, Butte Basin, Colusa Basin, Cottonwood Creek, Feather River/Sutter Basin, American River, Eastside Delta Tributaries, East San Joaquin, Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones.

RATIONALE: *Because of their life-history requirements, typical of all Pacific salmon, Central Valley chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are successfully maintained to varying degrees by existing ecological processes. Even though the quality and accessibility of the habitats have been diminished by human-caused actions, these habitats can be restored through a comprehensive program that strives to restore or reactivate ecological processes, functions, and habitat elements on a systematic basis, while reducing or eliminating known sources of mortality and other stressors that impair the survival of chinook salmon.*

There are three major programs to restore chinook salmon populations in the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (PL 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1996). The California Department of Fish and Game is required under state legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993).

Each of the major chinook salmon restoration /recovery programs has developed specific goals for Central Valley chinook salmon stocks. ERPP *embraces each of the restoration/recovery goals and will contribute to each agency's program by restoring critical ecological processes, functions, and habitats, and by reducing or eliminating stressors. ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERPP will contribute to maintaining a cohort replacement rate of 1.0.*

STEELHEAD TROUT (R)

POPULATION TARGET: Increase naturally spawning population number and sizes sufficient to maintain population resiliency and to allow meta-population persistence through periods of adverse climatic and ecological conditions. This would entail, at a minimum, restoring and maintaining viable populations in the upper Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, and Battle, Clear, Big Chico, Butte, Antelope, Mill, and Deer creeks (◆◆).

PROGRAMMATIC ACTION: Restoring steelhead trout populations will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants.

Actions in the Sacramento River Ecological Management Zone have been designed specifically to restore steelhead or their habitat. This species will directly benefit from previously described actions in this zone to improve or restore ecological processes and functions that create and maintain habitat and to reduce stressors that adversely affect processes, habitats, and steelhead directly. These programmatic actions address:

- Central Valley streamflows,
- natural sediment supply,
- Central Valley water temperatures,
- stream channel meander,
- natural flood and floodplain processes,
- riparian and riverine aquatic habitat,
- water diversions, dams, reservoirs, and weirs,
- levees, bridges, and bank protection,
- predation and competition,
- contaminants,
- harvest of fish and wildlife, and
- artificial propagation of fish.

Additional programmatic actions that will contribute to the recovery of steelhead are proposed for the North Sacramento Valley, Cottonwood Creek, Colusa Basin, Butte Basin, Feather River/Sutter Basin, American River, Eastside Delta Tributaries, San Joaquin River East San Joaquin, Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones.

***RATIONALE**: NMFS has identified steelhead populations in the Central Valley as composing a single evolutionarily significant unit (ESU) based on a variety of physical and biological data. These data include the physical environment (geology, soil type, air temperature, precipitation, riverflow patterns, water temperature, and vegetation); biogeography (marine, estuarine, and freshwater fish distributions); and life history traits (age at smolting, age at spawning, river entry timing, spawning timing, and genetic uniqueness).*

The Central Valley steelhead ESU encompasses the Sacramento River and its tributaries and the San Joaquin River and its tributaries downstream of the confluence with the Merced River (including the Merced River). Recent data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Hatchery are well differentiated from all other samples of steelhead from California Busby et al. 1996; NMFS 1997).

Within the broad context of ecosystem restoration, steelhead restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes, or that are nonspecific to steelhead trout. For example, restoration of riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetation/successional processes. These will be extremely important in providing shaded riverine aquatic habitat, woody debris, and other necessary habitats required by lower trophic organisms and juvenile and adult steelhead populations.

Operation of the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout. Inadequate connectivity between upstream holding, spawning, and rearing habitat in certain tributary streams has impaired or reduced the reproductive potential of most steelhead stocks. Providing stream flows, improving fish ladders, and removing dams will contribute greatly to efforts to rebuild steelhead populations.

Strategic Plan Priority Group II: At-risk native species dependent on the Bay-Delta system whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed (e.g., brackish water plants).

LAMPREY FAMILY

POPULATION TARGET: Evaluate the status and life history requirements of Pacific lamprey and river lamprey in the Central Valley and determine their use of the Delta and Suisun Bay for migration, breeding, and rearing (◆◆).

PROGRAMMATIC ACTION: Actions directed to remediate stream flow deficiencies, water temperatures, sediment transport, fish passage, and water quality will contribute to maintaining and increasing lamprey populations in Central Valley rivers and streams.

***RATIONALE**: Lampreys are anadromous species that clearly have declined in the Central Valley although the extent of the decline has not been documented. Pacific lamprey probably exist in much of the accessible habitat available today but this is not known. The decline of lampreys is presumably due to deterioration of their spawning and rearing habitat, to entrainment in diversions, and to other factors affecting fish health in the system.*

CALIFORNIA CLAPPER RAIL (r)

POPULATION TARGET: Restore sufficient saltmarsh habitat to connect and combine separated saltmarsh habitat areas that support California clapper rail populations. This will enlarge protected areas and reduce intermarsh distances (◆◆).

PROGRAMMATIC ACTION: Restoring saltmarsh and tidal emergent wetland habitat would directly benefit the California clapper rail population. Reduction in boat wakes which disturb nesting rails would also contribute to recovery.

***Rationale:** The primary reason attributable to the decline in California clapper rail populations is the extensive loss of its historical salt marsh habitat to urban, industrial, and agricultural uses (U.S. Fish and Wildlife Service 1984a). Restoration of large expanses of suitable salt marsh habitat within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

CALIFORNIA BLACK RAIL(r)

POPULATION TARGET: Enhance and restore tidal marshes and adjacent perennial grassland habitats in the Delta (◆◆).

PROGRAMMATIC ACTION: Restoring tidal marsh habitat would indirectly benefit California black rail population. Actions to reduce boat wake disturbance would also contribute to recovery.

RATIONALE: *The primary reason attributable to the decline in California black rail populations is the extensive loss of its historical tidal marsh habitat to urban, industrial, and agricultural uses. Restoration of large expanses of suitable tidal marsh habitat within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

SWAINSON'S HAWK (r)

POPULATION TARGET: Restore nesting density to nine nesting pairs per 100 square miles; improve foraging habitat on Delta land; and increase riparian forest and oak woodlands (◆◆◆).

PROGRAMMATIC ACTION: Restore riparian woodlands and improve wildlife habitat values on agricultural lands.

RATIONALE: *Historically, Swainson's hawk foraging habitat consisted of large expanses of open grasslands that supported abundant prey species. Swainson's hawks typically nest in riparian forests, small groves of trees, or lone trees within open habitats. Today, as a result of conversion of large expanses of historic grassland to urban, industrial, and agricultural uses, agricultural lands are major foraging habitat areas for Swainson's hawks. Some types of agriculture, however, are unsuitable because they do not support sufficient prey populations or because prey is unavailable as a result of dense vegetation (e.g., rice and vineyards). Over 85% of nesting territories in the Central Valley are associated with riparian systems adjacent to suitable foraging habitats (California Department of Fish and Game 1992). Consequently, improving prey abundance and availability on agricultural lands adjacent to restored riparian habitats will provide important elements of the specie's habitat necessary for the population to expand.*

SUISUN SONG SPARROW (R)

POPULATION TARGET: Increase the population of breeding pairs of Suisun song sparrow between 70 and 100 percent compared to existing population estimates of 6,000 (◆◆).

PROGRAMMATIC ACTION: Encourage the growth of upland vegetation on the upper banks of levees to provide upland cover to protect against predation during high tides and high flows.

PROGRAMMATIC ACTION: Establish additional and protect existing dispersal corridors of suitable tidal brackish marsh along the banks of tidal sloughs.

PROGRAMMATIC ACTION: Maintenance activities should be conducted to minimize disturbance to tidal brackish marsh vegetation and should not disturb breeding adults.

PROGRAMMATIC ACTION: Restore tidal habitat as specified for tidal saline emergent wetland in appropriate areas with particular emphasis on expanding existing fragments of habitat to expand the number of known nesting territories in the Suisun Marsh by 100 percent.

RATIONALE: *The Suisun song sparrow occurs only in and near Suisun Marsh, in about 13 isolated populations. Populations of this unusual subspecies are declining for a variety of reasons but mainly the degradation of their habitat. Reductions in fresh water outflow from the Sacramento-San Joaquin Rivers and diking and channelization of marsh lands have contributed to their decline. Restoration of their populations is* *likely to be a good indicator of the success of restoration of brackish tidal marshes in the Suisun Marsh area.*

ALAMEDA SONG SPARROW (nc)

POPULATION TARGET: Connect fragmented habitat to increase gene flow between populations. Conduct genetic studies as well as juvenile dispersal studies to determine effective management of the species (◆◆).

PROGRAMMATIC ACTION: All Alameda song sparrow populations will have been identified and protected from further development and habitat alteration. Pilot restoration projects will have been undertaken to develop protocols for habitat restoration efforts.

***RATIONALE**: Alameda song sparrows are one of the species that uses saltmarsh habitat in the south San Francisco Bay region. By protecting the saltmarsh habitat not only will this species benefit but the other inhabitants of the marsh ecosystem will also benefit. Restoration of this species would be a good indicator to the overall health of the marsh system.*

SALT MARSH HARVEST MOUSE (r)

POPULATION TARGET: Increase the existing population by 100% (◆◆).

PROGRAMMATIC ACTIONS: Restore high tidal marsh habitats in proximity to upland habitats in the Suisun Marsh/North San Francisco Bay Ecological Management Zone consistent with the recovery plan for this species.

***RATIONALE:** The primary reason attributable to the decline in salt marsh harvest mouse populations is the extensive loss of its historical high tidal salt marsh and adjacent upland habitats to urban, industrial, and agricultural uses (U.S. Fish and Wildlife Service 1984a). Restoration of large expanses of suitable salt marsh habitat adjacent to uplands within the species historical and current range, therefore, will provide habitat area necessary for populations to expand.*

SUISUN ORNATE SHREW (R)

POPULATION TARGET: Identify the remaining populations of Suisun ornate shrew and develop a conservation plan to stop the decline of this species (◆◆).

PROGRAMMATIC ACTION: Identify all remaining populations of Suisun ornate shrew and develop and implement protection/restoration plans.

***RATIONALE**: The Suisun ornate shrew is a listed as a species of special concern by the California Department of Fish and Game, but its limited habitat and distribution indicate it may qualify as a threatened species. Long-term survival of this subspecies is dependent upon tidal wetland, as opposed to diked wetlands, and has to have adequate physical structures and plant communities for survival. Its tidal marsh habitat has to have adjacent upland habitat for survival of the species during periods when the marsh is inundated. The upland habitat has to have relatively low densities of exotic predators. Restoring habitat would not only benefit the Suisun ornate shrew but other species, such as the salt marsh harvest mouse, that also use tidal marsh and upland marsh habitats.*

SAN PABLO CALIFORNIA VOLE (r)

POPULATION TARGET: Determine the distribution and taxonomic status of the vole while maintaining existing salt marsh habitat known to contain populations (◆◆).

PROGRAMMATIC ACTION: Undertake wetland restoration projects in and adjacent to known populations to increase available habitat.

***RATIONALE**: The San Pablo vole is a California Department of Fish and Game Special Concern species. Although little is known about its* *distribution, biology, or taxonomy, it appears to be a distinct form that is confined to salt marshes and adjoining grasslands in Contra Costa County. To limit the decline of the populations even further, salt marsh and adjoining grassland habitats in Contra Cosa County need to be protected and further degradation and loss of habitat halted.*

VALLEY ELDERBERRY LONGHORN BEETLE (R)

POPULATION TARGET: Protect known occupied habitat and suitable habitat within the suspected historical range of the valley elderberry longhorn beetle from loss or degradation (◆◆).

PROGRAMMATIC ACTION: Survey riparian vegetation along Central Valley rivers to determine the presence of additional populations and protect occupied habitat areas from activities detrimental to the valley elderberry longhorn beetle.

Programmatic actions designed to protect, restore, and enhance riparian habitats along Central Valley rivers, including elderberry shrubs (the valley elderberry longhorn beetle's host plant), will protect existing occupied habitat areas and increase the area of suitable habitat within the species suspected historical range.

RATIONALE: *The primary reason attributable to the decline in numbers and distribution of the valley elderberry longhorn beetle populations is the extensive loss or degradation of its historical riparian habitats in the Central Valley to urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1984b). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

Priority Group III: At-risk species that primarily live upstream of the estuary or in local watersheds of San Francisco Bay.

SACRAMENTO PERCH (r)

POPULATION TARGET: Evaluate the status and biology of Sacramento perch to determine if restoration of wild populations within its native range is feasible (◆).

PROGRAMMATIC ACTION: Complete a thorough status review of the Sacramento perch and develop a plan for its long-term preservation in the Central Valley. Establish at least one experimental population in the Delta.

***RATIONALE**: The Sacramento perch was once one of the most abundant fish in lowland habitats of the Central Valley. With the exception of a small population in Clear Lake, it has been extirpated from natural habitats within its native range due to competition and predation from introduced centrarchid fishes, such as black bass. It would be certainly be formally listed as an endangered species except that it has been widely introduced into reservoirs, lakes, and ponds outside its native habitats in California and other western states.*

RIPARIAN BRUSH RABBIT (r)

POPULATION TARGET: Establish five additional populations and increase the population of riparian brush rabbits by 200 percent over current estimates so that a census of the riparian brush rabbit population would be two times higher than the current estimate of 213 to 312 individuals (◆◆).

PROGRAMMATIC ACTION: Reestablish 500 acres of large contiguous areas of riparian forest habitat that have dense brushy understories with adjacent upland habitat. These restored/reestablished riparian forests would have adjacent upland habitat with sufficient cover. Establish five additional populations elsewhere within the historic range of the riparian brush rabbit; each population should have a self-sustaining populations with a minimum of 250 individuals each. Maintain and establish connectivity between key habitats.

PROGRAMMATIC ACTION: Prohibit ground cover and litter removal to allow for dense brushy and herbaceous areas of a minimum size of 550 square yards within the riparian forest.

PROGRAMMATIC ACTION: More closely approximate the natural hydrological regime which allows for establishment and maintenance of mature riparian forest habitat. Additionally, encourage growth of wild rose, coyote bush, blackberries, elderberries, wild grape, box elder, valley oak, and cottonwoods to provide habitat.

PROGRAMMATIC ACTION: Provide high ground adjacent to current and expanded habitat with cover for protection from floods. Existing flood control levees adjacent to the Park could be utilized for this escape habitat in this area to provide sufficient vegetative growth of grasses, forbs, and shrubs to lower predation pressure during these times.

PROGRAMMATIC ACTION: Provide fire breaks around current and expanded habitat to protect habitat destruction due to wildfire and control feral cat and dog population with yearly control efforts within and adjacent to the Park. Prohibit dogs within Caswell Memorial State Park.

RATIONALE: *Protection and restoration of existing occupied riparian brush rabbit habitat at Caswell Memorial State Park and actions to reduce the probability for mortality as a result of flooding, fire, and predation are major objectives of the species recovery plan (U.S. Fish and Wildlife Service 1997).*

SAN JOAQUIN VALLEY WOODRAT (r)

POPULATION TARGET: Increase the population sizes along the San Joaquin River in Stanislaus, Merced, and San Joaquin Counties to the point where the woodrat will no longer be regarded as threatened (◆◆).

PROGRAMMATIC ACTION: Actions to protect and restore riparian brush rabbit habitat at Caswell Memorial State Park where the only known San Joaquin valley woodrat population occurs and actions that will restore and protect riparian habitat along the San Joaquin River and its tributaries within the species current and historical range will benefit this species.

RATIONALE: *The primary reason attributable to the decline in numbers and distribution of the San Joaquin Valley woodrat populations is the extensive loss and fragmentation of its historical riparian habitats in the San Joaquin Valley urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1997). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

GREATER SANDHILL CRANE (r)

POPULATION TARGET: Establish two new suitable roosting habitat areas in the Delta; enhance foraging habitat on agricultural lands; restore perennial grasslands in the East Delta Ecological Management Unit, and restore seasonally managed nontidal marshes in the East Delta Ecological Management Unit (◆◆◆).

PROGRAMMATIC ACTIONS: Restoring nontidal emergent wetland, perennial grasslands, seasonal wetlands, and agricultural foraging habitat would indirectly benefit the greater sandhill crane population.

RATIONALE: *Suitable shallow-water roosting habitat used by greater sandhill cranes during winter in the Delta is limited. Restoration and management of seasonal wetlands specifically to provide suitable roosting habitat free from disturbance near suitable foraging habitats will increase the area of available roosting habitat and may improve distribution of wintering cranes. Increases in food availability and abundance on agricultural lands will also be likely to improve distribution and winter survival of cranes in the Delta.*

CALIFORNIA YELLOW WARBLER (r)

POPULATION TARGET: Increase breeding populations and develop restoration projects that will benefit migrating individuals (◆◆).

PROGRAMMATIC ACTION: Actions to protect and restore riparian habitats used by the California yellow warbler will increase the quantity and quality of habitat for this species.

RATIONALE: *Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds. Improved habitat for songbirds also provides habitat for many other species of animals and plants.*

WESTERN LEAST BITTERN (r)

POPULATION TARGET: Develop wintering habitat for least bitterns by creating "no disturbance" refuges along the central corridor of the Central Valley and Delta for all shore and wading birds (◆◆).

PROGRAMMATIC ACTION: Conduct a thorough review of the status and habitat requirements of western least bittern. Establish "no disturbance" refuges to protect wintering habitat of bitterns and other wading and shore birds from human disturbance.

RATIONALE: *The western least bittern, a California Department of Fish and Game Species of Special Concern nests in emergent wetlands of cattails and tules in the upper and lower reaches of the Central Valley and winters in marshlands along the main rivers and in the Delta. Least bitterns were apparently once a common wintering bird in the Central Valley but are now scarce. The loss of wintering habitat as a result of channelization and reclamation of marsh lands along the major rivers and Delta has been a major factor in their decline.*

LEAST BELL'S VIREO (r)

POPULATION TARGET: Recover least Bell's vireo populations to the point where it can be removed from state and federal endangered species lists (◆).

PROGRAMMATIC ACTION: Actions to protect and restore suitable riparian habitat within the historical range of the least Bell's vireo in the Central Valley will increase the quantity and quality of suitable habitat available to accommodate the potential future expansion of the species current range.

RATIONALE: *A major reason attributable to the extirpation of the least Bell's vireo from its historical range in the Central Valley is the extensive loss and fragmentation of its historical riparian habitats to urban and agricultural uses, and flood control and water supply projects to support those uses (U.S. Fish and Wildlife Service 1998). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical range is an objective of the least Bell's vireo recovery plan (U.S. Fish and Wildlife Service 1998) and will provide habitat area necessary for existing populations to expand.*

WESTERN YELLOW-BILLED (r) CUCKOO

POPULATION TARGET: Improve riparian forest habitat in the Delta (◆◆).

PROGRAMMATIC ACTIONS: Improve and restore riparian forest habitat.

TARGET: Protect existing large patches and restore suitable mature, dense willow-cottonwood riparian forests used by nesting cuckoos (◆◆).

PROGRAMMATIC ACTION: The primary focus area for restoration of the yellow-billed cuckoo is the Delta. No actions in the Sacramento River Ecological Management Zone have been designed specifically to restore yellow-billed cuckoos or their habitat. However, this species will directly benefit from actions in this zone to increase the areal extent and distribution of riparian and riverine aquatic habitats (see implementation objective, targets, and programmatic actions that address riparian and riverine aquatic habitat).

RATIONALE: *The primary reason attributable to the decline in numbers and distribution of the western yellow-billed cuckoo is the extensive loss or degradation of its historical riparian forest habitats in the Central Valley to urban and agricultural uses, and flood control and water supply projects to support those uses (California Department of Fish and Game 1992). Protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical and current range, therefore, will protect existing populations from future decline and provide habitat area necessary for existing populations to expand.*

BANK SWALLOW (r)

POPULATION TARGET: Protect existing nesting colonies and the ecological processes that contribute to the formation and maintenance of vertical stream banks (◆◆).

PROGRAMMATIC ACTIONS: No actions in the Sacramento River Ecological Management Zone have been designed specifically to restore bank swallows or their habitat. However, this species will directly benefit from actions in this zone to increase the areal extent and distribution of riparian and riverine aquatic habitats, stream channel corridor, natural flood and floodplain processes, and natural sediment supply (see implementation objective, targets, and programmatic actions that address riparian and riverine aquatic habitats, stream channel corridor, natural flood and floodplain processes, and natural sediment supply).

RATIONALE: *The decline in numbers and distribution of bank swallow populations is attributable to the loss of the natural depositional and erosional processes of rivers that create and sustain the types of channel bank nesting substrates required by the species largely as a result of flood control projects that have impeded the ability of rivers to erode their banks (California Department of Fish and Game 1992). Restoration of the ability of channels of major rivers in the Central Valley to erode their banks will increase the availability of suitable nesting habitat, providing the additional habitat area necessary for existing populations to expand.*

LITTLE WILLOW FLYCATCHER (r)

POPULATION TARGET: Establish enough self-sustaining populations of little willow flycatcher so that the species can be removed from the state list of endangered species (◆).

PROGRAMMATIC ACTION: Actions to protect and restore suitable riparian habitat within the historical breeding range of the little willow flycatcher in the Central Valley will increase the quantity and quality of suitable habitat available to accommodate the potential future expansion of the species current range.

***RATIONALE**: A major reason attributable to the extirpation of the little willow flycatcher as a breeding species from its historical range in the Central Valley is the extensive loss and fragmentation of its historical riparian habitats to urban and agricultural uses, and flood control and water supply projects to support those uses (Zeiner et al. 1990, California. Department of Fish and Game 1992). Consequently, the protection, restoration, and enhancement of large expanses of suitable riparian habitat within the species historical range will provide habitat area necessary for existing populations to expand.*

GIANT GARTER SNAKE (r)

POPULATION TARGET: Maintain present populations with no further declines in size by ensuring that waterways known to being used by giant garter snakes have water in them year round (◆◆).

PROGRAMMATIC ACTION: Maintain existing natural habitats that have available water all year and identify key habitats in agricultural areas for special management.

***RATIONALE**: The giant garter snake is listed by both state and federal governments as a threatened species. Most of the original giant garter snake habitat, freshwater marshes, has been lost to agriculture. This snake resides in marsh habitat where there are pools and sloughs that exist year round to provide the frogs and invertebrates on which they feed. This snake survives today because small numbers live in rice fields and along irrigation ditches. Survival of the species, however, is likely to depend upon increasing its natural habitat through marsh restoration combined with special protection measures on the agricultural land it currently inhabits.*

CALIFORNIA RED-LEGGED FROG (r)

POPULATION TARGET: Create viable, self-sustaining populations of red-legged frog while enhancing existing and restored aquatic habitats for other native species (◆).

PROGRAMMATIC ACTION 1A: Develop watershed management plans to protect riparian and wetland areas occupied by red-legged frogs.

TARGET: Manage restored aquatic and wetland habitat to minimize predation on red-legged frog by non-native fish, bullfrogs, and crayfish (◆).

PROGRAMMATIC ACTION: Reduce exotic predators such as bullfrogs, black bass, sunfish, and crayfish and restore habitat by creating canals, side channels, and backflow pools containing emergent vegetation. Provide the critical components of reproductive, forage and escape cover.

***RATIONALE:** Red-legged frogs are virtually extinct in the region, with just a handful of tenuous populations remaining in the Central Valley and bay region (none near the estuary). Their inability to recover from a presumed major population crash in the 19th century (due to overexploitation) has been the result of a combination of factors (in approximate order of importance): (1) predation and competition from introduced bullfrogs and fishes; (2) habitat loss, (3) pesticides and other toxins, (4) disease, and (5) other factors. Because of the poor condition of the few remaining frog populations and the continued existence of major* *causes of their decline, this objective may not be achievable in either the short or long term.*

CALIFORNIA TIGER SALAMANDER (m)

POPULATION TARGET: Increase populations of tiger salamanders by increasing natural flood plains, stream meander, seasonal pools, and perennial grasslands (◆).

PROGRAMMATIC ACTIONS: The California tiger salamander will benefit indirectly from restoration of natural flood plains. A regulated management grazing program could benefit vernal pool habitats that support these species. Mowing and cattle grazing should be minimized near seasonal wetlands utilized by either species from October to March. Reduce mortality from vehicle deaths, especially during the brief window when tiger salamanders are migrating by locating restored habitat in areas well removed from regular vehicle traffic. Fumigants to control rodents should be used only from October to March in known occupied habitats since rodent burrows are required during the summer. Draining pertinent water ways during the native species' dormant season could result in a reduction in populations of large, introduced, predatory fish and bullfrogs.

Restore at least five core areas of suitable habitat, each consisting of about 500 acres in each of the North, East, and South Delta Ecological Management Units.

PROGRAMMATIC ACTIONS: Enhance existing poor habitats and restore new habitats in historical wetlands, grasslands, and upland areas.

RATIONALE: *California tiger salamander populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat containing rodent burrows in which they can over-summer. Patches of suitable habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local conditions. Long-term survival of these diverse populations depends on numerous protected areas containing both breeding ponds and upland habitats.*

WESTERN POND TURTLE (m)

POPULATION TARGET: Determine the status and habitat requirements of pond turtles throughout the region and develop a conservation strategy in concert with habitat protection measures (◆◆).

PROGRAMMATIC ACTION: Locate and protect populations of turtles that appear to still have successful reproduction. Causes of the decline should be determined and a recovery plan developed based on the findings.

RATIONALE: *The western pond turtle is the only turtle native to the Central Valley region and to much of the western United States. Although considered to be just one widely distributed species, it is likely that the pond turtle is a complex of closely related species, each adapted for a different region. The Pacific pond turtle is still common enough in the Bay-Delta watershed so that it is not difficult to find them in habitats ranging from sloughs of the Delta and Suisun Marsh to pools in small streams. The problem is that most individuals seen are large, old individuals; hatchlings and small turtles are increasingly rare. The causes of the poor reproductive success are not well understood but factors that need to be considered include elimination of suitable breeding sites, predation on hatchlings by non-native predators (e.g., largemouth bass, bullfrogs), predation on eggs by non-native wild pigs, diseases introduced by non-native turtles, and shortage of safe upland over-wintering refuges. If present trends continue, the western pond turtle will deserve listing as a threatened species (it may already).*

DELTA GREEN GROUND BEETLE (r)

POPULATION TARGET: Expand the existing population of Delta green ground beetle and establish additional populations to remove it from the Federal threatened species list (◆◆).

PROGRAMMATIC ACTIONS: Increase populations of Delta Green Ground Beetle by establishing and securing habitat to support three additional viable and self-sustaining colonies of the Delta green ground beetle and maintain the existing populations.

RATIONALE: *The Delta green ground beetle is federally listed as a threatened species that is currently known only from Jepson Prairie Preserve (Solano County). Habitat requirements for this species are not clearly understood but the beetles seem to require open places near vernal pools. A better knowledge would help restoration efforts.*

LANGE'S METALMARK BUTTERFLY (R)

POPULATION TARGET: Create multiple populations of Lange's metalmark butterfly within the Antioch Dunes region (◆◆).

PROGRAMMATIC ACTION: Actions for protecting and restoring inland dune scrub habitat occupied by the Lange's metalmark at the Antioch Dunes will benefit this species.

RATIONALE: *Protection and restoration of Lange's metalmark habitat at the Antioch Dunes is a major objective of the species recovery plan (U.S. Fish and Wildlife Service 1984c).*

CALIFORNIA FRESHWATER SHRIMP (m)

POPULATION TARGET: Maintain California freshwater shrimp population abundance and distribution consistent with the recovery plan (◆).

PROGRAMMATIC ACTION: Protect and restore habitat required by the California freshwater shrimp including low elevation, low gradient perennial freshwater streams or intermittent streams with perennial pool where banks are structurally diverse with undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation.

RATIONALE: *The recovery objectives for California freshwater shrimp are: (1) to recover and delist the shrimp when viable, self-sustaining populations and their habitat are secured an managed within all watershed harboring shrimp, and (2) to enhance habitat conditions for aquatic organisms that currently coexist or have occurred historically with the California freshwater shrimp.*

Downlisting from endangered to threatened will be considered when: (1) a watershed plan has been implemented for each of four drainage units, (2) long-term protection is assured for at least one shrimp stream in each of the four drainage units, and (3) the abundance of California freshwater shrimp increases to over 2,000 individuals per stream in each of 16 streams harboring shrimp.

Delisting of California freshwater shrimp will be considered when: (1) a watershed plan has been implemented for each of four drainage units, (2) long-term protection is assured for at least eight shrimp stream with at least one in each of the four drainage units, (3) populations of California freshwater shrimp maintain stable or increasing populations of at least 2,000 individuals for at least 10 years in each of 16 streams harboring shrimp, and (4) at least 50 percent of shrimp-bearing streams have shrimp distributed over 8 kilometers (5 miles) or more (U.S. Fish and Wildlife Service 1997b).

Strategic Plan Priority Group IV: Native species in the estuary and watershed not yet at risk of extinction that have the potential to achieve that status if steps are not taken to reverse their declines or keep populations at present levels.

NATIVE RESIDENT FISHES (nc)

POPULATION TARGET: Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include improving habitat of native fishes and restoring the population of Sacramento perch (◆).

PROGRAMMATIC ACTION: Restoration of native resident species will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; improving aquatic, wetland, and riparian habitats; and reducing stressors including effects of water diversions and contaminants.

RATIONALE: *The Central Valley has a native resident fish fauna that is largely endemic to the region. Some species are extinct (thicktail chub) or nearly extinct (Sacramento perch) in the wild. While some native species (e.g., Sacramento pikeminnow [squawfish], Sacramento sucker) are clearly thriving under altered conditions, others are not (e.g., hitch, Sacramento blackfish, hardhead). There is a need to determine if some have unique problems or requirements that will prevent them from responding to general habitat improvements.*

WATERFOWL (nc)

POPULATION TARGET: Improve populations and distribution of waterfowl (◆◆).

PROGRAMMATIC ACTIONS: Waterfowl will indirectly benefit from restoration of sloughs, marshes, riparian, and tidal and nontidal ponds and lakes.

RATIONALE: *Waterfowl resources will be enhanced by protecting existing and restoring additional seasonal, permanent, and tidal wetlands. Improved management of agricultural lands using wildlife friendly methods will contribute to sustaining waterfowl resources in the Bay-Delta. The focus for seasonal wetlands should be in areas that may be too deep for tidal marsh restoration over the next 20 years. In concert with efforts to reduce or reverse subsidence, selected areas or islands would be managed as waterfowl habitat. Besides increasing waterfowl resources, efforts to sustain waterfowl and their habitat will help offset some of the effects of converting agricultural or seasonal wetlands to tidal action when such actions may reduce the value of an area to waterfowl such as white-fronted geese or mallard. Efforts should also be focused on improving waterfowl nesting success by improving nesting and brood habitat. Improving waterfowl populations will be done in a manner that reduces conflict with broader ecosystem restoration goals or with goals to recover endangered species. For example: Flooding of rice fields for waterfowl in late winter may require water needed by migratory salmon. Careful management of the amount and timing of those diversions and the manner in which the diversions occur (e.g. through screened diversions) can help reduce conflicts. Management of waterfowl areas will occur using management strategies developed for existing and new waterfowl areas that provide benefits to at-risk species.*

SHOREBIRD GUILD (nc)

POPULATION TARGET: Improve populations and distribution of shorebirds birds (◆◆).

PROGRAMMATIC ACTIONS: Shorebirds and wading birds will indirectly benefit from restoration of wetlands and tidal and nontidal perennial aquatic habitat (ponds and lakes).

RATIONALE: *Loss and degradation of wetland and aquatic habitats used by wintering and* *migrant shorebirds in the Central Valley is a factor limiting populations of these species. Large-scale restorations of these habitats will increase the available foraging habitat area to better accommodate existing populations and potential future expansions of shorebird populations.*

WADING BIRD GUILD (nc)

POPULATION TARGET: Improve populations and distribution of wading birds (◆◆).

PROGRAMMATIC ACTION: Wading birds will indirectly benefit from restoration of wetlands, tidal and nontidal perennial aquatic habitat (ponds and lakes), and riparian habitat.

RATIONALE: *Substantial loss and degradation of aquatic, wetland and riparian habitats used by wintering and resident wading birds in the Central Valley is a factor limiting populations of these species. Large-scale restorations of these habitats will increase the available foraging, roosting, and nesting habitat area to better accommodate existing populations and future potential expansions of wading bird populations.*

NEOTROPICAL MIGRATORY BIRDS (nc)

POPULATION TARGET: Increase the abundance and distribution of neotropical migratory birds in the Central Valley (◆◆).

PROGRAMMATIC ACTIONS: The following types of general programmatic actions will assist in meeting the target for neotropical migratory birds:

- increase wetland, riparian, grassland, and agricultural habitats,
- improve watershed health,
- improve specific nesting habitats for individual species within their existing and restored habitats, and
- protect nesting habitats from predators and human disturbance.

RATIONALE: *Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds.*

WESTERN SPADEFOOT (m)

POPULATION TARGET: Identify and protect remaining spadefoot toad populations in the Bay-Delta watershed (◆).

PROGRAMMATIC ACTION: Conduct a thorough survey of spadefoot toad populations in the Bay-Delta watershed and take actions to protect remaining populations in counties bordering the Bay-Delta system.

RATIONALE: *Spadefoot toad populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat in which they can burrow for over summering. These habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to* *local habitat conditions. Long-term survival of spadefoot toad populations depends on protected areas containing both breeding ponds and upland habitats.*

BAY-DELTA FOODWEB ORGANISMS (nc)

POPULATION TARGET: Increase populations and distribution of important foodweb organisms in Delta channels and reduce competition with invasive non-native species (◆◆).

PROGRAMMATIC ACTION: Actions in the Sacramento-San Joaquin Delta Ecological Management Zone that will contribute to reaching the target for Bay-Delta aquatic foodweb organisms include improvements to ecological processes such as Central Valley streamflows, natural floodplain and flood processes, and Delta channel hydraulics; improving habitats such as tidal perennial aquatic habitat, Delta sloughs, and fresh emergent wetland habitat; and the reduction or elimination of the adverse effects of stressors such as water diversion, dredging and sediment disposal, invasive aquatic plants, invasive aquatic organisms, and contaminants.

RATIONALE: *The population target is quite likely impossible to achieve because recent invading species, from the Asiatic clam to various crustacean zooplankters, will continue to play major ecological roles in the system, to the detriment of native organisms. However, at the very least it is possible to stop further introductions of non-native species which have the potential to further change the system unpredictably. This target is also a call to develop a thorough understanding of the planktonic portion of the Bay-Delta system to predict and understand the impacts of large-scale ecosystem alteration projects on the plankton.*

Strategic Plan Harvested Species

WHITE STURGEON (nc)

POPULATION TARGET: Meet Native Fish Recovery Plan goals (U.S. Fish and Wildlife Service 1996), which include 100,000 white sturgeon and 2,000 green sturgeon greater than 100 centimeters long as measured in the DFG mark-recapture program (◆◆).

PROGRAMMATIC ACTIONS: Sturgeon restoration will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics and the Delta aquatic foodweb, and reducing stressors, including effects of water diversions and contaminants.

RATIONALE: *White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game, have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.*

STRIPED BASS (nc)

POPULATION TARGET: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities (◆◆).

PROGRAMMATIC ACTION: Restoring striped bass will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants. To meet target population level may require, at least in the short-term, supplementing young production through artificial rearing and stocking of young striped bass salvaged at south Delta fish facilities or raised in hatcheries.

TARGET: Maintain an adult population of 3.0 million adult fish (◆).

PROGRAMMATIC ACTION: Achieving the target population of 3.0 million adult striped bass will require restoration actions in the San Joaquin River, Sacramento-San Joaquin Delta, and Sacramento River Ecological Management Zones. Within the Sacramento River Ecological Management Zone, proposed programmatic actions for Central Valley stream temperatures, Central Valley stream flow, and water diversions will contribute to restoration of striped bass.

RATIONALE: *The striped bass is a non-native species that is a favorite sport fish in the estuary. It is also the most abundant and voracious piscivorus fish in the system and it has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management for striped bass must juggle the objectives of providing opportunities for harvest while not jeopardizing recovery of native species. An appropriate policy may be to allow striped bass to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially artificial propagation. Artificially reared bass have the potential to depress not only native fish populations but also populations of wild striped bass, because larger juveniles (of hatchery origin) may prey on smaller juveniles (of wild origin). If increases in bass numbers appear to adversely affect recovery of native species, additional management measures may be required to keep bass numbers below the level that pose a threat to native species.*

AMERICAN SHAD (nc)

POPULATION TARGET: The target for American shad is to maintain production of young as measured in the fall midwater trawl survey and targets of the Anadromous Fish Restoration Program (US Fish and Wildlife Service 1997, in preparation). Specifically, the index of young American shad production should increase, especially in dry water years (◆).

PROGRAMMATIC ACTION: Restoring American shad populations will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics, improving the Delta aquatic foodweb, and reducing stressors, including the effects of water diversions and contaminants.

TARGET: Maintain a 25-year average index of abundance equal to the 1967 through 1976 fall midwater trawl index (◆).

PROGRAMMATIC ACTION: Actions in the Sacramento River Ecological Management Zone have been designed specifically to restore American shad and its habitat. This species will directly benefit from actions in this zone to increase the areal extent and distribution of riparian and riverine aquatic habitats (See implementation objective, targets, and programmatic actions that address riparian and riverine aquatic habitat.) Additional programmatic actions that will contribute to restoration of American shad are proposed for the Feather River/Sutter Basin, American River Basin, San Joaquin River, and Sacramento-San Joaquin Delta Ecological Management Zones.

RATIONALE: *The American shad is a non-native species that is an important sport fish in the estuary and its spawning streams, although less seems to be known about its life history in the* *estuary than any other major game fish. It is a common planktivore and occasional piscivore in the system and it may have the potential to limit the recovery of native species, such as chinook salmon. Therefore, the management for American shad must juggle the objectives of providing opportunities for harvest without jeopardizing recovery of native species. An appropriate policy may be to allow American shad to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially flow releases specifically to favor shad reproduction. If increases in shad numbers appear to adversely affect recovery of native species, additional management measures may be required to keep shad numbers below the level that pose a threat to native species.*

NON-NATIVE WARMWATER GAMEFISH (nc)

POPULATION TARGET: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health) (◆◆).

PROGRAMMATIC ACTION: Conduct studies to find out how major CALFED actions are likely to affect the warmwater fish and fisheries and how the fishes affect the recovery of native at-risk species. In particular, the potential of the non-native fishes to use and dominate newly created warmwater habitat will have been thoroughly investigated.

***RATIONALE**: White catfish, channel catfish, brown and black bullhead, largemouth bass, and various sunfishes are among the most common fishes caught in the sport fishery in the Delta, Suisun Marsh, riverine backwaters, reservoirs, and other lowland waters. Although this fishery is poorly documented, it is probably the largest sport fishery in central California in terms of people engaged in it and in terms of numbers of fish caught. There is no sign of overexploitation of the fishes, although some (e.g., white catfish) have remarkably slow growth rates, indicating vulnerability to overexploitation. The fishes and the fishers are always going to be part of the lowland environment and deserve support of the management agencies. However, habitat improvements that favor native fishes, especially improvements that increase flows or decrease summer temperatures, may not favor these game fishes. The effects of the various CALFED actions on these fish and fisheries need to be understood, as do the interactions among the non-native fishes and the native fish CALFED is trying to protect.*

PACIFIC HERRING (nc)

POPULATION TARGET: Increase abundance of marine/estuarine fish and large invertebrates, particularly in dry years (◆).

PROGRAMMATIC ACTIONS: General programmatic actions that will contribute to the target include improving winter/spring Delta outflow, restoring tidal wetland habitat, improving the aquatic foodweb, reducing losses of larvae and juvenile marine/estuarine fishes at water diversions in the Bay and Delta, limiting the introductions of non-native species, and reducing the input of toxic substances into Central Valley waterways.

***RATIONALE:** Pacific herring support the most valuable commercial fishery in San Francisco Bay. This seasonal, limited-entry fishery focuses on spawning fish, for the fish themselves, their roe, and kazunoko kombu (herring eggs on eel grass). It seems to be an example of successful fishery management because it has been able to sustain itself through a series of years with highly variable ocean and bay conditions. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since* *the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.*

GRASS SHRIMP (nc)

POPULATION TARGET: Maintain grass shrimp populations at present levels as a minimum to support the existing commercial fisheries. Determine factors regulating their populations in order to discover if the fisheries conflict with other ecosystem restoration objectives (◆◆).

PROGRAMMATIC ACTION: Conduct an investigation of the ecological role and requirements of the shrimp species and the effects of the fishery to find out if any special management for either is needed.

***RATIONALE**: Grass shrimp are a mixture of native and introduced species that support a small commercial fishery in San Francisco Bay, largely for bait. The relative abundance of the various species as well as their total abundance appears to be tied in part to outflow patterns. It is likely that these abundant shrimp are important in Bay-Delta food webs leading to many other species of interest. The role of these shrimp in the Bay-Delta system and the effects of the fishery on that role need to be investigated.*

SIGNAL CRAYFISH (nc)

POPULATION TARGET: Maintain signal crayfish populations at present levels, in order to support the existing fisheries (◆◆).

PROGRAMMATIC ACTION: Conduct an investigation of the ecological requirements of the crayfish and the effects of the fishery to find out if any special management for either is needed.

***RATIONALE**: The signal crayfish is an introduced species that supports a small commercial fishery, as well as a recreational fishery, in the Delta. It has been established in the Delta for nearly a century and appears to be integrated into the Bay-Delta system, appearing as a major food item for otters and some fish. The signal crayfish has fairly high water quality requirements so its populations will presumably increase as water quality in the freshwater portions of the Delta improves. Its role in the ecosystem and the effects of the fishery on that role need to be investigated.*

UPLAND GAME (nc)

POPULATION TARGET: Increase the populations and distribution of upland game (◆◆).

PROGRAMMATIC ACTION: Upland game will indirectly benefit from restoration of wetlands, perennial grasslands, riparian, and improved management of agricultural lands in the Delta.

PROGRAMMATIC ACTION: Provide high ground adjacent to current and expanded habitat with cover for protection from floods. Existing flood control levees adjacent to agricultural lands could be utilized for this escape habitat in this area to provide sufficient vegetative growth of grasses, forbs, and shrubs to lower predation pressure during these times and when adjacent lands are fallow.

***RATIONALE:** Upland game are supported by diverse agricultural and upland habitats. The key to maintaining these species is by maintaining the habitats upon which they depend.*

Table 2. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups.

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Delta Smelt	●	●												
Longfin Smelt	●	●										●		
Green Sturgeon	●	●	●					●						
Sacramento Splittail	●	●	●					●	●		●	●		
Winter-run Chinook Salmon	●	●	●	●	●		●	●	●	●	●	●	●	
Spring-run Chinook Salmon	●	●	●								●	●	●	
Fall-run Chinook Salmon (including late-fall-run)	●	●	●	●	●		●	●	●	●	●	●	●	
Steelhead Trout	●	●	●	●	●		●	●	●	●	●	●	●	
Lamprey	●	●	●	●	●		●	●	●	●	●	●	●	
California Clapper Rail		●												
California Black Rail	●	●												
Swainson's Hawk	●	●							●	●	●	●	●	
Suisun Song Sparrow		●												
Alameda Song Sparrow		●												
Salt Marsh Harvest Mouse		●												
Suisun Ornate Shrew		●												

Table 2. **Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups** (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
San Pablo California Vole		●												
Special-status Plant Species	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Valley Elderberry Longhorn Beetle	●	●	●	●	●									
Riparian Brush Rabbit	●												●	
San Joaquin Valley Woodrat	●												●	
Sacramento Perch	●	●	●	●							●	●	●	●
Greater Sandhill Crane	●													
Western Yellow-Billed Cuckoo	●		●									●	●	
Bank Swallow				●										
Western Least Bittern	●	●	●	●								●		
Least Bell's Vireo	●	●	●	●								●		
California Yellow Warbler	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Little Willow Flycatcher				●					●		●	●	●	
Giant Garter Snake	●	●				●	●		●		●	●	●	
California Tiger Salamander	●													

Table 2. **Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups** (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Western Spadefoot	●													
California Red-Legged Frog	●	●				●	●		●		●	●	●	●
Native Anuran Amphibians	●	●				●	●		●		●	●	●	●
Western Pond Turtle	●	●				●	●		●		●	●	●	
Delta Green Ground Beetle	●	●												
Lange's Metalmark butterfly	●	●												
California Freshwater Shrimp		●												
Native Resident Fish Species	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Bay-Delta Foodweb Organisms	●	●												
Shorebird and Wading Bird Guild	●	●											●	
Waterfowl	●	●	●	●	●	●	●	●	●		●	●	●	●
Neotropical Migratory Bird Guild	●	●	●	●						●	●	●	●	●
Upland Game	●		●	●						●	●	●	●	●

Table 2. Ecological Management Zones in which programmatic actions are proposed that will assist in the recovery of species and species groups (continued).

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plant Community Groups	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Striped Bass	●	●	●					●	●			●		
White Sturgeon	●	●	●					●				●		
American Shad	●	●	●					●	●			●		
Non-native Warmwater Gamefish	●	●	●							●	●	●	●	●
Pacific Herring		●												
Signal Crayfish	●		●											
Grass Shrimp		●												

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

REFERENCES

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. National Oceanic and Atmospheric Administration Technical Memorandum, NMFS-NWFSC-27: Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, Seattle.

California Department of Fish and Game. 1992. Annual report on the status of California state listed threatened and endangered animals and plants. California Department of Fish and Game. Sacramento, CA.

California Department of Fish and Game. 1998. Report to the Fish and Game Commission: a status review of the spring-run chinook salmon (Oncorhynchys tshawytscha) in the Sacramento River drainage. Candidate species report 98-01.

National Marine Fisheries Service. 1997. NMFS proposed recovery plan for the Sacramento River winter-run chinook salmon. Southwest Region, Long Beach, California. August 1997.

National Marine Fisheries Service. 1997. Status review update for deferred and candidate ESUs of west coast steelhead. National Marine Fisheries Service, West Coast Steelhead Biological Review Team.

U.S. Fish and Wildlife Service. 1984a. The salt marsh harvest mouse/California clapper rail recovery plan. U.S. Fish and Wildlife Service. Portland, OR.

U.S. Fish and Wildlife Service. 1984b. Valley elderberry longhorn beetle recovery plan. U.S. Fish and Wildlife Service. Portland, OR.

U.S. Fish and Wildlife Service. 1984c. Recovery plan for three endangered species endemic to Antioch Dunes, California. U.S. Fish and Wildlife Service. Portland, OR.

U.S. Fish and Wildlife Service. 1996. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 195 pp.

U.S. Fish and Wildlife Service. 1997a. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

U.S. Fish and Wildlife Service. 1997b. Draft California Freshwater Shrimp Recovery Plan. U.S. Fish and Wildlife Service, Region 1, Portland, Oregon.

U.S. Fish and Wildlife Service. 1997. Draft recovery plan for upland species of the San Joaquin Valley, California. U.S. Fish and Wildlife Service. Portland, OR.

U.S. Fish and Wildlife Service. 1998. Draft recovery plan for the least Bell's vireo (*Vireo bellii pusillus*). U.S. Fish and Wildlife Service. Portland, OR.

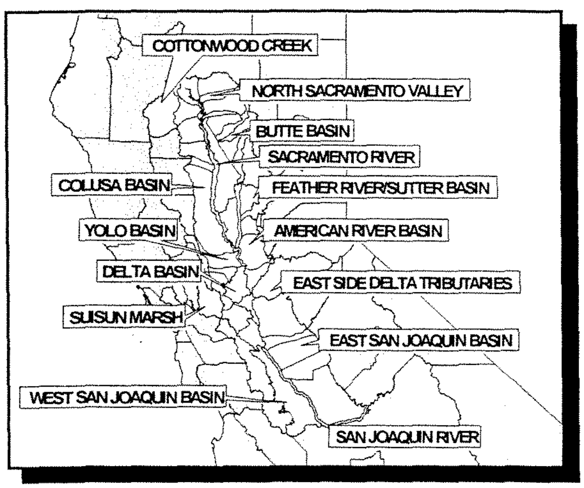
Zeiner, D.C., W.F. Laudenslayer, K.E. Mayer, and M. White. 1990. California's wildlife: volume 2: birds. California Department of Fish and Game. Sacramento, CA.

◆ ECOLOGICAL MANAGEMENT ZONES

INTRODUCTION

The following section provides the ecological management zone visions for the 14 areas that compose the ERPP study area. These include the following ecological management zones:

- Sacramento-San Joaquin Delta
- Suisun Marsh/North San Francisco Bay
- Sacramento River
- North Sacramento Valley
- Cottonwood Creek
- Colusa Basin
- Butte Basin
- Feather River/Sutter Basin
- American River Basin
- Yolo Basin
- Eastside Delta Tributaries
- San Joaquin River
- East San Joaquin
- West San Joaquin.



Location Map of the 14 ERP Ecological Management Zones

DISTINGUISHING CHARACTERISTICS

Understanding the structure, function and organization of ecosystems is necessary for planning and implementing environmental restoration, rehabilitation and protection projects. Such understanding enables managers to assess, during planning phases of a program, the degree to which prospective restoration sites diverge from a "healthy" or "natural" condition, as well as to evaluate, after actions have been undertaken, project progress and effectiveness. In a management context, perhaps the most practical means of summarizing the most relevant existing information on ecosystems is to develop, over an appropriate hierarchy of spatial and ecological scales, a list of key system attributes - those fundamental natural ecological characteristics that together define and distinguish these systems, their status, and/or their interrelationships. Such lists of attributes may serve as a convenient and necessary "check list" of environmental factors that might be addressed in an ecological restoration/rehabilitation context. At sites for which comprehensive restoration is the goal, a full suite of applicable attributes would presumably be addressed. More commonly, at sites where partial restoration (rehabilitation) is the goal, actions and efforts would be focused upon an appropriate subset of attributes.

Some individual system attributes - such as water temperature - may be evaluated directly. Others, such as "habitat continuity," are more nebulous, and must be evaluated by developing appropriate "indicators" - measurable parameters that provide a means to objectively (preferably quantitatively) evaluate individual attributes that in themselves are not readily measured. The term indicators is also used in a broader context to refer to a *subset* of system attributes (or their measurable parameters) that are derived and used *as a group* to provide a convenient way to evaluate *overall* system status. Thus, the term "indicator" is commonly used in two somewhat different ecosystem management/restoration contexts, representing two differing scales of resolution: that of *individual* attributes, or alternately, that of *groups* of attributes. In either case, "indicators" are simply a convenient way of measuring or evaluating that which is of primary concern - system attributes. An additional, and most useful tool in understanding and describing fundamental characteristics of complex systems is the use of conceptual models that integrate and diagrammatically represent the three basic *kinds* of system components: elements (attributes), their states, and the relationships that affect attribute states.

ECOSYSTEM TYPOLOGY

The ERPP study area is divided into four ecological zones, based on similarities and differences in their respective attributes. (Refer to the Key Ecological Attributes of the San Francisco Bay-Delta Watershed section of ERPP Volume I for additional details regarding the ecosystem typology.) The ecological zone designations follow:

- Upland River-Floodplain Ecological Zone
- Alluvial River-Floodplain Ecological Zone
- Delta Ecological Zone
- Greater San Francisco Bay Ecological Zone

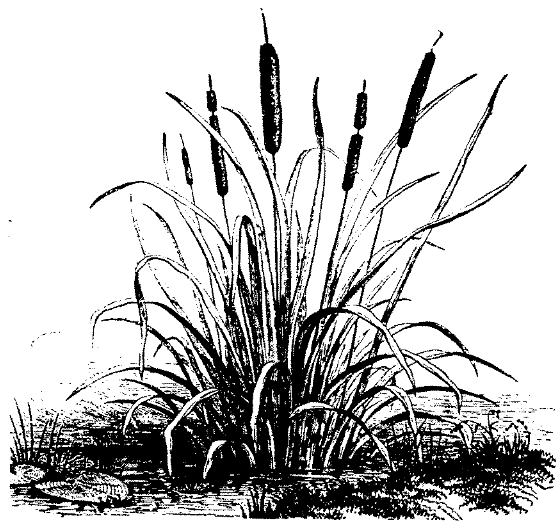
Each of the 14 ecological management zone is contained within one or more ecological zones. The following tables display the distribution of ecological managements zones within each ecological zone.

Table 3. Distribution of Ecological Management Zones within the Ecological Zone Typology.

Ecological Management Zone	Ecological Zone			
	Upland River-Floodplain	Alluvial River-Floodplain	Delta	Greater San Francisco Bay
Sacramento San Joaquin Delta			●	
Suisun Marsh/North San Francisco Bay	❍			●
Sacramento River		●		
North Sacramento Valley	●	❍		
Cottonwood Creek	●			
Colusa Basin	●	●		
Butte Basin	●	❍		
Feather River/Sutter Basin	❍	●		
American River Basin	●	●		
Yolo Basin	●	●		
Eastside Delta Tributaries	❍	●		
San Joaquin River		●		
East San Joaquin		●		
West San Joaquin	●			

● Denotes primary ecological zone, ❍ Denotes secondary or less prevalent ecological zone.

◆ SACRAMENTO-SAN JOAQUIN DELTA ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

The Sacramento-San Joaquin River Delta (Delta) is the tidal confluence of the Sacramento and San Joaquin rivers. Between the upper extent of tidewater (i.e., near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and the confluence of the two rivers near Collinsville is a maze of tidal channels and sloughs known as the Delta. 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.

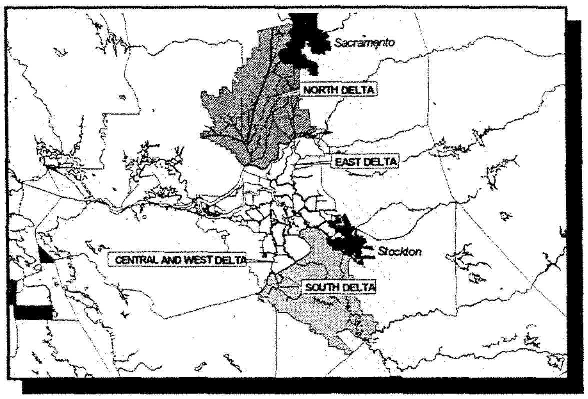
The Delta is home to many species of native and non-native fish, waterfowl, shorebirds, and wildlife. All anadromous fish of the Central Valley either migrate through the Delta or spawn in, rear in, or are dependent on the Delta for some critical part of their life cycle. Many of the Pacific Flyway's waterfowl and shorebirds pass through or winter in the Delta. Many migratory song birds 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, green sturgeon, white 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 plant communities. Special status plant species include Mason's lilaeopsis, rose-mallow (hibiscus), eel-grass pondweed, Delta tule pea, and Delta mudwort. Important plant groups or communities include pondweed with floating or submerged leaves, bulrush series, cattail series, common reed series, vernal pool communities, black willow series, narrowleaf willow series, white alder series, buttonbush series, Mexican elderberry series, and valley oak series.

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, 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.

DESCRIPTION OF THE MANAGEMENT ZONE

The Sacramento-San Joaquin Delta Ecological Management Zone is defined by the legal boundary of the Sacramento-San Joaquin River Delta. It is divided into four regional Ecological Management Units: North Delta, East Delta, South Delta, and Central and West Delta Ecological Management Units.



Location Map of the Sacramento-San Joaquin Delta Ecological Management Zone and Units.

The Delta is the easternmost portion of the estuary, and today is clearly delineated by a legal boundary that 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 (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, Calaveras River).

The Sacramento-San Joaquin Delta Ecological Management Zone is characterized by a mosaic of habitats that support the system's fish, wildlife, and plant resources. Instream and surrounding topographic features influence ecological processes and functions and are major determinants of aquatic community potential. Both the quality and quantity of available habitat affect the structure and composition of the Delta's biological communities. Currently, much of the remaining natural habitats consists 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.

Important aquatic habitats in the Delta include shaded riverine aquatic (SRA) habitat; vegetated and nonvegetated shallow shoal areas; open-ended sloughs, both large and small; and small dead-end sloughs. The large, open river channels of the Sacramento and San Joaquin rivers in the central and western Delta are more like the tidal embayments of Suisun Bay to the west of the Delta. Areas with SRA habitat are fragmented and subject to excessive erosion from wind- and boat-generated waves. Shallow shoal areas are small and fragmented and are subject to excessive water velocities and periodic dredging that degrade or scour them.

In many areas, agricultural lands have become surrogate habitat for wildlife, partially replacing native habitats. For example, natural wetlands have been replaced by rice fields as habitat for waterfowl and natural grasses have been replaced by agricultural grains, corn, and alfalfa which provide food for geese and cranes. Agricultural lands have important benefits for wildlife in the Delta, but are not a substitute for natural habitat.

Remaining channels and sloughs have been modified to become water conveyance "facilities" and flood control features. These modifications resulted in elevated water velocities and loss of structural diversity. The few remaining small dead-end sloughs have lost their SRA habitat, are choked with water hyacinth, and have poor water quality from agricultural and dairy runoff. Reclamation of Delta islands has cut off miles of dead-end sloughs that once drained extensive tidal wetlands and has significantly reduced the amount of land-water interface.

Geographic Information System (GIS) program analysis of 1906 U.S. Geological Survey maps by the Department of Fish and Game (Bay-Delta and Special Water Projects Division) provided estimates of the historical wetted perimeter in Delta sloughs and channels and tidal wetlands. *[Note: Wetted perimeter is the linear measurement of shoreline. Total wetted perimeter is compared to the total acreages of related dry land within a defined area to calculate a ratio of wetted perimeter to land acreage. Higher ratios of wetted perimeter indicate a more extensive mosaic of habitats (e.g., backwaters, sloughs, floodplains, marshes, and islands).]* The 1906 maps were the earliest available, and even then many Delta levees had already been constructed. These perimeter calculations were compared to similar data from GIS mapping by Pacific Meridian for the California Department of Fish and Game (DFG) using 1993 satellite imagery. That comparison indicated that there have been wetted perimeter reductions in three of the four Delta Ecological Management Units since 1906. Wetted perimeter reductions ranged from 25.2% to 44.7%.

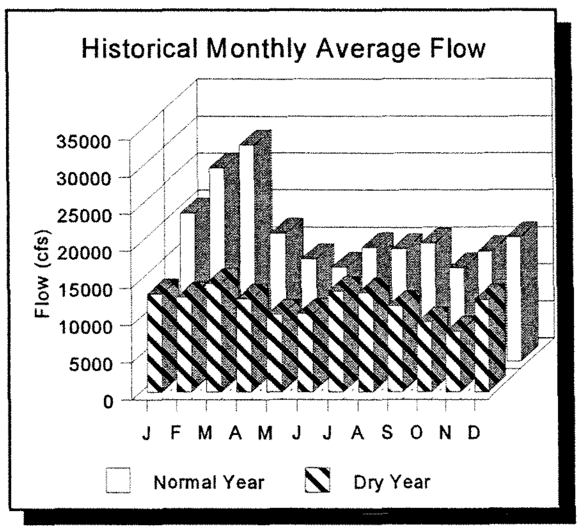
Change in Ratio of Wetted Perimeter 1906 to 1993
(Ratio of water to land acreage)

Ecological Unit	1906	1993	Percentage of change
North Delta	3.4	4.5	+32.3%
East Delta	10.5	7.1	-32.4%

Central Valley water supply and hydroelectric projects have had a large effect on the freshwater flow through the Delta. Spring flows that, before water projects, averaged 20,000 to 40,000 cubic feet per second (cfs) in dry years and 40,000 to 60,000 cfs in normal years have, in recent decades, averaged only 6,000 to 10,000 cfs in dry years and 15,000 to 30,000 cfs in normal years. In the driest years, spring flows were once 8,000 to 14,000 cfs, while under present conditions they average only 2,500 to 3,000 cfs.

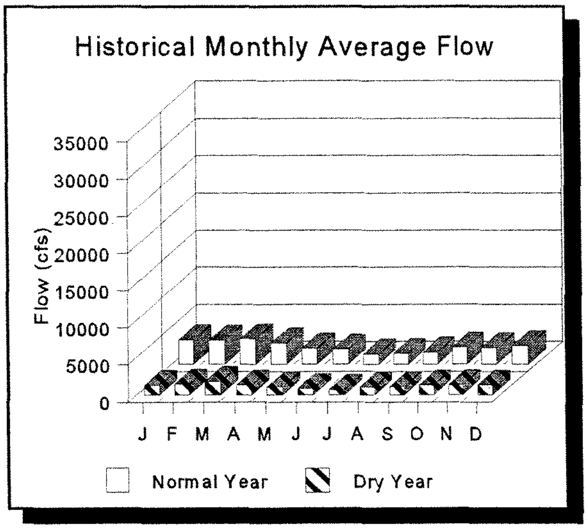
In dry and normal years, summer outflow from the Delta has remained in the 4,000 to 8,000 cfs range because water is released from reservoirs to keep salt-water from entering the Delta. Summer inflows that were only 4,000 to 8,000 cfs in dry and normal years now exceed 10,000 cfs as water is released from reservoirs to satisfy demands for water diversions.

Winter flows have fallen from the 15,000- to 60,000-cfs range to the 7,000- to 35,000-cfs range because much runoff from winter rains is now stored in foothill reservoirs. Flows in years with the highest rainfall are relatively unchanged, although short-term peaks are attenuated by flood control storage in the larger foothill reservoirs.



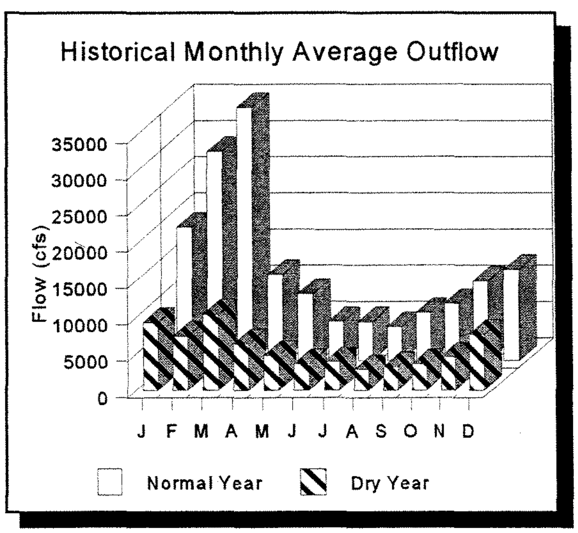
Historical Delta Inflow from Sacramento River measured at Freeport, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Much of the Delta outflow is made up of Sacramento River flow entering the Delta near Sacramento. Although inflows through the Sacramento River channel reach 60,000 to 80,000 cfs in winter and spring of wet years, inflows are generally less than 30,000 cfs. In the driest years, inflows range from 5,000 to 9,000 cfs through the entire year, while in dry years they range from 8,000 to 15,000 cfs. In wet years, floodflows that average up to 130,000 cfs per month enter the Delta from the Yolo Bypass through Cache Slough.



Historical Delta Inflow from San Joaquin River Flow measured at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

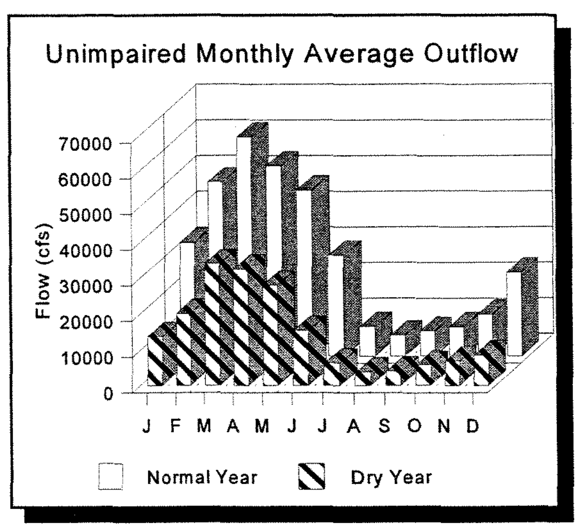
Most of the remaining inflow to the Delta comes from the Mokelumne River and the San Joaquin River. The Mokelumne River contributes only 100 to 300 cfs in dry and normal years. The San Joaquin River flows make up most of the remainder with average monthly flows of 500 to 1,500 cfs in dry years, 1,500 to 3,500 cfs in normal years, and up to 20,000 to 40,000 cfs in wet years.



Historical Delta Outflow for 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Water diversions from the Delta may reduce outflows by as much as 14,000 cfs. Of that total, small Delta agriculture diversions combine to divert up to approximately 3,000 cfs during peak irrigation seasons. State Water Project (SWP) and Central Valley Project (CVP) pumping plants in the southern Delta can divert up to 11,000 cfs. Natural floodplains and flood processes are the periodic flooding of the floodplain during peak flow events that would typically occur in late winter and spring of all but the driest years. Land reclamation and levee construction have eliminated much of the natural Delta floodplain, forcing waters to rapidly exit the Delta through confined channels. Only the Yolo Bypass and adjoining leveed islands are periodically flooded to help carry large flows coming down the Sacramento River.

Reductions in spring freshwater flow into the Delta and the loss of riparian vegetative cover



Unimpaired Delta Outflow Estimated for Period 1972-1992 (Dry year is the 20th percentile; normal year is the 50th percentile or median year.)

have led to slightly increased water temperatures in the Delta. Agricultural and other discharges into the Delta including power plant cooling water have also increased Delta water temperatures. Maintaining water temperatures in the Delta during the transitions in spring and fall is necessary to meet the needs of migrating salmon and steelhead passing through the Delta. Reduced March to May inflows and loss of riparian (waterside) and SRA habitats in the Delta have also contributed to higher water temperatures in the Delta.

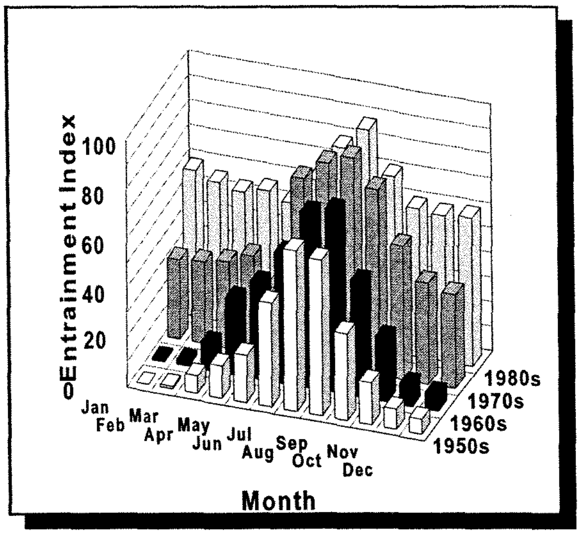
Changes in Delta channel hydraulics (water flows) began in the mid-19th century with land reclamation that restricted flows to narrow channels of levees. Floodflows that once spilled into a vast floodplain are now confined to narrow channels. These same channels later became conduits for carrying water to water-export facilities in the central and south Delta. In 1951, the CVP began to transport water from the south Delta at Tracy to the Delta-Mendota Canal. That same year, operation of the Delta Cross Channel (DCC) began to allow Sacramento River water to flow through interior Delta channels to the south Delta export facilities at Tracy. South Delta export facilities were increased with the addition of the SWP pumping plant at Byron in the late 1960s. In 1968, the SWP began to transport Delta water through the California Aqueduct to southern California.

Existing hydraulic conditions inhibit the function of Delta channels as migration corridors and rearing habitat for salmon and other anadromous fish, including steelhead, striped bass, American shad, white sturgeon, and green sturgeon. Native resident fish such as delta smelt and splittail also depend on natural hydraulic processes, as hydraulic conditions determine physical habitat characteristics and foodweb (all of the food chains) production (i.e., by controlling the residence time of water in Delta channels). Natural hydraulic conditions benefit other resident freshwater and estuarine fish, including longfin smelt, tule perch, threadfin shad, white catfish, largemouth bass, and starry flounder. Low residence time in Delta channels and sloughs decreases biological productivity and habitat value.

Species-Habitat Associations

Species	***Habitats***
Swainson's hawk	*Riparian/Agricultural*
Clapper rail	*Tidal emergent wetland*
Black rail	*Tidal Emergent wetland*
Sandhill crane	*Seasonal aquatic and wetland, agricultural, and grassland*
Riparian brush rabbit	*Contiguous riparian woodland*
Shore and wading birds	*Aquatic and wetland, seasonal aquatic, and agricultural*
Upland game birds	*Agricultural, riparian, and upland*
Waterfowl	*Tidal perennial aquatic, seasonal aquatic, riparian, agricultural, and wetland*
Neotropical migratory birds	*Riparian, grassland, agricultural land*
Delta smelt	*Shallow water, sloughs, bays*
Splittail	*Marsh, floodplain, sloughs*
Striped bass	*Shallow water, sloughs*

Channel hydraulics once were relatively unaltered in the Delta. In November through March, an important period for aquatic species, hydraulic changes were insignificant in the 1950s and 1960s, as measured using an indicator of hydraulic conditions provided by output from a particle transport model (DeltaMOVE). However, by the 1980s, there had been a dramatic increase in unhealthy channel hydraulic conditions in locations such as the Central and West Delta.



Historic Calculated Entrainment Indices of the Central and West Delta Ecological Management Unit.

Aquatic foodweb productivity in the Delta has declined over the past several decades and is the subject of ongoing focused research activities. The decline was caused by changes in freshwater inflow, Delta channel hydraulics (i.e., water residence time), water diversions, water quality, and the species composition of aquatic organism communities. Foodweb productivity, beginning at the primary production (i.e., plant cell production) level, is essential to provide enough food to maintain populations of important fish. Primary productivity in the Delta depends on spring flow events in dry and normal years. Spring flows deliver essential nutrients, increase residence time in channels and sloughs, and increase shallow water and wetland habitat.

The loss of tidal marshes (historic tule marshes) to agricultural conversion probably constituted one of the greatest causes of loss of productivity and a change in the nature of the aquatic foodweb (i.e., a change from a detritus-based food web characteristic of marshes to a more phytoplankton-based food web). Along with the loss of tidal marshes in the Delta to land reclamation came the loss of shallow-water aquatic habitats (e.g., small sloughs, ponds). Many native resident and anadromous fish and estuarine invertebrates depend on these habitats. Shallow-water habitats around the Delta provide spawning and rearing habitats for many native resident Delta fishes. They also provide important rearing and migratory habitats for many Central Valley chinook salmon and steelhead. Tidal perennial aquatic habitat benefits native waterfowl, wading and shorebirds, and wildlife, as well as native plants that depend on such habitats.

Acres of Tidal Fresh Emergent Wetland (Marsh)

Ecological Management Unit	1906	1993	Percentage of change
North Delta	53,660	4,640	-91.3
East Delta	7,600	1,270	-83.3
South Delta	470	650	+38.3
Central and West Delta	37,170	5,040	-86.4

Lakes and ponds support simple invertebrate communities, riparian habitat, and wintering waterfowl. Examples of nontidal perennial aquatic habitats include the Stone Lakes in the North Delta Ecological Management Unit near Sacramento and the "blow out ponds," or ponds remaining after levee breaks on islands such as Venice Island and Webb Tract. Most ponds also support introduced species such as the bullfrog and largemouth bass, which reduce the value of these ponds to special-status species such as the red-legged frog. Introduced species also reduce the habitat's value as brood water for nesting waterfowl. Such habitats within the Delta also benefit waterfowl, as well as many plant and wildlife species, including many rare or declining special status species.

After more than 100 years of land reclamation activities in the Delta, many linear miles of natural sloughs have been lost. Sloughs are important spawning and rearing areas for many native Delta fish species, as well as waterfowl and wildlife. Of those natural sloughs that remain, most have been severely degraded by dredging, levee confinement, loss of riparian vegetation, high water flow, infestation of water hyacinth, and poor water quality (i.e., many receive agricultural drain water).

Shoals are simple underwater islands or shallows in otherwise deeper channels of the Delta. Channel islands and shoals provide valuable fish and wildlife habitat within the confined reaches of Delta channels. Only "tule islands" or "berm islands" contain some original native Delta habitats. These islands are found in Delta channels where the distance between levees is wide enough that past dredging activities left a remnant strip where soils were deposited at an elevation high enough to support tules and cattails. Such islands generally have shallow water and SRA habitats, as well as tidal marsh and riparian habitats. The number and acreage of channel islands have declined over the past several decades from dredging, wave and wake erosion, and levee maintenance.

Tidal marshes, once the most widespread habitat in the Delta, are now restricted to remnant patches. A GIS analysis of 1906 U.S. Geological Survey maps determined the extent of change in tidal wetland since 1906. Extensive losses of tidal wetland habitats in three of the four Delta Ecological Management Units have exceeded 87,000 acres from 1906 to 1993. These losses represent only a portion of the change that have taken place since reclamation began in the mid-nineteenth century. It has been estimated that circa 1850, about 310,000 acres of the Delta consisted of tidal wetlands in a mosaic dominated by emergent vegetation, and included smaller tidal marsh drainage channels and open-water lakes and ponds (Atwater and Belknap 1980).

Nearly two-thirds of the reclamation of the Sacramento-San Joaquin Delta Ecological Management Zone for farmland occurred before 1906. Thirty percent of the lands reclaimed before 1900 were in the North Delta and East Delta Ecological Management Units, 38% in the South Delta Ecological Management Unit, and only 2% in the Central and West Delta Ecological Management Unit. Most of the remaining tidal wetlands lack adjacent upland transition habitat and other attributes of fully functioning tidal wetlands. This was caused by upstream water development, in-Delta export facilities, adjacent levee maintenance practices, agricultural practices, and urban and industrial development.

Tidal wetlands provide important habitats for many species of plants, waterfowl, and wildlife. In addition, wetlands provide an important contribution of plant (dead material) and nutrient recycling to the aquatic foodweb of the Bay-Delta estuary, as well as important habitat to some species of fish and aquatic invertebrates.

Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats such as managed duck clubs in the Delta floodplain. Most of this habitat is located on leveed lands or in floodplain bypasses such as the Yolo Bypass. Such habitats were once very abundant during the winter rainy season or after seasonal flooding of the Delta. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and wildlife.

Upland habitats are found mainly on the outer edges of the Delta and consist primarily of grasslands and remnant oak woodland and oak savanna. Of these, perennial grasslands are an important transition habitat for many Delta wildlife species. They are also buffers to protect wetland and riparian habitats. Much of the grassland habitat adjacent to the Delta has been lost to agriculture (e.g., grain, vineyards, and orchards) and development (e.g., home construction, golf courses). Grasslands provide habitats for many Delta plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees, berms, berm islands, and in the interior of some Delta islands. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitats provide shaded riverine aquatic habitats on which many important fish and wildlife depend during some portion of the life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse, habitat structure with low diversity.

Riparian habitat is used by more terrestrial wildlife species than any other Delta habitat type. From about 1850 to the turn of the century most of the riparian forests in the Delta were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, channel islands, and along the margins of the Delta. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many species of fish and wildlife.

Inland dune scrub habitat is found in the south and west portions of the Delta in areas where wind-blown sand is deposited along margins of the Delta. Inland dune habitat has unique native plant communities including two special-status species. Much of the dune habitat has been lost to industrial and urban development.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors. Nonflooded fields and pastures are also habitats for pheasant, quail, and dove. The Delta supports a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields that support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations.

The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Delta. One of the highest breeding densities of Swainson's hawks in the Central Valley is found on the eastern edges of the Delta, primarily along the upland margins in areas adjacent with pastures, alfalfa croplands, and grasslands. The present-day Delta is mostly farmland, occupying over 86% of the dry-land area. The wildlife habitat value of these lands depends on crop types and agricultural practices employed, including flooding and tillage regimes. The farmed "wetlands" of the Delta are important for wintering water birds, including shorebirds, geese, swans, ducks, and sandhill cranes, supporting 10% of all waterfowl wintering in the State. The value of agricultural lands to other migratory birds is much greater. For example, the Delta is extremely important for tundra swans and greater sandhill cranes. In average years, 70% to 85% of the tundra swans in the Pacific Flyway winter in the Central Valley; 90% of this use occurs in just eight counties with the Delta being a major use area.

Water diversions in the Delta divert up to 14,000 cfs of the freshwater inflow to the Delta. Though diversions vary seasonally, relatively high rates can occur in any month. Water diverted from the Delta is used throughout much of the central and southern portion of the State.

With many diversions unscreened or poorly screened great numbers of fish and aquatic invertebrates are entrained with the water. Lack of adequate screening and location of water diversions in sensitive areas of the Delta contribute to the loss of important fish and aquatic foodweb organisms.

Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat on levees and shorelines needs improvement to restore the variety of species and ecological functions needed for aquatic and wildlife resources of the Delta.

Dredging and disposal of dredge materials have contributed to the loss and degradation of important aquatic habitat and vegetated berm islands in the Delta.

Over the past several decades, the accidental introduction of many marine and estuarine organisms from the ballast waters of ships from the Far East has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta with further effects up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Other important routes for the introduction of invasive species include overland at border crossings, aquaculture operations, and commercial bait dealers.

The numbers of predatory fish have increased at certain locations in the Delta (e.g., Clifton Court Forebay, docks, piers, etc.) and losses of some resident and anadromous fish to predation may limit their recovery. Predators may reduce populations of important fish, including chinook salmon, steelhead, and delta smelt.

Large amounts of toxins continue to enter the Delta from municipal, industrial, and agricultural discharges. The toxins have demonstrated in bioassay potential adverse effect on the health, survival, and reproduction of many important Delta fish and their foodweb organisms. Toxins in the tissues of the fish are also a human health risk to people who eat Delta fish. Continued reductions of toxins from discharges and from releases of toxins from the sediment (e.g., those disturbed by natural forces and dredging) are essential to the restoration program.

The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Harvest of chinook salmon, steelhead, and sturgeon in the Delta may affect recovery of these populations. Harvest enforcement and management help sustain important fish populations from overharvest.

Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitat along Delta channels and degrades water quality from fuel and oil spills. High boat speeds and traffic endanger remnant habitat and limit the success of habitat restoration.

The delta smelt population of the Bay-Delta estuary is a federally listed threatened species. It depends on the Delta for spawning and rearing habitat. It lives in fresh and brackish bays and sloughs of the Delta. Delta smelt decline is related to poor habitat conditions during periods of drought, but are also adversely affected by water diversions throughout the Delta. Delta smelt benefit from high freshwater inflow, particularly during the late winter and spring of dry years. Their recovery depends on adequate slough and shallow water habitat, reduced effects of water diversions, and increased productivity of the aquatic foodweb.

The longfin smelt populations of the Bay-Delta live within the brackish water and saltwater of northern San Francisco Bay and migrate upstream into the Delta to spawn. The decline in the longfin smelt population has coincided with a number of changes in the estuary including: low flows in late winter and spring, reduced freshwater flows through the Delta and into Suisun Bay, water diversion (particularly in drier years), and contaminants.

Like delta smelt, splittail are a native resident species of the Delta and Bay that depend on the Delta for spawning, rearing, and feeding. The Delta splittail population declined during droughts but has rebounded in recent years. Splittail depend primarily on shallow water habitats for spawning including shorelines, sloughs, and aquatic habitats associated with wetlands and seasonal floodplains (e.g., the Yolo Bypass in the north Delta). The splittail population will benefit from improved wetland and slough habitat, a more productive aquatic foodweb, reduced loss to predation, improved estuarine hydraulics, and higher late-winter and spring freshwater flows during dry years.

White sturgeon and green sturgeon populations in the Central Valley use the Delta for migrating, feeding, and as a nursery area. Populations appear to be stable. Do to lack of specific data for green sturgeon, however, the implication that this species is stable may be inaccurate. Sturgeon benefit from high late-winter and spring freshwater inflow, a productive aquatic foodweb, and slough habitats in the Delta. Legal and illegal harvest and losses to water diversions may be limiting their abundance.

Four runs of chinook salmon use Central Valley waterways. All four runs depend on the Delta during at least a portion of their life cycle. The Delta provides migratory and rearing habitat for salmon in all but the warmest summer months. Tidal perennial marsh habitat and adjoining sloughs and aquatic habitats in the Delta are important fry rearing habitats.

Many populations of chinook salmon have declined in recent decades. The decline was caused by a combination of ocean, river, and Delta factors. Reductions in freshwater flow through the Delta and increases in water diversions have led to declines in salmon populations. Improving late-winter and spring freshwater flows through the Delta and reducing losses to diversions are essential to the recovery of salmon. Chinook salmon also benefit from lower water temperatures in spring and fall, adequate aquatic habitats, and high foodweb productivity. Many juvenile chinook salmon are lost to water diversions and predators.

Steelhead usage of the delta-estuary is not well known and has not been studied. At the very least, they utilize the delta waterways for migration to and from the spawning and rearing tributaries. Generally, estuaries provide important - and on some small coastal tributaries, essential - rearing habitat for steelhead, but usage of the Sacramento-San Joaquin delta-estuary by steelhead for this purpose is unknown. Occurrences of juvenile steelhead are not uncommon at the CVP and SWP fish salvage facilities, but they are not salvaged in as great a number as are chinook salmon. This could reflect a much lower abundance of steelhead in the Central Valley system or it could be the result of the larger size of steelhead smolts, compared to salmon smolts, when they are emigrating to the ocean (larger fish are better able to avoid entrainment).

The striped bass population of San Francisco Bay and the Sacramento and San Joaquin rivers depends on the Delta for much of its life cycle. The Delta provides important spawning and rearing habitat for striped bass. Reductions in freshwater flow and increases water diversions have resulted in striped bass population declines over the past several decades. Poor water quality in the Delta may also be limiting the survival of young and adults. Striped bass also benefit from high aquatic foodweb productivity. Loss of tidal perennial aquatic, wetland, and slough habitats may also limit production of striped bass. Many striped bass young are lost in water exported through water diversions. Artificially rearing young striped bass salvaged at the south Delta pumping plant fish facilities or supplementing production with hatchery-reared fish may be necessary to sustain the population under present limiting factors.

American shad is an anadromous fish that spawns in the Sacramento River and its major tributaries. They pass through the Delta on their upstream spawning migration in spring. In the fall, young migrate through the Delta on their way to the ocean. A portion of the population spawns and rears in the Delta. Low productivity in periods of drought is a concern. American shad production increases with higher late-winter and spring freshwater flow through the Delta in dry and normal rainfall years. Improved aquatic foodweb production and lower relative export rates at water diversions will benefit American Shad.

Many native and non-native fish species are residents of the Delta. Resident fish populations, like delta smelt and splittail, will benefit from improved aquatic habitats and foodweb production. Many native fish species have declined gradually over the past century from loss of habitats and introductions of non-native fishes. More recently, native resident species have further declined from changes in freshwater flow, water diversions, poor water quality, and further non-native species introductions and habitat degradation. For many of these species, improvements in their native habitats such as sloughs and tidal marshes, is essential to their restoration. Native residents will also benefit from more natural freshwater flow patterns, improved water quality, and reduced losses to water diversions.

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

The western spadefoot and California tiger salamander occur throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

The California red-legged frog is California's largest native frog. Its habitat is characterized by dense, shrubby riparian vegetation associated with deep, still, or slow-moving water that supports emergent vegetation. The distribution and population of this species has declined substantially, primarily as a result of habitat loss or degradation and excessive predation. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the federal Endangered Species Act and a Species of Special Concern by DFG. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of the loss or degradation of critical wetland and riparian habitats and the introduction of non-native predators.

Once possibly abundant in the Delta, the giant garter snake and western pond turtle are now rare there. Improvements in wetland, riparian, and grassland habitats around the margins of the Delta could greatly benefit these species.

Once abundant in the Delta, Swainson's hawk is now rare. Improvements in agricultural and riparian habitats will aid in the recovery of the Swainson's hawk.

A long-term decline in emergent wetlands has reduced the population of California black rail in the Delta. Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail.

The population of greater sandhill crane in the Central Valley has declined over the past century with the loss of permanent and seasonally flooded wetlands. Improvements in seasonally flooded wetlands and agricultural habitats should help toward recovery of the greater sandhill crane population.

Herons, egrets, and other shorebirds and wading birds breed and winter throughout the Central Valley and the Delta. Their populations depend on aquatic and wetland habitats. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats.

The riparian brush rabbit is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta from loss of riparian habitat. Elsewhere, the population and distribution of this species have declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as endangered under the California Endangered Species Act.

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the riparian brush rabbit depends, in the Delta and San Joaquin River floodplain.

Many species of waterfowl overwinter in the Delta and depend on high-quality foraging habitats to replenish their energy reserves. They depend on wetland, riparian, aquatic, and agricultural habitats. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats.

Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and hunting-related expenditures. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native upland habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

Neotropical bird species breed in North America and winter in Central and South America. Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are a significant component of the ecosystem. These species are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels for many of these species is declining.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

The Lange's metalmark and the delta green ground beetle, both federally listed endangered species, and the valley elderberry longhorn beetle (VELB), a federally listed threatened species, are respectively associated with inland dune, vernal pool, and riparian habitats. The distribution and populations of these species have declined substantially, primarily as a result of the loss or degradation of these habitats within their range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

Once abundant in riparian woodlands of the Delta, yellow-billed cuckoo have declined with the loss of riparian habitats there. The yellow-billed cuckoo will benefit from improvements in habitat that result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta.

List of Species to Benefit from Restoration Actions in the Delta Ecological Management Zone

- delta smelt
- longfin smelt
- green sturgeon
- Sacramento splittail
- chinook salmon (all runs)
- steelhead trout
- lamprey (all species)
- California black rail
- Swainson's hawk
- special status plant species
- Sacramento perch
- riparian brush rabbit
- greater sandhill crane
- western yellow-billed cuckoo
- California red-legged frog
- western pond turtle
- Lange's metalmark butterfly
- native resident fishes
- migratory waterfowl
- shorebird guild
- wading bird guild
- neotropical migratory bird guild
- Bay-Delta foodweb organisms
- white sturgeon
- striped bass
- American shad
- non-native warmwater gamefish
- upland game

Descriptions of Ecological Management Units

North Delta Ecological Management Unit

The North Delta Ecological Management Unit is bounded on the south and east by the Sacramento River. Notable features are the Yolo Bypass, the Sacramento deep water channel, the Cache Slough complex, the Sacramento River and adjoining sloughs, the Snodgrass Slough and Stone Lakes complex, and the Delta Cross Channel (DCC) gates which, when open, allow Sacramento River water to flow into the forks of the lower Mokelumne River. Land elevations generally range from 5 feet below to 10 feet above mean sea level.

The size of the unit is approximately 235,000 acres. As with the Delta's other units, the primary land use is agriculture with more than 60% or 141,000 acres in field crops, orchards, and vineyards. Approximately 5% of the unit consists of riparian, oak woodland, freshwater marsh, and seasonal wetland. (See tables in this section.) Much of the permanent and seasonal wetland habitat is found in the Yolo Bypass, Cosumnes River Preserve, and Stone Lakes area.

North Delta Ecological Management Unit
Land Use

Land use	*Acres*
Non-flooded Ag	*118,011*
Flooded Ag	*14,528*
Orchard	*2,832*
Vines	*5,805*
Total cultivated	*141,176*
Grass	*42,194*
Other	*52,480*

Hydraulic processes in the North Delta Ecological Management Unit are influenced by tides, upstream water releases, weather, channel diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands and natural marsh successional processes. Tidal action and floodwater discharges from the rivers and Yolo Bypass transport nutrients and organic carbon into aquatic habitats of the Delta and San Francisco Bay.

Hydraulic processes have been modified in the North Delta Ecological Management Unit since the 1890s. Reductions in flow from the Mokelumne River began in the early 1890s with diversions by the Woodbridge Irrigation District. Further diversions began with the completion of the Mokelumne River Aqueduct in the 1930s. Additional agricultural diversions from the river were developed in the 1960s when the present level of diversions from the Mokelumne River was reached. The construction of the Yolo Bypass significantly altered hydraulic patterns during above normal and wet water years. The DCC gates began operation in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Management Unit and away from the mainstem Sacramento River below Walnut Grove.

Hydraulic patterns have been further modified by the significant export pumping beginning in 1951 for the CVP and in 1968 for the SWP. The Barker Slough pumping plant at the east end of Lindsey Slough in the Cache Slough complex was completed in 1988; it exports water directly from the North Delta Ecological Management Unit to the North Bay Aqueduct.

Current hydraulic conditions in the North Delta Ecological Management Unit affect the ability of this Ecological Management Unit to support channels with suitable residence times and natural net flows; to provide adequate transport flows to the lower estuary; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of many small unscreened diversions in the North Delta Ecological Management Unit are undocumented.

EAST DELTA ECOLOGICAL MANAGEMENT UNIT

The East Delta Ecological Management Unit is bounded on the northwest by the Sacramento River; on the northeast by the Mokelumne and Cosumnes rivers; and on the south by Highway 12, the South Fork of the Mokelumne River, White and Disappointment Sloughs, and the San Joaquin River. Notable features are Georgiana Slough, the DCC, the Cosumnes River Preserve, and the Woodbridge Ecological Reserve.

Land elevations in this unit generally range from 10 feet below to 10 feet above mean sea level with the western half of the unit ranging from 10 feet below to 5 feet below mean sea level and the eastern half ranging from 5 feet below to 10 feet above mean sea level. These elevations are generally higher that elevations in other regions of the Delta. Elevation is an important factor in evaluating the quality of habitats and in designing habitat restoration projects.

This Ecological Management Unit consists of more than 100,000 acres. It contains both forks of the Mokelumne River, the Cosumnes River, three dead-end sloughs (Beaver, Hog, and Sycamore), and important waterfowl wintering and sandhill crane foraging and roosting areas. As with the Delta's other units, the primary land use is agriculture with more than 68% in field crops, orchards, and vineyards. (See the table in this section for land use acreage.)

Less than 5% of the east Delta consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitats. Much of the riparian and permanent and seasonal wetland habitats are found along the Cosumnes and Mokelumne rivers and in the White Slough Wildlife Area.

East Delta Ecological Management Unit Habitat Acreage	
Habitat	*Acres*
Riparian scrub	*714*
Riparian woodland	*2,201*
Fresh emergent wetland (marsh)	*1,270*
Seasonal wetland	*635*
Total	***4,820***

Hydraulic processes in the east Delta are influenced by tides, river inflow, weather, channel diversions, and upstream water releases. Unimpeded tidal action into tidal wetlands affects the habitat's sediment and nutrient supplies. These supplies influence the natural marsh successional processes. Tidal outflows transport nutrients and carbon into Bay-Delta aquatic habitats.

East Delta Ecological Management Unit Land Use	
Land Use	*Acres*
Non-flooded Ag	*58,937*
Flooded Ag	*6,054*
Orchard	*870*
Vines	*2,653*
Total cultivated	*68,514*
Grass	*10,906*
Other	*21,152*
Total	***100,572***

Hydraulic processes have been modified in the east Delta since the 1800s. Reductions in flow from the Mokelumne River began in the late 1800s and continued to decline into the 1960s. The DCC gates began operating in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Management Unit. Hydraulic patterns have been further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

Current hydraulic conditions in the east Delta are unhealthy. These conditions reduce the ability of this Ecological Management Unit to provide suitable residence times and more natural net flows, to provide adequate transport flows to the central and west Delta, and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of the many small unscreened diversions in the east Delta are unknown.

SOUTH DELTA ECOLOGICAL MANAGEMENT UNIT

The South Delta Ecological Management Unit is bounded on the north by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the San Joaquin, Old, and Middle rivers; Clifton Court Forebay; and the State and federal fish protection and export facilities. Land elevations generally range from 10 feet below to 10 feet above mean sea level. Only about half of the unit is at or slightly higher than sea level.

This Ecological Management Unit consists of more than 177,000 acres. The primary land use is agriculture with more than 60% in field crops, orchards, and vineyards. Less than 2% of this Ecological Management Unit consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitats. Much of the riparian and wetland habitat is found in narrow bands along the San Joaquin River and on small channel islands in Old River. (See tables in this section for acreages.)

Hydraulic processes in the south Delta are influenced by tides, river inflow, weather, channel diversions, temporary rock barriers in Middle River, Old River at Tracy, head of Old River, Grantline Canal, and water releases from upstream reservoirs. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies. These supplies influence the natural marsh successional processes. Outflows from tidal wetlands transport nutrients and carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the south Delta since the 1800s. Further reduction in flow started in the 1930s with the completion of the Hetch Hetchy Aqueduct from the Tuolumne River. In the early 1940s, construction of Friant Dam began to significantly alter hydraulic patterns, particularly during drier water years. The South Bay Aqueduct began diversions directly from the South Delta Ecological Management Unit starting in 1962. Hydraulic patterns were further modified by the significant export pumping near Tracy, which began in 1951 for the CVP and in 1968 near Byron for the SWP.

South Delta Ecological Management Unit Habitat Acreage

Habitat	*Acres*
Riparian scrub	*899*
Riparian woodland	*263*
Fresh emergent wetland (marsh)	*650*
Seasonal wetland	*430*
Total	*2,242*

Current hydraulic conditions in the south Delta are unhealthy and affect the ability of this Ecological Management Unit to support channels with suitable residence times and more natural net flows; to provide adequate transport flows to the entrapment zone; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

South Delta Ecological Management Unit Land Use

Land Use	*Acres*
Nonflooded Ag	*98,269*
Flooded Ag	*1,909*
Orchard	*3,668*
Vines	*3,466*
Total cultivated	*107,312*
Grass	*40,483*
Other	*29,434*
Total	*177,229*

While the effects of many small unscreened diversions in the south Delta are undocumented, effects of the two large export facilities on nearly all Delta anadromous and resident fishes have been well described and are very significant (See Water Diversions Vision in Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed.)

CENTRAL AND WEST DELTA ECOLOGICAL MANAGEMENT UNIT

The Central and West Delta Ecological Management Unit is bounded on the west and north by Suisun Bay, the Sacramento River, Highway 12, the South Fork of the Mokelumne River, and White and Disappointment Sloughs; and on the south by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the

San Joaquin and Sacramento rivers, Franks Tract, the channel islands in Middle and Old rivers, and Potato and Disappointment Sloughs. Land elevations generally range from 10 feet below to as deep as 21 feet below mean sea level. This Ecological Management Unit consists of more than 200,000 acres. It contains most of the mainstem of the San Joaquin River in the Delta. Agricultural uses account for 48% of the area and include field crops, orchards, and vineyards. Approximately 3% of the area consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland. Much of the riparian and wetland habitat is found on the extensive network of small channel islands in Old and Middle rivers; on White, Potato, and Disappointment Sloughs; along the edges of Big Break and Franks Track; on the Lower Sherman Island Wildlife Area; and on adjacent tide lands on both sides of the Sacramento River channel between Collinsville and Rio Vista, including Decker Island and adjacent channels. (See the table in this section for habitat acreage.)

Central and West Delta Ecological Management Unit Habitat Acreage

Habitat	*Acres*
Riparian scrub	*1,004*
Riparian Woodland	*248*
Fresh emergent wetland	*5,040*
Seasonal wetland	*544*
Total	***6,836***

The central and west Delta contains most of the heavily subsided (sunken) islands in the Delta. Although nearly 98% of this unit was not reclaimed until after 1900, the highly organic soils of this unit have oxidized at an accelerated rate. This has resulted in subsidence (sinking) of 20 to 30 feet in many places. The subsidence has led to serious potential erosion of the levees around the islands and numerous levee breaks in the last several decades.

The central and west Delta has some of the highest levels of wintering waterfowl within the Delta. They use seasonally flooded croplands on the deeper islands in this unit. The California Department of Water Resources is one of the most significant landowners in this unit owning most of Twitchell and Sherman islands.

Hydraulic processes in the central and west Delta are influenced by tides, river inflow, weather, channel configuration, water diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands to complement natural marsh successional processes. Tidal action associated with flows out of tidal wetlands transport nutrients and organic carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the central and west Delta since the 1800s. The South Bay Aqueduct began diversions directly from the south Delta starting in 1962. Deliveries to the Contra Costa Canal began in 1962 directly from Rock Slough in the western portion of this unit. Hydraulic patterns were further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

Current hydraulic conditions in the central and west Delta are unhealthy. The ability of this Ecological Management Unit to maintain suitable residence times and provide more natural flows are restricted. These restrictions inhibit adequate transport flows to the entrapment zone and reduce high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

In addition to many small unscreened agricultural diversions (e.g., siphons and pumps), electric generating stations divert up to 1,500 cfs of Delta water. The water is diverted at Antioch, along the San Joaquin River channel, for cooling purposes. Some juvenile Delta fish are stressed or killed in the water diverted for plant cooling. Though the amount of heat added to the Delta is small, it is locally measurable. This combined with other heated discharges contributes to significant seasonal warming of Delta waters.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Sacramento-San Joaquin Delta Ecological Management Zone is to achieve a healthier system that better provides for the ecological needs of plants and animals using the system. A healthy ecosystem will have more natural freshwater flow and channel hydraulic patterns. A more natural channel configuration with greater amounts of slough and permanent and seasonal wetland habitats will provide more habitat for fish, waterfowl, and wildlife, and improve aquatic foodweb production and water quality. Improvements in riparian vegetation along waterways will reduce heating of the water and provide habitat for fish and wildlife. A healthy Delta ecosystem will lead to improved survival of anadromous fish that depend on the Delta for a portion of their life cycles, including chinook salmon and steelhead, striped bass, white and green sturgeon, and American shad. A healthy Delta will also help toward improving the native resident fish community including delta smelt and splittail, as well as resident wildlife, migratory waterfowl, neotropical birds, and special-status plants and plant communities.

A restored Delta ecosystem will have improved ecological processes and habitats and reduced stressors. Ecological processes that will be improved include freshwater inflow and outflow, Delta hydraulics, channel configuration, water temperature, floodplain processes, and aquatic and terrestrial foodweb productivity. There will be substantial increases in the acreage of tidal emergent wetlands, seasonal and permanent nontidal wetlands, and shallow water, riparian, and tidal slough habitats. Stresses from land use, urban and industrial development, contaminants, land reclamation, water diversions, flood control (i.e., levees and bank protection), non-native plant and animal species, recreational activity (e.g., boating), water conveyance structures, livestock grazing, and agricultural practices will be reduced.

Following restoration, the Delta will be a better fish spawning, rearing, and migration habitats. A healthy Delta will be more effective in nutrient cycling and will increase primary (plant) and secondary (animal) productivity. Productivity will increase through improved freshwater inflow and outflow, longer hydraulic residence time in Delta channels, and an increase in the amount of tidal wetlands. Improved Delta productivity will also improve the productivity of northern San Francisco Bay.

Both the endangered winter-run chinook salmon and the threatened delta smelt will benefit from improved Delta inflow and outflow during the late winter and spring, greater estuary (river mouth) foodweb productivity, riparian and wetland habitat improvements, and improved screening systems at water diversions.

Much of the new fish and wildlife habitats will come from agricultural lands that are either no longer productive or too expensive to maintain (e.g., levee maintenance costs are too high). These lands will be purchased from willing sellers. Productive agricultural lands will continue to be an integral part of the Delta habitat mosaic and will be protected by upgrading channel configurations and levees.

The Delta's levee system will be effectively maintained to reduce the risk of failure. This will also minimize loss of water quality (e.g., saltwater intrusion) and loss of high-value wildlife habitat and agricultural land. Riparian, wetland, and aquatic habitats along the levees will be improved where possible. In those areas where leveed lands can eventually be restored to tidal action, the exterior levees will be maintained until the island interiors are restored to the proper elevations necessary to support the desired habitats.

A basic restoration strategy is to protect and enlarge areas of remaining native habitats and establish the connectivity of these areas. For example, the Cosumnes River Preserve (Badger Creek Marsh) supports a sizable population of giant garter snake. Caldoni Marsh (White Slough Wildlife Area) west of Lodi is also an area of several recent and historical giant garter snake sightings. Stone Lakes Refuge-Morrision Creek drainage and the Yolo Basin also contain suitable garter snake habitat, though population sizes are thought to be quite small. Restoring connectivity of these areas would benefit giant garter snakes and contribute to their recovery by providing corridors for the reestablishment of historic population. Such areas in the Delta include:

- the Cache Slough complex,
- Stone Lakes,
- the Cosumnes River Preserve in the north Delta, and
- the Sherman Island Wildlife Area in the western Delta.

Benefits to species and habitats will come predominantly through changes to important physical processes. These processes include:

- freshwater flow into and through the Delta
- hydraulic conditions within Delta channels, and
- the channel configuration of the Delta.

Increasing the amount of the floodplain that is inundated by flood waters and tides, and increasing the amount of shallow water and shorelines will increase tidal aquatic, wetland, and riparian habitats. Habitat improvements will be made in concert with floodplain and levee improvements. Levees will be rebuilt and maintained to include shallow water and riparian habitats that not only protect the integrity of the levees, but also provide valuable fish and wildlife habitats. Agricultural lands on Delta islands will be managed to better support waterfowl and wildlife. Tidal sloughs and creeks will be restored to their former health from improved channel hydraulics, water quality, and riparian vegetation, and reductions in non-native aquatic plants (e.g., water hyacinth).

To ensure this recovery, it will be necessary to reduce stressors. Examples of stressors include the alteration of Delta hydraulic patterns by pumping in the South Delta, unscreened or poorly screened diversions, non-native invasive plant species (e.g., water hyacinth), toxic substances, and human disturbance such as erosion of sensitive habitats from boat wakes. In some cases, fish and wildlife may need temporary or even long-term support through artificial habitat construction, reductions in legal and illegal harvest, or artificial reproduction (e.g., hatcheries).

Improvements to restore the health of the estuary need to be made in a way that contribute to the quality of life for Delta fish and wildlife populations, while protecting the region's agricultural economy and preserving landowner property rights. Rebuilt levees will protect valuable agricultural lands and other properties. Improved fish and wildlife populations will benefit recreation. Greater areas of wetlands and riparian habitats will benefit water quality. With restoration, the Delta would provide improved educational and recreational opportunities. The Delta will provide increased public opportunities for wildlife observation, photography, nature study and wildlife interpretation, fishing, hunting, picnicking, and other activities in a manner that is consistent with maintaining the fish and wildlife values of the Delta and protecting adjacent private properties.

Attaining this vision requires extensive efforts in the Delta, and in watersheds above the Delta. For this reason, this Delta vision is closely tied to the visions for the other 13 Ecological Management

Zones. Important ecological processes such as streamflow are controlled by upstream reservoirs and watersheds to the Delta. Delta habitat and the productivity of that habitat are greatly dependent on physical, chemical, and biological processes upstream of the Delta.

A focus on natural processes may reduce the need for measures that artificially maintain habitat and plant and animal populations (e.g., hatcheries). It may be necessary, however, to artificially sustain habitats, severely inhibit stressors, and increase population abundance until such time when natural ecological processes and functions are restored. This will be particularly true during the recovery period.

INTEGRATION OF ACTIONS FOR STAGE 1 IMPLEMENTATION

Stage 1 actions are those actions to be implemented during the first 7 years of the program. The selection of Stage 1 actions is guided by the Strategic Plan for Ecosystem Restoration (1999). The Strategic Plan identifies 12 important issues related to substantial uncertainties about Bay-Delta ecosystem dynamics that should be addressed by adaptive management and adaptive probing early in Stage 1. Many of the issues address the uncertainty resulting from incomplete information and unverified conceptual models, sampling variability, and highly variable system dynamics.

Relevant issues in the Sacramento-San Joaquin Delta Ecological Management Zone that need resolution during Stage 1 include:

- The impact of introduced species and the degree to which they may pose a significant threat to reaching restoration objectives.
- Recognition that channel dynamics, sediment transport, and riparian vegetation are important elements in a successful restoration program and the need to identify which parts of the system can be restored to provide the desired benefits.
- Development of an alternative approach to manage floods by allowing rivers access to more of their natural floodplains and integrating ecosystem restoration activities with the Army Corps of Engineers' Comprehensive Study of Central Valley flood management programs.
- Increasing the ecological benefits from existing flood bypasses, such as the Yolo Bypass, so that they provide improved habitat for waterfowl, fish spawning and rearing, and possibly as a source of food and nutrients for the estuarine foodwebs.
- Thoroughly testing the assumptions that shallow water tidal and freshwater marsh habitats are limiting the fish and wildlife populations of interest in the Delta.
- A better understanding of the underlying mechanisms of the X2 salinity standard in the Delta and the resultant effects on aquatic organisms.
- A need to better understand the linkage between the decline at the base of the estuarine foodweb and the accompanying decline of some, but not all, species and trophic groups.
- Clarifying the extent to which entrainment at the CVP and SWP pumping plants affects the population size of species and invertebrates.
- Clarifying the suitability and use of the Delta for rearing by juvenile salmon and steelhead.

The proposed Stage 1 approach for the Sacramento-San Joaquin Delta Ecological Management Zone is to broadly design and implement actions that will make a substantial contribution to developing aquatic and terrestrial habitat corridors through the Delta which connect with upstream areas. In addition to the focus on the corridor concept, a variety of general actions will be implemented. Implementation of these actions and linking their implementation with adaptive management through the Comprehensive Monitoring, Research and Monitoring Program will be major steps toward resolving the important Stage 1 issues and will set the direction for subsequent implementation stages.

The three major habitat corridors envisioned include the following:

- **THE NORTH DELTA HABITAT CORRIDOR** will provide a large, contiguous habitat corridor connecting the mosaic of tidal marsh, seasonal floodplain, riparian and perennial grassland habitats in the Yolo Bypass, Cache Slough Complex, Jepson Prairie Preserve, Prospect Island, Little Holland Tract, Liberty Island, and Steamboat Slough.

- **THE EAST DELTA HABITAT CORRIDOR** will restore a large, contiguous corridor containing a mosaic of habitat types including tidal perennial aquatic, riparian and riverine aquatic habitat, freshwater fish habitat, essential fish habitat, and improved floodplain-stream channel interactions along the Cosumnes River. The focus area includes the South Fork Mokelumne River, East Delta dead-end sloughs, Georgiana Slough, Snodgrass Slough, and the Cosumnes River.

- **THE SAN JOAQUIN RIVER HABITAT CORRIDOR** will provide a contiguous habitat corridor of tidal perennial aquatic habitats, riparian and riverine aquatic habitat, freshwater fish habitat, essential fish habitat, and improve river-floodplain interactions.

In addition to the three habitat corridors, many other restoration actions are proposed for implementation during Stage 1. These additional actions range from conversion of Frank's Tract to shallow water habitats to developing a ballast water management program to halt the accidental introductions of invasive aquatic organisms.

The proposed Stage 1 actions are described in the Restoration Targets and Programmatic Actions section.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

NORTH DELTA ECOLOGICAL MANAGEMENT UNIT

Habitat restoration, fish passage improvement, and floodplain modifications are the primary focus of the restoration program in the North Delta Ecological Management Unit Restoring a mosaic of tidal emergent wetland and SRA habitat at the ecological-unit level should provide essential resources for all species, particularly communities or assemblages of species that have declined significantly within the Delta.

Habitat restoration will focus on four areas:

- the Yolo Bypass including shallow agricultural islands at the south end of the bypass (i.e., Prospect, Little Holland, and Liberty)

- tidal sloughs between the Sacramento Ship Channel and the Sacramento River (i.e., Steamboat, Miner, Oxford, and Elk)

- the Stone Lakes-Cosumnes Preserve complex, and

- the main channel of the Sacramento River from Sacramento to Rio Vista.

Seasonal patterns of freshwater inflow from the Sacramento River, Yolo basin (Cache and Putah creeks), and the Cosumnes and Mokelumne rivers would be improved. Fish passage problems in the Yolo Bypass, DCC, Sacramento Ship Channel, and Snodgrass Slough should be resolved.

Unscreened diversions in important habitat and migration pathways should be screened. Non-native plants will be controlled.

The vision for the North Delta Ecological Management Unit focuses heavily on habitat restoration in the major subunits and the creation of a North Delta habitat corridor. In the Yolo Bypass, channels should be constructed to connect to channel improvements in the Yolo basin (i.e., connections with Putah and Cache creeks, the Colusa drain, and the Sacramento River through the Sacramento and Fremont weirs). These channels should be constructed as permanent sloughs along either side of the bypass.

The sloughs will feed permanent tidal wetlands constructed along the bypass and connected with existing wetlands within the Yolo Basin Wildlife Area. The sloughs would provide rearing and migrating habitat for juvenile and adult salmon, and other native fishes. The sloughs would drain into extensive marsh-slough complexes developed in shallow islands (i.e., Liberty, Little Holland, and Prospect) at the lower end of the bypass. These changes, in conjunction with structural improvements to the bypass floodway (e.g., reducing the hydraulic impedance of the railroad causeway paralleling Interstate 80, and removing levees along the lower Sacramento Ship Channel (see below), will retain and possibly increase the flood bearing capacity of the Yolo Bypass.

To the east of the Yolo Bypass, the vision includes some improvements to the Sacramento Ship Channel. Fish passage problems at the gate structure on the Sacramento River at the north end of the ship channel should be resolved by constructing fish passage facilities. Connections between the ship channel and the new island complexes at Liberty, Little Holland, and Prospect Islands would be considered.

The major sloughs to the east between the ship channel and the Sacramento River, including Miner, Steamboat, Oxford, and Elk, should be improved as salmon migration corridors. A riparian habitat would be improved along these sloughs. Setback levees along portions of these sloughs may expand the slough and adjacent marsh complexes. Increases in the hydraulic connections at the northern end of the slough complex on the Sacramento River and at the southern end at Prospect Island would increase tidal and net flows through the complex, which along with habitat improvements, could represent important rearing and migrating habitat improvements for salmon and other anadromous and resident fish.

Along the Sacramento River channel between Sacramento and Rio Vista, restoration is limited to improvements to riparian vegetation along the major federal levees and to protection and possible improvements to retain remaining shallow-water habitat and tule berms along the river sides of the levees. In addition, habitats would benefit from improving and maintain flows that contribute to riparian regeneration. These habitats may be important spawning habitat of delta smelt and other native Delta fishes and important rearing and migratory habitats of juvenile salmon and steelhead.

The vision for the Stone Lakes-Snodgrass Slough-Lower Cosumnes/Mokelumne complex at the northeast side of the North Delta Ecological Management Unit includes extensive habitat improvements. These improvements will be consistent with increasing the connection of wetlands and riparian woodlands in the Stone Lakes and Cosumnes preserves. Remnant marshes, riparian woodlands, and tidal sloughs along Snodgrass Slough would be protected and improved. Some small units of leveed agricultural lands would be converted to marsh-slough complexes. Flood control levees would be upgraded and riparian and shallow-water habitats improved on the waterside of the levees. Gated connections with appropriate fish passage facilities (and, potentially, screens) would be considered on the Sacramento River at the north end of Snodgrass Slough and Morrison Creek near Hood to provide this portion of the unit with water at a level consistent with pre-levee flows. Water hyacinth infestations would be controlled throughout the complex. All unscreened agricultural diversions located along salmon migratory corridors or spawning habitat of delta smelt would be screened.

Changes in the operation of the DCC gates would be considered depending on which program alternative is chosen.

EAST DELTA ECOLOGICAL MANAGEMENT UNIT

The vision for the East Delta Ecological Management Unit focuses on restoration of native Delta habitats that will improve spawning, rearing, and migration habitats of native Delta fishes, as well as provide extensive new amounts of wetland, waterfowl, and wildlife habitat. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, especially communities or assemblages of species that are rare within the Delta. Improvements along the south Mokelumne River and adjoining dead-end sloughs on the east edge of the Delta should be the focus of restoration efforts.

The vision for Georgiana Slough, Snodgrass Slough, the Cosumnes River and the South Ford of the Mokelumne River channel is to improve riparian and tidal marsh habitats and restore ecological processes, such as floodplain-river interactions, to the degree feasible to create a sustainable East Delta habitat corridor.

The vision for the east side of the unit along the South Mokelumne River and its adjoining dead-end sloughs (Beaver, Hog, and Sycamore) is extensive restoration of native Delta habitats. Levee setbacks and improvements along the river and sloughs would be accompanied by shallow-water and riparian habitat improvements.

Subsided leveed lands between the sloughs would be converted to floodplain overflow basins. These floodplains would support non-tidal, permanent tule-marsh wetlands, or seasonal agricultural production. After many decades of flooding, marsh growth, and sediment-laden flood overflow, these floodplains could be converted to tidal wetland.

Tidal headwaters of sloughs and adjacent lands would be opened to provide permanent tidal wetland marsh-slough complexes. Conversion of these agricultural lands would also reduce water diversions (i.e., loss of water and juvenile fish). Levee setbacks and a wider floodplain would improve habitat for fish including resident delta smelt and splittail and seasonal migrant salmon and steelhead from the Cosumnes and Mokelumne rivers.

SOUTH DELTA ECOLOGICAL MANAGEMENT UNIT

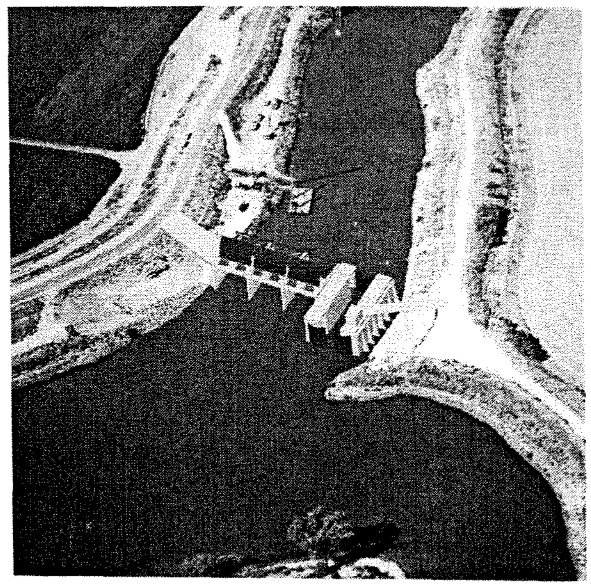
Large-scale habitat restoration, channel and floodplain improvements, hydraulics, and losses at unscreened diversions and water export facilities are the primary focus of the restoration program in the South Delta Ecological Management Unit. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, particularly communities or assemblages of species that are rare within the Delta.

The vision for the South Delta Ecological Management Unit focuses on restoring floodplain habitat along the lower San Joaquin River between Mossdale and Stockton and improving riparian habitat along leveed sloughs throughout the unit. This is integral to the creation of the San Joaquin River habitat corridor. Improving interior slough complexes of the Old and Middle rivers would depend on which CALFED alternative is chosen for conveyance through the Delta. Minimal improvements would be made under alternatives that use existing Delta channels because these channels would remain major conduits for moving water to the export pumps. Other alternatives would provide more flexibility in the form of improvements in riparian and emergent wetland habitat and channel configurations. Depending on the preferred alternative, the South Delta Ecological Management Unit could be a location in which extensive restoration of tidal emergent wetlands and tidal perennial aquatic habitats occurs. This is influenced by the present land elevations and because land subsidence has been less dramatic that in other regions of the Delta.

A major focus of the vision in the south Delta will be expansion of the floodway in the lower San Joaquin River floodplain between Mossdale and Stockton. Setback levees and overflow basins offer opportunities to increase the flood-bearing capacity of the existing configuration of the river floodplain, as well as potential for creating significant amounts of native tidal emergent wetlands within the floodplain, regardless of which conveyance alternative is chosen.

Another important focus of the vision is to solve the problems associated with the export of water from the south Delta export facilities of the SWP and CVP near Byron and Tracy, respectively. Under all three CALFED alternatives, it is imperative that the loss of juvenile anadromous and resident fishes at the two export facilities be reduced as soon as possible. A new fish screen facility would be constructed that would screen all water for both facilities. The screen system would include a state-of-the-art fish collection, handling, and transport system that would reduce fish losses. Some alternatives would further reduce losses of fish from the south Delta by limiting diversions from the south Delta in seasons when fish are most abundant or vulnerable. Fish losses could also be reduced by providing alternative sources of water to south Delta islands, which would otherwise divert water from existing channels.

A barrier at the head of Old River would be installed to prevent San Joaquin River water and fish from moving into the southern Delta. The barrier would help ensure that San Joaquin River water and juvenile salmon would have some chance of reaching the western Delta and the San Francisco Bay. Precautions would be taken in the operation of the barrier to not cause increased delta smelt, winter-run chinook salmon, and other fishes movement south into the South Delta and greater losses at south Delta export facilities.



Conceptual view of a fish barrier at the Head of Old River (DWR).

Central and West Delta Ecological Management Unit

Restoring habitat is the primary focus of the restoration program in the Central and West Delta Ecological Management Unit. Restoring a mosaic of tidal emergent wetland and SRA habitat on a large scale should provide essential resources for all species dependent on the Delta. Protecting and enhancing levees around all the deeper islands should include major adjacent shoal and shallow-water habitats, as well as riparian and tule-berm (midchannel islands) improvements. Changes in channel hydraulics will protect and improve habitats in specific sloughs. Water conveyance through the Delta should be concentrated in specific channels that should be reinforced for that purpose, and little habitat restoration should be conducted along these channels so as not to encourage residence of juvenile fishes. Portions of deeper islands should be reclaimed where possible for tidal or nontidal marsh habitat. Unscreened diversions in important migration pathways of salmon and delta smelt should be screened or relocated to other channels.

The vision for the Central and West Delta Ecological Management Unit is to restore fresh emergent wetland habitat, shoal and shallow-water aquatic habitat, and adjacent riparian habitat. Along the main channel of the San Joaquin River where levees are being upgraded; wetland, shoal, shallow-water, and adjacent riparian habitat should be improved. Where feasible, new construction should set back levees on portions of islands where the ratio of levee length to protected agricultural acreage is high. This will potentially reduce levee construction and maintenance costs and provide new tidal shallow-water, slough, wetland, and riparian habitat.

These selected islands would be on higher elevation lands to minimize the need for fill; however, some fill would be needed on deeper corners. This might be closely linked with the LTMS strategy for the beneficial reuse of dredge materials as it would accelerate marsh rebuilding processes. On such setbacks, levees would initially be maintained while fill was applied and habitats developed. Eventually, the levees would be breached or gated to allow tidal flows into the newly developed habitats. In some cases, entire small islands may be reclaimed, similar to the way in which portions of western Sherman Island in the west Delta were reclaimed for aquatic and marsh habitat. Along the margins of the unit selected levees could be breached or removed to provide areas of tidal wetlands and adjacent grasslands. The amount of new habitats potentially derived from these actions represents as much as 10% of the total acreage in the Central and West Delta Ecological Management Unit.

Selected tidal channels and sloughs in the Central and West Delta Ecological Management Unit (e.g., Potato Slough and Disappointment Slough) retain good habitats in the form of midchannel islands, shoreline marshes and riparian woodlands, and shallow waters. These habitats would be protected and would also require active water hyacinth control.

On deeper Delta islands, levees should be upgraded to protect them from catastrophic failure. Portions of or all of some islands would be considered for establishing permanent nontidal wetlands. Approximately 30,000 acres of these islands would be appropriate for consideration of permanent or seasonal wetland development, or combination wildlife habitat and agricultural use. Selected islands may also be appropriate for flood overflow basins or seasonal water storage reservoirs.

Along the west side of the unit in the Highway 4 corridor, there are many opportunities to combine urban, agricultural, and native Delta habitat developments. There are many opportunities for tidal slough and marsh habitat development in this area.

Unscreened diversions along major pathways of salmon and delta smelt would be relocated or screened. Screening systems at Antioch electric power plants would be upgraded to reduce loss of fish to entrainment through or impingement on the fish screens. The extent of screening needs would depend on which program alternative is chosen

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Much of the fresh water of the State drains the watersheds of the Central Valley through the Delta. A healthy pattern of freshwater inflow into and through the Delta would entail natural late winter and spring flow events especially in dry and normal water-year types. Such flow events would support many ecological processes and functions essential to the health of important Bay-Delta fish populations. Inflow to the Delta is impaired in dry and normal rainfall years from the storage and diversion of natural inflow to the basin watersheds. The need for inflow coincides with the need for natural flows in the mainstem rivers, their tributaries, and

San Francisco Bay. Increasing low salinity habitat at Roe Island, Chipps Island, and at Collinsville will benefit rearing native fishes dependent on this type of habitat.

COARSE SEDIMENT SUPPLY: Maintain a sustainable supply of natural sediments to the Delta. Sediments are one of the basic ecological components contributing to the development of the Delta landscape over the past 6,000 years. Sediments are needed to maintain floodplains, shallow shoals, mudflats, mid-channel islands, and contribute to maintaining and restoring riparian, wetland, and aquatic habitats. In the longer term, sediments may play an important role in reversing land subsidence on many Delta islands.

NATURAL FLOODPLAINS AND FLOOD PROCESSES: Expand the Delta floodplain by setting back or removing portions of the levee. This would enhance floodwater and sediment retention in the Delta and provide direct and indirect benefits to floodplain dependent fish and wildlife. Such floodplain expansion should also help alleviate flooding potential in other areas of the Delta.

CENTRAL VALLEY STREAM TEMPERATURES: During spring and fall, Delta channels are used by anadromous fish for migrating between rivers and the Pacific Ocean and are used as rearing areas as well. Untimely high water temperatures stress migrating fish by delaying their movement or causing mortality. Improvements in riparian and SRA habitat along Delta channels would improve water temperatures in small but important increments in these areas during critical fall and spring migrating periods. Higher inflow in late winter and early spring will help delay warming of the Delta channels.

DELTA CHANNEL HYDRAULICS: Confinement of Delta channels and use of channels to convey water across the Delta has led to reduced productivity and habitat value of Delta channels. Restoration of natural hydraulic conditions in some Delta channels would improve productivity and habitat values.

BAY-DELTA AQUATIC FOODWEB: The aquatic foodweb of the Delta, which supports important resident and anadromous fish, has been severely impaired. The major foodweb stressors include drought, reductions in freshwater flow, water diversions, introductions of non-native species (e.g., Asiatic clams), and loss of shallow water and wetland habitats. Proposed improvements in spring flows, channel hydraulics, wetland habitats, and floodplain inundation should lead to a healthier and more productive aquatic foodweb. Improved water quality and greater sediment retention in wetland, riparian, and floodplain habitats will also increase foodweb productivity.

VISIONS FOR HABITATS

TIDAL PERENNIAL AQUATIC HABITAT: Land reclamation in the Delta has reduced the area of tidal aquatic habitats such as small sloughs, ponds, and embayments in tidal wetlands. Increased tidal wetland acreage and associated aquatic habitats will provide additional valuable fish and waterfowl habitats.

NONTIDAL PERENNIAL AQUATIC HABITAT: Increasing the area of ponds and lakes on leveed land in the Delta will provide needed habitats for shorebirds, waterfowl, and wildlife.

DELTA SLOUGHS: Increasing the number, length, and area of dead-end and open-end sloughs in the Delta will benefit native fishes, as well as waterfowl, wildlife, and neotropical songbirds.

MIDCHANNEL ISLANDS AND SHOALS: Channel islands in the Delta have associated remnant shallow-water, wetland, and riparian habitats that are valuable for fish and wildlife and sensitive plants. Maintaining and restoring these islands is important given the lack of such habitats and limited potential for creating new habitats within the Delta channels.

FRESH EMERGENT WETLAND HABITAT: Restoring tidal and nontidal marshes in the Delta will benefit foodweb productivity and water quality. It will also provide important habitat for fish, waterfowl, wildlife, and sensitive plant species and communities.

SEASONAL WETLAND HABITAT: Increased seasonal flooding of leveed lands and flood bypasses will provide important habitats for shorebirds, waterfowl, and raptors, particularly Swainson's hawk, as well as native plants and wildlife. Flooding and draining of seasonal wetlands also contributes to the aquatic and terrestrial foodwebs of the Delta and Bay.

RIPARIAN AND RIVERINE AQUATIC HABITAT: Restoring riparian (waterside) vegetation corridors along levees and associated SRA habitats will benefit many native fish and wildlife species dependent on this type of habitat.

INLAND DUNE SCRUB: Protecting remaining inland dune scrub habitat will protect special-status wildlife populations and special plant species.

PERENNIAL GRASSLANDS: Protecting and improving perennial grassland habitats will benefit special-status wildlife populations, special status plants, and help protect adjoining wetland habitats.

FRESHWATER FISH HABITAT: Freshwater fish habitats are an important component needed to ensure the sustainability of resident native and anadromous fish species. The Delta provides floodplain pool ephemeral water habitat, sloughs, oxbow lakes, and backwater habitats, valley floor rivers which include the main channels of the Sacramento and San Joaquin (Moyle and Ellison 1991). The quality of freshwater fish habitat in the Delta will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats and tidally influenced shallow water habitats.

ESSENTIAL FISH HABITAT: The Delta has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in the Delta include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Delta will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit special-status wildlife such as sandhill cranes.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Screening, consolidating, reducing, and relocating water diversions will reduce loss of important fish and aquatic foodweb organisms. These actions will also improve Delta outflow and channel hydraulics. Relocating south Delta diversion and rehabilitating fish facilities should greatly reduce the annual losses to these diversions. Improved screening at large Delta power plants should reduce entrainment and impingement losses of many important Delta fish species.

LEVEES, BRIDGES, AND BANK PROTECTION: Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat improvement on levees and shorelines should help restore biodiversity and ecological functions needed for aquatic and wildlife resources of the Delta.

DREDGING AND SEDIMENT DISPOSAL: Reducing the loss of and degradation to important aquatic habitat and vegetated berm islands caused by dredging activities would protect, restore, and maintain the health of aquatic resources in and dependent on the Delta.

INVASIVE SPECIES: Over the past several decades, the accidental introduction of many marine and estuarine organisms has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta. These organisms come mainly from the ballast waters of ships from the Far East. The introduction of these invasive species has had further ramifications up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Border inspections and enforcement of regulations regarding ballast water releases should reduce the number of invasions each year to the Delta. Where invasive species have become a serious problem, possible means will be developed to control their distribution and abundance.

PREDATION AND COMPETITION: The numbers of predatory fish at certain locations in the Delta (e.g., Clifton Court Forebay) are high and contribute to the loss of resident and anadromous fish. Reductions in these local predator concentrations may reduce predation on important fish, including juvenile chinook salmon, steelhead, striped bass, and delta smelt. Predator control would also improve fish salvage at the State Water Project facilities at Clifton Court Forebay. Programs and projects that exclude fish such as salmon and delta smelt from areas that harbor concentrations of predators will contribute to reducing the adverse effects of predation.

CONTAMINANTS: Reducing toxin inputs in discharges and from contaminated sediments is essential to maintain water quality. Reduced concentrations in waters entering the Delta should lead to lower concentrations in Delta water and in fish and invertebrate tissues. Fewer health warnings for human consumption of Delta fish and improved foodweb productivity would also be expected.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Increasing enforcement will help reduce illegal harvest of striped bass and sturgeon in the Delta. Increased enforcement and public education should lead to reduced frequency of violations per check by enforcement personnel.

STRANDING: The loss of aquatic organisms, primarily fish species, will be better understood and remedial actions developed and implemented. The primary focus of this effort will be in the Yolo Bypass.

DISTURBANCE: Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitats along Delta channels. Reducing boat speeds and traffic in channels where remnant or restored habitats are susceptible to wave erosion damage would help preserve existing remnant habitat and ensure the success of habitat restoration efforts. Reduced rates of erosion and loss of shoreline habitats would be expected in areas of reduced disturbance. Enforcement and /or stricter boating regulations on bilge pumping, refueling, and oil changes will result in decreased contaminant loading and improve water quality. Boating also adversely affect two critical biological events in the Delta: spawning seasons for fish, particularly shallow water spawners such as delta smelt, and wintering periods for waterfowl and shorebirds.

VISIONS FOR SPECIES

DELTA SMELT: The vision for delta smelt is to recover this State- and federally listed threatened species. Recovery of the delta smelt population in the Delta will occur through improved Delta inflow, greater foodweb productivity, increased areas and quality of aquatic habitats, including the South Delta, and reduced effects of water diversions. Higher production should be apparent in dry and normal water year types in response to improvement in flows, habitats, and foodweb and to reductions in stressors.

LONGFIN SMELT: The vision for longfin smelt is to recover this California species of special concern in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt.

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species in order to contribute to the overall species richness and diversity and to reduce conflict between splittail protective measures and other beneficial uses of water in the Bay-Delta. Recovery of the Delta splittail population will occur through increased flooding of floodplains, higher late-winter Delta inflow, and improved tidal aquatic and wetland habitats. Greater production of young would be expected in dry and normal water year types.

GREEN STURGEON: The vision for green sturgeon is to recover this California species of special concern and to restore population distribution and abundance to historical levels. Restoration of this species contributes to overall species richness and diversity and reduces conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta. Green sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food).

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks that are listed or proposed for listing under CESA or ESA. Central Valley chinook salmon populations will increase with improved late-winter and spring flows through the Delta, increases in wetland and floodplain habitats, lower spring water temperatures, an improved aquatic foodweb, and reduced effects of water diversions. Survival rates through the Delta should increase. Numbers of young salmon rearing in the Delta should increase with improved winter-spring flows and wetland habitats.

STEELHEAD TROUT: The vision for steelhead is to recover this federally listed threatened species. Steelhead will benefit from improved Delta inflow and outflow, channel hydraulics, and increased area of tidal marshlands. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

LAMPREY: The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.

SACRAMENTO PERCH: The vision for the Sacramento perch is to contribute to the recovery of this California species of special concern and to contribute to the overall species richness and diversity. Although extirpated from the Delta, restoration of Delta islands and heavily vegetated shallow water habitats may contribute to its restoration.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Restoration would support a sport fishery for white sturgeon and contribute to overall species richness and diversity and reduce conflict between the need for protection of this species and other beneficial uses of water in the Bay-Delta.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring natives species, to their 1960s levels of abundance to support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta. The striped bass population will benefit from increased inflows to the Delta in late winter and spring, an improved aquatic foodweb, and reduced effects of water diversions. Improvements in water quality and reducing summer losses to diversions may be important in the long-term recovery of striped bass. Given the high reproductive capacity of striped bass, improvements in production of young should quickly follow improvements in flow and foodweb and reductions in stressors.

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. Central Valley American shad populations will benefit from improved spring Delta inflow and an improved Delta aquatic foodweb. Populations would be expected to remain stable or increase. Increases would be expected in dry and normal rainfall years.

NON-NATIVE WARMWATER GAMEFISH: The vision for non-native warmwater gamefish is to maintain self-sustaining populations, consistent with restoring native species, in order to provide opportunities for consumptive uses such as angling.

NATIVE RESIDENT FISH SPECIES: The vision for native resident fish species is to maintain and restore the distribution and abundance of native species such as Sacramento blackfish, hardhead, and tule perch. Many native fish species will benefit from improved aquatic habitats and foodweb. Population abundance indices should remain stable or increase. The distribution of native resident fishes should increase with widespread habitat restoration. The extirpated Sacramento perch could be restored to new habitats in the Delta.

BAY-DELTA FOODWEB ORGANISMS: The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and evaluating the need to reduce loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Another important element includes reducing the amount of toxic substances entering the system which may adversely affect foodweb organisms.

WESTERN SPADEFOOT: The vision for the western spadefoot is to maintain this California species of special concern in the Bay-Delta. Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the western spadefoot. Restoration of aquatic, seasonal wetland, and floodplain habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area.

CALIFORNIA TIGER SALAMANDER: The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta. Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California tiger salamander.

Restoration of aquatic, seasonal wetland, and floodplain habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area.

CALIFORNIA RED-LEGGED FROG: The vision for the California red-legged frog is to maintain populations of this federally listed threatened species. Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog. Restoration of aquatic, wetland, and riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to its recovery in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area.

WESTERN POND TURTLE: The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the western pond turtle. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

SWAINSON'S HAWK: The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species to contribute to the overall species richness and diversity. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected in the Delta as a result of improved habitats.

CALIFORNIA BLACK RAIL: The vision for the California black rail is to contribute to the recovery of this State-listed threatened species to contribute to overall species richness and diversity. Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail. Population abundance and distribution should increase in the Delta.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this State-listed threatened species is the Bay-Delta. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitats.

SHOREBIRDS AND WADING BIRDS: The vision for shorebird and wading birds is to maintain and restore healthy populations through habitat protection and restoration and reduction is stressors. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the Delta by these birds should increase.

RIPARIAN BRUSH RABBIT: The vision for the riparian brush rabbit is to contribute to the recovery of this State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat. Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing five new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the South Delta Ecological Management Unit of the Sacramento-San Joaquin Delta Ecological Management Zone and the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture as part of the North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Delta and possibly increases in some populations would be expected.

PLANT SPECIES AND COMMUNITIES: The vision for plant species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland, riparian, grassland, and upland habitats.

UPLAND GAME: The vision is to maintain healthy populations of upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Protecting and restoring existing and additional suitable grassland, seasonal and emergent wetland, midchannel island and shoal, and riparian habitats, and improving management of agricultural lands and reducing the effect of stressors that can suppress breeding success will be critical to maintaining healthy upland game populations in the Bay-Delta.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta. Large-scale restoration of nesting habitats will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors.

LANGE'S METALMARK BUTTERFLY: The vision for Lange's metalmark butterfly is to recover this federally listed endangered species by increasing its distributing and abundance through habitat protection and restoration.

DELTA GREEN GROUND BEETLE: The vision for the delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing its populations and abundance through habitat restoration.

VALLEY ELDERBERRY LONGHORN BEETLE: The vision for the valley elderberry longhorn beetle is to recover this federally listed threatened species by increasing its populations and abundance through habitat restoration.

WESTERN YELLOW-BILLED CUCKOO: The vision for the western yellow-billed cuckoo is to contribute to recovery of this State-listed endangered species. There is no recent occurrence information for the yellow-billed cuckoo in the Delta. However, the cuckoo would become reestablished in the Delta and will benefit from improvements in riparian habitats. Improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Delta will involve a long-term commitment with short-term and long-term elements. Short-term elements include features that can and need to be implemented as quickly as possible either because of a long-standing need or a pressing opportunity. Plan elements where need, priority, technical and engineering feasibility, or cost effectiveness are questionable would be long-term. However, even long-term elements would in most cases benefit from short-term pilot studies that would address need, feasibility, science, and cost effectiveness.

Changes in freshwater inflow patterns to the Delta is a long-standing need; however, without developed supplies, the prescribed spring flows may not be possible in all year types. In the short-term, efforts would be made to provide the flows with available CVP water supplies in Shasta, Folsom, and New Melones Reservoirs using water prescribed by the Central Valley Project Improvement Act (§3406 b2 water) and additional water purchased from willing sellers (CVPIA §3406 b3 or CALFED purchased water). The effectiveness of water dedicated for such purposes would be maximized through use of tools such as water transfers. In the long term, additional environmental water supplies may be needed to meet all flow needs.

Related programs in this Ecological Management Zone include the CVPIA and Anadromous Fisheries Restoration Program, the SB 34 levee subvention program, Central Valley Habitat Joint Venture, the Riparian Habitat Joint Venture (a multiagency cooperative effort), Ducks Unlimited's Valley Care program, the Nature Conservancy's Cosumnes River and Jepson Prairie Preserves, the USFWS's Stone Lakes Refuge, the DFG's Yolo Basin Wildlife Area, East Bay Park's Big Break and Little Franks Tract recreation areas, and outreach programs that compensate private landowners who improve wildlife management of their lands. The U.S. Army Corps of Engineer's program to mitigate for habitat losses from levee protection in the Delta should coordinate closely with the restoration program.

Much of the infrastructure to implement the vision for the Delta now exists. Existing programs could implement many of the restoration actions outlined in this vision. In areas where cooperative agency and stakeholder efforts do not now exist, such organizations can be developed to help implement the program. Cooperative efforts where agencies have formed partnerships to restore valuable aquatic, wetland, and riparian habitats in the east Delta would be supported and used as a model for other similar efforts (e.g., the Cosumnes River Preserve, with the Nature Conservancy and Ducks Unlimited). Other examples include the establishment of wildlife refuges at Stone Lakes and the Yolo Bypass, each with multiple partners and commitments. The California Department of Water Resources, DFG, and the U.S. Fish and Wildlife Service (USFWS) own considerable properties in the Delta (e.g., West Sherman Island Wildlife Area), which with funding support can be restored or upgraded to fit the vision. The Interagency Ecological Program (IEP) is an established research and monitoring unit that, with support, can accomplish the expanded evaluation and monitoring needs.

ENDANGERED SPECIES RECOVERY PLAN IMPLEMENTATION

The ERPP will be an important, if not major, component in the successful implementation of recovery measures for species listed under either the State or Federal ESAs. For example, many of the targets and programmatic actions listed later in this section are derived from existing recovery plans. Two plans of major importance include the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) and the NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997).

Because the ERPP addresses endangered species from a broader ecosystem perspective, many restoration actions will benefit broad species communities and the habitats upon which they depend. These include actions to benefit aquatic and terrestrial fish and wildlife species as well as special plants and plant communities.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the Delta Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. The Anadromous Fish Restoration Program of the CVPIA (USFWS 1997) has a goal to double the natural production of anadromous fish in the system over the average production during 1967 through 1991. CVPIA authorized the dedication and management of 800,000 af of CVP yield annually for the purpose of implementing the fish, wildlife, and habitat restoration purposes and measures that include water purchased for inflow to and outflow from the Delta.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture is a component of the USFWS's North American Waterfowl Management Plan, with funding and cooperative project participation by federal, State, and private agencies. New funding sources, including CALFED restoration funds, are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes objectives to protect wetlands by acquiring fee-title or conservation easements and to enhance waterfowl habitat in wetlands and agricultural lands. Joint Venture objectives and targets have been adopted by the ERPP.

SAN JOAQUIN COUNTY HABITAT CONSERVATION PLAN

The San Joaquin County Habitat Conservation Plan is nearing completion and describes mechanisms for offsetting past and future impacts associated with land use changes. The habitat conservation plan outlines an approach for acquiring lands using preservation criteria.

DELTA WILDLIFE HABITAT PROTECTION AND RESTORATION PLAN

While not a formal plan, this plan is used to guide California Department of Fish and Game (DFG), USFWS, and other agencies' programs to wisely use and protect riparian and wetland habitats in the Bay and Delta. Its goals are to protect and improve habitat and inform the public of the magnitude of problems that threaten wildlife and their habitat. It also provides mechanisms for cooperation between local governments and State and federal agencies.

CALFED BAY-DELTA PROGRAM

CALFED has funded over 20 ecosystem restoration projects in the Sacramento-San Joaquin Delta. Many of these projects deal with restoration of tidal aquatic habitat and screening of water diversions. Two of the more significant projects address the land subsidence problem, by studying methods to return the land to its pre-disturbance elevation. Department of Water Resources is allowing biomass to accumulate on Twitchell Island to reverse the subsidence. In another project, the United States Geological Survey is studying the movement and availability of sediment supplies in the Delta.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Realizing the vision in this Ecological Management Zone depends in part on achieving the targets in the Sacramento River, Eastside Delta Tributaries, Yolo basin, and San Joaquin River Ecological Management Zones. Targets in the Suisun Marsh/North San Francisco Bay Ecological Management Zone should be pursued in combination with the Delta to restore important rearing habitats, reduce the introduction of contaminants, and control the introduction of non-native aquatic species. Meeting the flow needs for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers is essential to the Delta freshwater inflow needs. Aquatic, riparian, and wetland corridors in the Yolo and Eastside Delta Tributaries Ecological Management Zones are also directly linked and integral to habitat corridors in the Delta.

One important ecological process that needs further evaluation is sediment. The sediment budget of the Delta is of particular interest and there is a need to quantify sediment input, sediment depositional patterns in the Delta, and sediment output.

RESTORATION TARGETS, AND PROGRAMMATIC ACTIONS

Targets developed for the Sacramento-San Joaquin Delta Ecological Management Zone (and the 13 other ecological management zones) can be classified by their reliability in contributing to attainment of the Strategic Objectives. The target classification system used in the following section is as follows:

Class	Description
◆	Target for which additional research, demonstration, and evaluation is needed to determine feasibility or ecosystem response.
◆◆	Target which will be implemented in stages with the appropriate monitoring to judge benefit and success.
◆◆◆	Target that has sufficient certainty of success to justify full implementation in accordance with adaptive management, program priority setting, and phased implementation.

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

GENERAL TARGET: The general target is to more closely approach the natural (unimpaired) seasonal Delta outflow patterns that:

- transport sediments,
- stimulate the estuary foodweb,
- provide for up and downstream fish passage,
- contribute to riparian vegetation succession,
- transport larval fish to the entrapment zone,
- maintain the entrapment zone and natural salinity gradient, and
- provide adequate attraction and migrating flows for salmon, steelhead, American shad, white sturgeon, green sturgeon, lamprey striped bass, splittail, delta smelt, and longfin smelt.

Besides seasonal peak flows, low and varying flows are also essential elements of the natural Delta outflow pattern to which native plant and animal species have adapted. Specific targets for different flow pattern attributes may vary with the different storage and conveyance alternatives being considered in the CALFED Program.

TARGET 1: Provide a March outflow that occurs from the natural late-winter and early-spring peak inflow from the Sacramento River. This outflow should be at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal water years, and 40,000 cfs for 10 days in above-normal water years. Wet-year outflow is generally adequate under the present level of development (◆◆).

PROGRAMMATIC ACTION 1A: Prescribed outflows in March should be met by the cumulative flows of prescribed flows for the Sacramento, Feather, Yuba, and American rivers. Assurances must be obtained (e.g., to limit Delta diversions) that these prescribed flows will be allowed to contribute to Delta outflow. A portion of the inflow would be from base (minimum) flows from the east Delta tributaries and the San Joaquin River and its tributaries.

TARGET 2: Provide a late-April to early May outflow that emulates the spring inflow from the San Joaquin River. The outflow should be at least 20,000 cfs for 10 days in dry years, 30,000 cfs in below normal years, and 40,000 cfs in above normal years. These flows would be achieved through base flows from the Sacramento River and flow events from the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers (◆).

PROGRAMMATIC ACTION 2A: Prescribed outflows in late April and early May should be met by the cumulative prescribed flows from the Stanislaus, Tuolumne, and Merced rivers (see East San Joaquin Basin Ecological Management Zone), and Mokelumne and Calaveras rivers (see Eastside Delta Tributaries Ecological Management Zone). It will be necessary to obtain assurances that these prescribed flows are allowed to contribute to Delta outflow. The flow event would be made up of:

- the Cosumnes River,
- Mokelumne, Calaveras, and San Joaquin tributary pulsed flows prescribed under the May 1995 Water Quality Control Plan, and
- supplemental flows.

TARGET 3: Provide a fall or early winter outflow that approximates the first "winter" rain through the Delta (◆).

PROGRAMMATIC ACTION 3A: Allow the first "significant" fall/winter natural flow into the Delta (most likely either from rainfall or from unimpaired flows from tributaries and lower watersheds below storage reservoirs or from flows recommended by DFG and the Anadromous Fish Restoration Program [AFRP]) to pass through the Delta to the San Francisco Bay by limiting water diversions for up to 10 days. (No supplementary release of stored water from reservoirs would be required above that required to meet flows prescribed by DFG and AFRP.)

TARGET 4: Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years (U.S. Fish and Wildlife Service 1995) (◆).

PROGRAMMATIC ACTION 4A: Supplement flows in May of all but critical years as needed from Shasta, Oroville, and Folsom reservoirs to maintain an inflow of 13,000 cfs to the Delta.

RATIONALE: *Changing the seasonal pattern of freshwater flows into and through the Delta will help restore the Delta's ecosystem processes and functions. This ecosystem restoration is fundamental to the health of aquatic, wetland, and riparian resources.*

Providing Delta outflow at the prescribed level in dry and normal years in March will provide the following benefits:

- *improve survival of juvenile chinook salmon rearing in and passing downstream through the Delta,*

- *provide attraction flows to adult winter-run and spring-run chinook salmon, steelhead, striped bass, white and green sturgeon, splittail, and American shad migrating upstream through the Delta to spawning grounds in the Sacramento River and its tributaries,*

- *provide attraction flows for longfin and delta smelt moving upstream within the Delta to spawn in the Delta,*

- *provide downstream passage flows for steelhead, splittail, longfin smelt, and delta smelt to move through the Delta to the San Francisco Bay,*

- *help maintain lower water temperatures further into the spring to benefit adult and juvenile salmon, steelhead, longfin smelt, delta smelt, and splittail,*

- *stimulate the foodweb in the Delta and Bay,*

- *reduce potential effects of toxins released into Delta waters,*

- *promote growth of riparian vegetation along Delta waterways, and*

- *reduce loss of eggs, larvae, and juvenile fish into south Delta water diversions.*

Supplementing an existing prescription for late April-early May pulse flow through the Delta from the San Joaquin River will assist juvenile San Joaquin chinook salmon and steelhead moving through the Delta to the Bay. The added flow will also help transport Delta and San Joaquin plankton and nutrients that have built up during the spring to the western Delta and Suisun Bay where they will stimulate the spring foodweb on which many of the important fish species living in the Delta depend. In addition, this flow will provide many of the same benefits described above for the March flow event. The flow event would be provided by supplementing the prescribed pulse flow in the 1995 Water Quality Control Plan with additional waters purchased from willing sellers on the Mokelumne, Stanislaus, Tuolumne, and Merced rivers.

Restoring the natural first "fall" flow through the Delta will provide the following benefits:

- *support spring-run and other chinook salmon, steelhead, and American shad juveniles migrating from the mainstem rivers and tributaries in passing through the Delta to the Bay,*

- *provide attraction flows for adult fall-run and late-fall run chinook salmon, splittail, longfin smelt, delta smelt, and steelhead migrating upstream into or through the Delta, and*

- *reduce losses of migrating juvenile fish in south Delta pumping plants.*

Maintaining a minimum inflow of 13,000 cfs from the Sacramento River in May will help maintain survival and transport of striped bass eggs and larvae, and white and green sturgeon from the Sacramento River above Sacramento into the Delta. This flow will also benefit remaining downstream migrating juvenile chinook salmon and steelhead from the Sacramento River and its tributaries, as well as upstream migrating winter- and spring-run chinook salmon and American shad. Supplemental average monthly storage releases of up to 2,500 cfs for 30 days (150,000 total acre-feet) may be necessary in dry years to meet this requirement. In normal and wet years, flows would generally exceed 13,000 cfs. Implementation of this action requires the development and application of an adaptive management program that includes development of testable hypothesis and implementation of a monitoring program to collect and analyze the data to evaluate the hypothesis.

Providing for larger flows during the seasons with when those flows occurred historically, particularly in normal or dry years, will help restore important ecological processes and *functions that create and maintain habitat in the Delta. Delta channel maintenance, sediment and nutrient transport, and introductions of plant debris are some examples of processes improved by flow events. Spring flow events in dry and normal years will help sustain riparian and wetland vegetation.*

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain sediment supply to the Delta from upstream areas at levels needed to maintain existing habitats and to contribute to present and future efforts to reverse subsidence on Delta islands.

PROGRAMMATIC ACTION 1A: Develop a cooperative investigation to determine the existing sediment budget in the Delta based on sediment input, use within the Delta, and sediment output.

RATIONALE: *Natural sediments of streams, rivers, and estuaries consist of mineral and organic silts, sands, gravel, cobble, and woody debris. These materials naturally enter, deposit, erode, and are transported through the Bay-Delta and its watershed. Sediment, like water, is one of the natural building blocks of the ecosystem. Many other ecological processes and functions, and habitats and species require specific types and amounts of sediment and the habitats sediments create.*

Finer sediments are important in the natural development of riparian and wetland habitats. Major factors that influence the sediment supply in the Bay-Delta and its watersheds include many human activities such as dams, levees, and other structures, dredging, and gravel and sand mining.

River-transported sediments are an essential component of the physical structure and nutrient base of the Bay-Delta ecosystem and its riverine and tidal arteries. The size, volume, and seasonal timing of sediments entering the riverine and estuarine systems should be compatible with both natural and altered flow regimes. Sediment transport should match channel and floodplain characteristics of individual rivers, streams, and tidal sloughs. A specific sediment management objective is to redistribute sediment in the watersheds and valley components of the ecosystem. An appropriate level, rate, and size of sediment should be redistributed to match specific habitat requirements and ecological functions.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Expand the floodplain area in the North, East, South, and Central and West Delta Ecological Management Units by putting approximately 10% of leveed lands into the active floodplain of the Delta (◆◆).

PROGRAMMATIC ACTION 1A: Convert leveed lands to tidal wetland/slough complexes in the North Delta Ecological Management Unit. Permanently convert island tracts (Little Holland, Liberty, and Prospect) at the south end of the Yolo Bypass to tidal wetland/slough complexes. Convert small tracts along Snodgrass Slough to tidal wetland/slough complexes. Construct setback levees along Minor, Steamboat, Oxford, and Elk Sloughs.

PROGRAMMATIC ACTION 1B: In the East Delta Ecological Management Unit, construct setback levees along the South Mokelumne River and connecting dead-end sloughs (Beaver, Hog, and Sycamore).

PROGRAMMATIC ACTION 1C: Remove levees that hinder tidal and floodflows in the headwater basins of east Delta dead-end sloughs (Beaver, Hog, and Sycamore) and allow these lands to be subject to flood overflow and tidal action.

PROGRAMMATIC ACTION 1D: Convert deeper subsided (sunken) lands between dead-end sloughs in the East Delta Ecological Management Unit east of the South Mokelumne River channel either to overflow basins and nontidal wetlands or to land designated for agricultural use.

PROGRAMMATIC ACTION 1E: Construct setback levees in the South Delta Ecological Management Unit along the San Joaquin River between Mossdale and Stockton.

PROGRAMMATIC ACTION 1F: Convert adjacent lands along the San Joaquin River between Mossdale and Stockton either to overflow basins and nontidal wetlands or to land designated for agricultural use.

PROGRAMMATIC ACTION 1G: Construct setback levees on corners of Delta islands along the San Joaquin River channel in the Central and West Delta Ecological Management Unit. Open leveed lands to tidal action where possible along the margins of the West Delta Ecological Management Unit.

RATIONALE: *Subjecting approximately 10% of existing Delta leveed lands to tidal action and floodflows will greatly enhance the floodwater and sediment retention capacity of the Delta. The tracts at the south end of the Yolo Bypass, along the South Mokelumne River, and along the San Joaquin River channel are logical choices for this because they have limited levee systems and are already at high flood risk. These lands have had limited subsidence and offer good opportunities for restoring tidal wetland/slough complexes.*

The other significant area for setbacks is along the main channel of the San Joaquin River. "Cutting corners" on some islands where the levee length to land area maintained is now high would reduce levee construction and maintenance.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: More frequently maintain daily water temperatures in the Delta channels below 60°F in the spring and 65°F in the fall to meet the temperature needs of salmon and steelhead migrating through or rearing in the Delta (◆).

PROGRAMMATIC ACTION 1A: Improve riparian woodland habitats along migrating channels and sloughs of the Delta.

PROGRAMMATIC ACTION 1B: Improve SRA habitat along migration routes in Delta.

RATIONALE: *Maintaining water temperatures of less than 60 °F in the spring and 65 °F in the fall can improve survival of juvenile chinook salmon rearing in or migrating through the Delta. Maintaining maximum daily water temperatures in the channels and sloughs of the Sacramento-San Joaquin Delta Ecological Management Zone of less than 66 °F in the fall will ensure healthy conditions for upstream migrating adult chinook salmon and early emigrating juveniles. Improved riparian habitat along Delta channels and the spring flow events should maintain cooler spring temperatures in dry and normal years. Improved riparian and SRA habitat will help to maintain lower Delta water temperatures from spring through fall.*

DELTA CHANNEL HYDRAULICS

TARGET 1: Reestablish more natural internal Delta water flows in channels (◆◆◆).

PROGRAMMATIC ACTION 1A: Reduce velocities in selected Delta channels by increasing cross-sectional areas of channel by means of setback levees or by constricting flows into and out of the channels.

PROGRAMMATIC ACTION 1B: Increase tidal flow and cross-Delta transfer of water to south Delta pumping plants to selected channels to lessen flow through other channels.

PROGRAMMATIC ACTION 1C: Manage the operation of existing physical barriers so that resulting hydraulics upstream and downstream of the barrier are more like levels in the mid-1960s.

PROGRAMMATIC ACTION 1D: Close the DCC when opportunities allow, as specified in the 1995

Water Quality Control Plan and recommended by the U.S. Fish and Wildlife Service (1995), in the period from November through January when appropriate conditions trigger closure (i.e., internal Delta exports are occurring).

TARGET 2: Restore hydrodynamic conditions in the rivers and sloughs of the Delta sufficient to support targets for the restoration of aquatic resources (◆◆).

PROGRAMMATIC ACTION 2A: Restore 3,000 to 4,000 acres of tidal perennial aquatic habitat and 20,000 to 25,000 acres of tidally influenced freshwater marsh. *(Note: These recommendations are contained within programmatic actions presented in this section for tidal perennial aquatic habitat and fresh emergent wetland (tidal) and are not additions to acreages presented in the targets and programmatic actions for habitat.)*

TARGET 3: Maintain net downstream flows in the mainstem San Joaquin River from Vernalis to immediately west of Stockton from September through November to help sustain dissolved oxygen levels and water temperatures adequate for upstream migrating adult fall-run chinook salmon (◆◆).

PROGRAMMATIC ACTION 3A: Operate a barrier at the head of Old River from August through November.

TARGET 4: Restore 50 to 100 miles of tidal channels in the southern Yolo Bypass within the north Delta, while maintaining or improving the flood carrying capacity of the Yolo Bypass (◆). *(Note: This target is in addition to targets and programmatic actions presented in the Delta Slough habitat section.)*

PROGRAMMATIC ACTION 4A: Construct a network of channels within the Yolo Bypass to connect the Putah and Cache Creek sinks, and potentially the Colusa drain, to the Delta. These channels should effectively drain all flooded lands in the bypass after floodflows stop entering the bypass from the Fremont and Sacramento weirs. The channels would maintain a base flow through the spring to allow juvenile anadromous and resident fish to move from rearing and migratory areas.

PROGRAMMATIC ACTION 4B: Reduce flow constrictions in the Yolo Bypass such as those in the openings in the railway causeway that parallels Interstate 80.

RATIONALE: *Internal Delta hydraulics have been highly modified since the early 1950s. Adverse hydraulic action has created poor conditions for sustaining spawning, rearing, and foodweb production in the Delta and for the transport of larval fish such as delta smelt and striped bass; (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995; Independent Scientific Group 1996).*

Restoring hydraulic conditions within the Delta by modifying physical barriers in the Delta will support natural transport functions, reduce entrainment (in diversions) into parts of the Delta where survival is low, and assist in transporting juvenile fish into and through the Delta to highly productive nursery areas in the western Delta and Suisun Bay. Modifying DCC operation will restore historical hydraulic conditions in lower Mokelumne channels of the north Delta (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995). Internal Delta hydraulics can be improved through several operational or structural approaches. The removal of structural barriers that alter internal Delta hydraulic patterns may be possible, depending on which alternative is selected.

Maintaining adequate flows past Stockton will improve existing harmful conditions of low *dissolved oxygen and high water temperatures that can hinder the upstream movement of adult San Joaquin fall-run chinook salmon. In addition, improved flows past Stockton will reduce straying of adult salmon into Central and South Delta channels (California Department of Fish and Game 1972).*

Improving the channel network in the Yolo Bypass will improve the migration pathway for salmon produced in Putah and Cache creeks, as well as for upper Sacramento River salmon using the Yolo Bypass as a pathway to the Delta. A well-drained system with permanent sloughs will keep juvenile salmon from being stranded in the bypass when flows stop. Permanent sloughs will provide valuable juvenile salmon rearing habitat in late winter and early spring.

Improving habitats along riparian corridors in the Yolo Bypass will provide additional spawning and rearing habitat for splittail and rearing and migration habitat for juvenile chinook salmon and perhaps for delta smelt and other native resident fishes. Conditions will also improve for wildlife and waterfowl.

Restoring connections among Delta channels, freshwater marsh, and seasonal wetland habitats will enhance habitat conditions for special-status species such as the splittail. Restoring this habitat connectivity in a large-scale mosaic in the North Delta will help restore the ecosystem processes and functions fundamental to supporting the foodweb and will improve conditions for rearing chinook salmon, steelhead, sturgeon, juvenile delta smelt, striped bass, and splittail (Fahrig and Merriam 1985).

BAY-DELTA AQUATIC FOODWEB

TARGET 1: Increase primary and secondary nutrient productivity in the Delta to levels historically observed in the 1960s and early 1970s (◆).

PROGRAMMATIC ACTION 1A: Actions described above to restore streamflow, floodplain flooding, Delta hydraulics, tidal wetlands and sloughs, and riparian habitat would increase primary and secondary productivity in the Delta. Relocating the intake of the South Delta pumping plants to the North Delta would also increase Delta productivity.

RATIONALE: *Increasing the area of tidal wetland/slough habitat and the residence time of Delta waters will increase primary and secondary productivity. More flooding of floodplains will provide more nutrients and organic carbon inputs to Delta waters. Relocating the intakes of the South Delta pumping plants will increase the residence time of Central and South Delta waters and allow more of the highly productive San Joaquin waters to be retained in the Delta.*

HABITATS

GENERAL RATIONALE

Restoring wetland and riparian habitats along with tidal perennial aquatic habitats is an essential element of the restoration strategy for the Sacramento-San Joaquin Delta Ecological Management Zone. The general approach for habitat restoration is to mimic to the extent feasible a well-connected mosaic of aquatic and riparian habitats. In some areas, these habitat should be a contiguous as possible avoiding small habitat patches in favor of larger. Habitat corridors in the Delta should be emphasized that interconnect with habitat corridors on the main stem Sacramento and San Joaquin rivers as well as the eastside tributaries such as the Mokelumne River.

The extent and distribution of the land-water interface (contact) between aquatic habitats and interconnected wetland and riparian habitats have been altered since the mid-1850s by Delta reclamation. Since 1906, the amount of land-water interface has been reduced 32% in the East Delta Ecological Management Unit, 25% in the

South Delta Ecological Management Unit, and 45% in the Central and West Delta Ecological Management Unit.

Increasing the ratio of land-water interface and increasing the shoreline perimeter will help restore a complex habitat mosaic on a large scale in the Delta. This will support essential ecosystem processes and functions. These measures are also fundamental to supporting the foodweb and improving conditions for rearing chinook salmon, steelhead, sturgeon, delta smelt, striped bass, and splittail. Foodweb support functions for wildlife will also benefit (Cummins 1974; Clark 1992).

Restoring high-quality freshwater marsh and brackish water marsh, both seasonal and permanent, will increase the production and availability of natural forage for waterfowl and other wildlife. This restoration will also increase the overwinter survival rates of wildlife that winter in this Ecological Management Zone and will strengthen them for migration, thus improving their breeding success. Expanding these habitats will also reduce the amount and concentrations of contaminants that could, upon entering the Delta's sloughs, damage the health of the aquatic resources.

The restoration of all habitats will be within the structure of adaptive management. The program will move forward in a step-wise progression. Each element will be designed with a testable hypothesis and a monitoring program to collect the scientific data needed to evaluate the hypothesis will be in place. Implementation will begin on a small scale and depending on the monitoring results will either continue or be modified based on results of completed projects.

TIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Restore 1,500 acres of shallow-water habitat in the North Delta Ecological Management Unit; 1,000 acres of shallow-water habitat in the East Delta Ecological Management Unit; 2,000 acres of shallow-water habitat in the South Delta Ecological Management Unit; and 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Management Unit (◆◆).

PROGRAMMATIC ACTION 1A: Restore 500 acres of shallow-water habitat at Prospect Island in the North Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Restore 1,000 acres of shallow-water habitat in the downstream (south) end of the Yolo Bypass (Little Holland and Liberty islands) within the North Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1C: Restore 1,000 acres of shallow-water habitat at the eastern edge of the East Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level.

PROGRAMMATIC ACTION 1D: Restore 2,000 acres of shallow-water habitat at the south and eastern edge of the South Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level.

PROGRAMMATIC ACTION 1E: Restore 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Management Unit where existing land elevations range from 5 to 9 feet below mean sea level. A program of fill placement or longer-term subsidence reversal may be needed to accomplish this action.

PROGRAMMATIC ACTION 1F: Restore Frank's Tract to a mosaic of habitats using clean dredge materials and natural sediment accretion.

TARGET 2: Restore 500 acres of shoals in the westernmost portion of the Central and West Delta (◆◆).

PROGRAMMATIC ACTION 2A: Implement a sediment management program that results in deposition and accretion within portions of Central and West Delta channels and bays, forming 500 acres of shallow shoal habitat restored to tidal influence.

RATIONALE: *Restoring, improving, and protecting high-quality shallow-water habitat will provide greater foraging areas for rearing juvenile fish and waterfowl in this Ecological Management Zone. These areas typically provide high primary and secondary productivity and support nutrient cycling that sustains good forage. These areas also provide good forage for waterfowl that use underwater vegetation growing in the shoals and for diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984; Shloss 1991; Sweetnam and Stevens 1993; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1996; Lindberg and Marzuola 1993).*

Restoring, improving, and protecting high-quality shallow shoal habitat will provide foraging habitat for rearing juvenile fish. These areas typically provide high primary and secondary productivity and support nutrient cycling that sustains good forage. These areas also provide good forage for shorebirds that feed on invertebrates, waterfowl that use underwater vegetation growing in the shoals, and diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984).

Franks's Tract is a flooded Delta island that can be restored to a mosaic of habitat types with no impact to agriculture. Frank's Tract levees were breached and the island has been flooded since the early 1900s. The deep bed of the island does not provide good quality habitat for native fishes. Parts of the island could be elevated through a combination of dredge material placement, natural sediment accretion, and peat accumulation. Frank's Tract will be a functional component of the San Joaquin River corridor, a major fish rearing and migration area, as well as providing continuity with existing and other proposed habitats in the Central and West Delta Ecological Management Unit. Developing the tract must also occur in conjunction with the control or eradication of introduced, nuisance aquatic plants for restoration to be most beneficial to native species.

NONTIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Develop 500 acres of deep open-water areas (more than 4 to 6 feet deep) within restored fresh emergent wetlands in the Delta to provide resting habitat for water birds, foraging habitat for diving ducks and other water birds and semi-aquatic mammals that feed in deep water, and habitat for associated resident pond fish species (◆).

PROGRAMMATIC ACTION 1A: Develop 100 acres of open-water areas within restored fresh emergent wetland habitats in the West and Central Delta Ecological Management Unit such as on Twitchell or Sherman islands.

PROGRAMMATIC ACTION 1B: Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1C: Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Management Unit.

TARGET 2: Develop 2,100 acres of shallow, open-water areas (less than 4 to 6 feet deep) in restored fresh emergent wetland habitat areas in the Delta to provide resting, foraging, and brood habitat for water birds and habitat for fish and aquatic plants and semi-aquatic animals (◆◆).

PROGRAMMATIC ACTION 2A: Develop 500 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the Central and West Delta Ecological Management Unit such as on Twitchell or Sherman Islands.

PROGRAMMATIC ACTION 2B: Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Management Unit.

PROGRAMMATIC ACTION 2C: Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Management Unit.

PROGRAMMATIC ACTION 2D: Develop 1,000 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the North Delta Ecological Management Unit.

RATIONALE: *Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rate. Other water-associated wildlife will also benefit (Madrone and Associates 1980).*

Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rates. Other water-associated wildlife will also benefit (Madrone and Associates 1980).

Implementation of actions designed to increase or improve acreages of nontidal perennial aquatic habitats need to develop or integrate subsidence reversal and sediment accretion. These will assist in raising bottom elevations to levels that can support rooted submergent and emergent vegetation.

DELTA SLOUGHS

TARGET 1: Restore ecological structure and functions of the Delta waterways network by increasing the land-water interface ratio a minimum of 50% to 75% compared to 1906 conditions and by restoring 100 to 150 miles of small distributary sloughs (less than 50 to 75 feet wide) hydrologically connected to larger Delta channels (◆◆). *(Note: This target is in addition to the Delta slough target presented in the target section for Delta Channel Hydraulics.)*

PROGRAMMATIC ACTION 1A: To replace lost slough habitat and provide high-quality habitat areas for fish and associated wildlife, the short-term solution for the Central and West Delta Ecological Management Unit is to restore 20 miles of slough habitat. The long-term solution is to restore 50 miles of slough habitat. In both the North Delta and East Delta Ecological Management Units, the short-term solution is to restore 10 miles of slough habitat. The long-term solution is to restore 30 miles of slough habitat. In the South Delta Ecological Management Unit, the short-term solution is to restore 25 miles of slough habitat and the long-term solution is to restore 50 miles of slough habitat.

PROGRAMMATIC ACTION 1B: Restore tidal action to portions of islands and tracts in the North and East Delta Ecological Management Units with appropriate elevation, topography, and water-landform conditions. This will sustain tidally influenced freshwater marshes with 20 to 30 linear miles of narrow, serpentine-shaped sloughs within the wetlands and floodplain.

RATIONALE: *Restoring, improving, and protecting sloughs in the Ecological Management Units of the Sacramento-San Joaquin Delta Ecological Management Zone will help sustain high-quality shallow-water habitat for spawning of native fish and for foraging of juvenile fish. Restoring small dead-end sloughs and tidally influenced freshwater marshes and mudflats in the Sacramento-San Joaquin Delta Ecological Management Zone will provide habitat for spawning of native fish and for foraging of juvenile fish, increase production of primary and secondary food species, and support nutrient cycling that sustains quality forage. These sloughs can also provide loafing sites for waterfowl and habitat for the western pond turtle (Simenstad et al. 1992 and 1993; Lindberg and Marzuola 1993; Madrone and Associates 1980).*

Land-water interface targets represent a reasonable level necessary to restore Bay-Delta ecosystem functions and overall health by *increasing water-to-perimeter shoreline ratios and patterns to those of the early 1900s. Delta slough habitat will be restored as a mosaic of habitats including slough, tidal perennial, and tidal emergent habitats.*

MIDCHANNEL ISLANDS AND SHOALS

TARGET 1: Maintain existing channel islands and restore 50 to 200 acres of high-value islands in selected sloughs and channels in each of the Delta's Ecological Management Units (◆◆).

PROGRAMMATIC ACTION 1A: Actively protect and improve existing channel islands in the Delta.

PROGRAMMATIC ACTION 1B: Restore 50 to 200 acres of channel islands in the Delta where channel islands once existed.

RATIONALE: *Many of the remnant channel or "berm" islands in the Delta have been lost to continuing erosion and degradation. Restoring, improving, and protecting the riverine-edge habitat of these islands will provide habitat for juvenile salmon rearing in this Ecological Management Zone. Terrestrial vertebrates that will receive indirect benefits include the western pond turtle and shorebirds and wading birds (Fris and DeHaven 1993; Mahoney and Ermin 1984; Knight and Bottorf 1983; Knox 1984; Novick and Hein 1982; Moore and Gregory 1988; May and Levin 1991; Levin et al. 1995).*

Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These habitats typically provide high levels of primary (plant) and secondary (animal) productivity and support nutrient cycling functions that can sustain quality forage. These habitats also provide high-quality forage habitat for waterfowl who use submergent vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984).

Restoring high-quality brackish tidal marshes on and adjacent to these islands will contribute to cycling nutrients, maintaining the foodweb, and increasing production of primary and secondary food species in a geographic location already noted for its value as a rearing habitat for estuarine fish. Several plant species of special concern such as the Suisun aster will benefit from increasing the area of brackish tidal marsh in the Delta (Landin and Newling 1988; Dionne et al. 1994; Lindberg and Marzuola 1993).

FRESH EMERGENT WETLAND HABITAT (TIDAL)

TARGET 1: Increase existing tidal freshwater marsh habitat in the Delta by restoring 30,000 to 45,000 acres of lands designated for floodplain restoration (◆◆).

PROGRAMMATIC ACTION 1A: Develop tidal freshwater marshes in the North Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Develop tidal freshwater marshes on small tracts of converted leveed lands along Snodgrass Slough.

PROGRAMMATIC ACTION 1C: Develop tidal freshwater marshes along the upper ends of dead-end sloughs in the east Delta.

PROGRAMMATIC ACTION 1D: Develop tidal freshwater marshes along all setback levees and levees with restored riparian habitat.

PROGRAMMATIC ACTION 1E: Develop tidal freshwater marshes on restored channel island habitat. *(Note: Any tidal freshwater marsh habitat developed is included in Target 1 for this habitat type.)*

RATIONALE: *Restoring tidally influenced freshwater marshes in the Sacramento-San Joaquin Delta Ecological Management Zone will increase production of primary and secondary food species and support nutrient cycling* *functions that can sustain quality forage conditions for fish, waterfowl, shorebirds, and wildlife (Lindberg and Marzuola 1993; Miller 1993; Simenstad et al. 1992 and 1993). Increasing the area of freshwater tidal marshes in each of the four Delta Ecological Management Units will help support the proper aquatic habitat for rearing and outmigrating juvenile chinook salmon, steelhead, and sturgeon and for rearing delta smelt, striped bass, and splittail. Restoring high-quality freshwater marshes, both tidal and nontidal, will contribute to nutrient cycling, maintaining the foodweb, and increased production of primary and secondary food species. In addition, increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. This can only be effective, however, if upland migration corridors are available for the marshes to expand as sea level rises.*

The targets selected take into account the large losses of tidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Management Zone lost nearly 90,000 acres, with the greatest losses in the North Delta and Central and West Delta Ecological Management Units. Acreage changes in the South Delta were insignificant during that period because most losses these occurred before 1900. Restoration targets are to restore between 30% and 50% of the losses since 1900. The level of restoration was increased in the South Delta because of the prior losses documented by Landin and Newling (1988). There was a substantial loss of fresh emergent wetlands in the South Delta Ecological Management Unit prior to the 1900s and a significant amount of wetlands could be restored in this unit depending on which alternative is selected.

FRESH EMERGENT WETLAND HABITAT (NONTIDAL)

TARGET 1: Restore a total of 3,000 acres of nontidal freshwater marshes in the North and the East Delta Ecological Management Units; restore 4,000 acres of nontidal fresh emergent wetland in the South Delta Ecological Management Unit as part of a subsidence control program; and restore 10,000 acres of nontidal fresh emergent wetland in the Central and West Delta Ecological Management Unit as part of a subsidence control program (◆◆).

PROGRAMMATIC ACTION 1A: Restore 1,000 acres of nontidal freshwater marshes on Twitchell Island.

PROGRAMMATIC ACTION 1B: Restore 1,000 acres of nontidal freshwater marshes in the Yolo Bypass.

PROGRAMMATIC ACTION 1C: Restore 1,000 acres of nontidal freshwater marshes in leveed lands designated for floodplain overflow adjacent to the dead-end sloughs in the East Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1D: Restore 4,000 acres of nontidal freshwater marshes in the South Delta in lands designated for floodplain overflow.

PROGRAMMATIC ACTION 1E: Restore 10,000 acres of nontidal freshwater marshes on Delta Islands of the Central and West Delta Ecological Management Unit. *(Note: Up to 75% of this acreage may be restored to tidal actions after the appropriate land elevations are achieved through island accretion. Upon restoring tidal action, targets for the Central and West Delta Ecological Management Unit would be adjusted to avoid the need to restore additional non-tidal wetland above 2,500 acres.)*

RATIONALE: *The restoration of high-quality nontidal freshwater marshes will contribute to nutrient cycling, maintaining the foodweb, and supporting enhanced levels of primary and secondary food production. Increasing the areal extent of nontidal freshwater marsh in the Delta, particularly in the Central and West Delta Ecological Management Unit, will be an important component of subsidence control and island accretion. Permanent freshwater marsh can* *help arrest and in some cases reverse subsidence where peat oxidation has resulted in land elevations more than 15 feet below sea level. Increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. Habitats for wetland wildlife will be improved. The targets selected take into account the large losses of nontidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Management Zone lost nearly 90,000 acres with the greatest losses in the North Delta and Central and West Delta Ecological Management Units. Acreage changes in the South Delta were insignificant during that period because most losses there occurred before 1900.*

SEASONAL WETLAND HABITAT

TARGET 1: Restore and manage at least 4,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the North Delta Ecological Management Unit (◆◆).

PROGRAMMATIC ACTION 1A: Improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the Yolo Bypass.

PROGRAMMATIC ACTION 1B: Restore and manage 2,000 acres of additional seasonal wetland habitat in association with the Yolo Basin Wildlife Area.

TARGET 2: Restore and manage at least 6,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the East Delta Ecological Management Unit (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore and manage 1,000 acres of additional seasonal wetland habitat on Canal Ranch.

PROGRAMMATIC ACTION 2B: Develop a cooperative program to restore and manage 5,000 acres of additional seasonal wetland habitat.

PROGRAMMATIC ACTION 2C: Improve management of 1,000 acres of existing degraded seasonal wetland habitat.

TARGET 3: Restore and manage at least 8,000 acres of additional seasonal wetland habitat and improve management of 1,500 acres of existing, degraded seasonal wetland habitat in the Central and West Delta Ecological Management Unit (◆◆).

PROGRAMMATIC ACTION 3A: Restore and manage 4,000 acres of additional seasonal wetland habitat on Twitchell Island.

PROGRAMMATIC ACTION 3B: Restore and manage 4,000 acres of additional seasonal wetland habitat on Sherman Island.

PROGRAMMATIC ACTION 3C: Develop a cooperative program to improve management of 1,500 acres of existing degraded seasonal wetland habitat.

TARGET 4: Restore and manage at least 12,000 acres of additional seasonal wetland habitat and improve management of 500 acres of existing, degraded seasonal wetland habitat in the South Delta Ecological Management Unit (◆◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative program to restore and manage 12,000 acres of additional seasonal wetland habitat.

PROGRAMMATIC ACTION 4B: Develop a cooperative program to improve management of 500 acres of existing degraded seasonal wetland habitat.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the* *restoration strategy for the Sacramento-San Joaquin Delta Ecological Management Zone. Restoring the ratio of land-water interface will help restore a mosaic of complex habitats that will restore important ecosystem processes and functions. Restoring these habitats will also reduce the amount and concentrations of contaminants that could, once they enter the Delta's sloughs, interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions for the Delta aquatic zone, significant areas of restored seasonal wetlands in the Sacramento-San Joaquin Delta Ecological Management Zone should be subject to periodic flooding and overland flow from Delta and river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Restore 10 to 20 linear miles of riparian and riverine aquatic habitat along the San Joaquin River in the South Delta Ecological Management Unit to create corridors of riparian vegetation of which 50% is to be over 75 feet wide and 40% is to be no less than 300 feet wide and 1 mile long (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

TARGET 2: Restore 15 to 25 linear miles of riparian and riverine aquatic habitat along other Delta island levees throughout the South Delta Ecological Management Unit. This will create riparian vegetation corridors of which 60% is to be more than 75 feet wide and 10%, no less than 300 feet wide and 1 mile long (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

TARGET 3: Restore 10 to 15 linear miles of riparian and riverine aquatic habitat along the Sacramento River below Sacramento of which 40% is to be more than 75 feet wide and 20% over 300 feet wide (◆).

PROGRAMMATIC ACTION 3A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore 10 to 15 linear miles of riparian habitat along the Sacramento River in the North Delta Ecological Management Unit. Obtain conservation easements for, or purchase from willing sellers, land needed to create corridors of riparian vegetation.

TARGET 4: Restore 8 to 15 linear miles of riparian and riverine aquatic habitat in the East Delta Ecological Management Unit of which 40% is to be more than 75 feet wide and 20% over 300 feet wide (◆◆).

PROGRAMMATIC ACTION 4A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore 5 to 10 linear miles along the Mokelumne River and 3 to 5 miles along the Cosumnes River in the East Delta Ecological Management Unit to create corridors of riparian vegetation.

TARGET 5: Restore 10 to 20 linear miles of riparian and riverine aquatic habitat in the North Delta Ecological Management Unit of which 40% is to be more than 75 feet wide and 20% over 300 feet wide (◆◆).

PROGRAMMATIC ACTION 5A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore 5 to 10 linear miles along the Steamboat Slough as part of the development of a North Delta Habitat Corridor.

TARGET 6: Restore or plant riparian and riverine aquatic habitats and recreate slough habitat and set back levees (◆).

PROGRAMMATIC ACTION 6A: Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along newly created sloughs and sloughs with new levee setbacks.

PROGRAMMATIC ACTION 6B: Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along new or upgraded Delta levees.

TARGET 7: Protect existing riparian woodlands in North, East, and South Delta Ecological Management Units (◆◆).

PROGRAMMATIC ACTION 7A: Expand the Stone Lakes and Cosumnes River Preserves from their current size by an additional 500 acres of existing woodland habitat. Share costs with the Nature Conservancy to acquire in-fee title to the lands needed from willing landowners.

PROGRAMMATIC ACTION 7B: Purchase riparian woodland property or easements.

RATIONALE: *Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley are dependent on or closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than any other habitat type in California. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support.*

Restoring, improving, and protecting high-quality riparian woodland habitat will enhance nutrient cycling and foodweb support and provide habitat for terrestrial invertebrates that will sustain resident fish and rearing juvenile anadromous fish in the Delta. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, wading birds, neotropical birds, and the riparian brush rabbit. This habitat will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; Knight and Bottorff 1983).

Large-scale riparian restoration projects are needed to restore the biodiversity (variety of species) and the sustainability and resilience of these habitats. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large landscape scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994). Large-scale restoration of broad, diverse riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will support increased nesting populations of Swainson's hawks and other raptors, as well as the yellow-billed cuckoo. Wood ducks will also benefit from increases in riparian habitat. Heron and egret rookeries will increase as well (Baltz and Moyle 1984; Hudson 1991; Motroni 1981; National Resource Council 1992; Gaines 1974 and 1977).

Riparian woodland habitats are important habitat use areas for many species of wildlife in the Central Valley. The loss or degradation of historic stands of riparian woodland has substantially reduced the habitat area available for associated wildlife. Such woodlands will also contribute to the recovery of species such as Swainson's hawk. Actions to restore ecological processes and functions, increase and improve habitats, and *reduce stressors are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; splittail; and delta smelt. These actions will also benefit the Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake.*

INLAND DUNE SCRUB

TARGET 1: Enhance 50 to 100 acres of low- to moderate-quality Antioch inland dune scrub habitat in the Delta to provide high-quality habitat for special-status plant and animal species and associated wildlife (♦♦).

PROGRAMMATIC ACTION 1A: Support programs for protecting and restoring inland dune scrub habitat at existing ecological preserves in the Central and West Delta Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Protect and restore inland dune scrub habitat areas adjacent to existing ecological preserves in the Central and West Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

RATIONALE: *An analysis of soils indicated that the historical extent of inland sand dunes in the Delta was probably less than 10,000 acres. The extent and habitat quality of inland dune scrub has declined as a result of recent land use changes. Inland dune scrub is a unique Delta community and supports several special-status plant and animal species, including the Lange's metalmark, which is federally listed as endangered. Protection and restoration of inland dune scrub habitat will help maintain existing special-status species and assist in recovery of their populations.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Delta ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of rivers and streams and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

PERENNIAL GRASSLAND

TARGET 1: Restore 4,000 to 6,000 acres of perennial grasses in the North, East, South, and Central and West Delta Ecological Management Units associated with existing or proposed wetlands and floodplain habitats (♦).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore 1,000 acres of perennial grassland in the North Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to restore 1,000 acres of perennial grassland in the East Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to restore 1,000 to 2,000 acres of perennial grassland in the South Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to restore 1,000 to 2,000 acres of perennial grassland in the Central and West Delta Ecological Management Unit through either conservation easements or purchase from willing sellers.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this Ecological Management Zone. Eliminating fragmentation and restoring connection of habitats will enhance habitat conditions for special-status species such as the California black rail and foraging habitat for Swainson's hawk. For instance, the habitats for these species have been degraded by a loss of the adjacent escape cover needed during periods of high flows or high tides.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively manage 40,000 to 75,000 acres of agricultural lands (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of Delta corn fields and pastures flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

PROGRAMMATIC ACTION 1B: Periodically flood pasture from October through March in portions of the Delta relatively free of human disturbance to create suitable roosting habitat for wintering greater sandhill crane, and for other wintering sandhill crane subspecies.

PROGRAMMATIC ACTION 1C: Create permanent or semipermanent ponds in Delta farm areas that provide suitable waterfowl nesting habitat but lack suitable brooding habitat, to increase resident dabbling duck production.

PROGRAMMATIC ACTION 1D: Increase the acreage farmed for wheat and other crops that provide suitable nesting habitat for waterfowl and other ground-nesting species in the Delta.

PROGRAMMATIC ACTION 1E: Convert agricultural lands in the Delta from crop types of low forage value for wintering waterfowl, wintering sandhill cranes, and other wildlife to crop types of greater forage value.

PROGRAMMATIC ACTION 1F: Defer fall tillage on corn fields in the Delta to increase the forage for wintering waterfowl, wintering sandhill cranes, and associated wildlife.

PROGRAMMATIC ACTION 1G: Develop a cooperative program to improve management on 8,000 acres of Delta corn and wheat fields and to reimburse farmers for leaving a portion of the crop in each field unharvested as forage for waterfowl, sandhill cranes, and other wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed, salinity, and pest control; stubble management; and tailwater circulation ponds.*

Reducing the entrainment of lower trophic organisms (food species) such as phytoplankton and zooplankton, and of life stages of higher trophic organisms such as fish eggs, larvae, and juveniles into agricultural and export water diversions will increase production of primary and secondary food species. This will also support nutrient cycling functions that can sustain quality forage for aquatic resources in and dependent on the Delta (Chadwick 1974).

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980; Fredrickson and Reid 1988; Schultz 1990; and, Ringelman 1990).

Restoring roosting habitat in this Ecological Management Zone, especially when it is near forage habitat, will increase the overwinter survival of sandhill cranes and strengthen them for migration, thus improving breeding success. Decreasing in human disturbance in the roosting sites will also improve the health of the crane in the Delta. Actions to restore ecological processes and functions, increase and improve habitats, and reduce stressors are prescribed primarily to increase populations of lower level food species, aquatic and terrestrial invertebrates, and forage fish such as threadfin shad. Improving the foodweb of the Delta will help restore the health of the Bay-Delta's aquatic ecosystem.

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the red-legged frog, tiger salamander, giant garter snake, and western pond turtle will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground-nesting birds.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980; Fredrickson and Reid 1988; Schultz 1990; and Ringelman 1990). Following the extensive loss of native upland habitats, upland wildlife species have adapted to the artificial upland environment of some agricultural land uses and have become dependent on agricultural upland areas and field-border shelter belts to sustain their populations.

Habitat restoration will occur over a 30 year period. Initial efforts will be directed at lands presently in State or Federal ownership. Restoration will be strictly guided by adaptive management in which conceptual ecosystem models and hypotheses will be developed. Small projects will be implemented to test the hypotheses regarding habitat restoration. For example, one hypothesis might be that delta smelt will occupy tidal perennial aquatic habitat for foraging, spawning, and rearing. Monitoring will determine it the hypothesis is true or false (e.g., do delta smelt use restored habitat). Based on the results of monitoring under the adaptive management program, an evaluation will be made regarding the need and benefit of restoring additional acres of tidal perennial aquatic habitat.

The Delta Protection Commission suggested (letter to CALFED dated July 10, 1998) some alternatives for meeting habitat restoration targets in the Delta. Although it is premature to set priorities for the targets and programmatic actions in the Delta, the Commission suggested the following approaches:

- *Restore and/or enhance lands currently in public or non-profit ownership (or currently in the acquisition process) and designated for restoration, including Twitchell Island,* *Sherman Island, and Prospect Island. Approximately 35,000 acres fall into this category.*

- *Acquire and/or enhance currently flooded lands to create and/or enhance emergent habitat, including Frank's Tract, Big Break, Mildred Island, Little Mandeville Island, etc. Approximately 7,000 acres fall into this category.*

- *Develop and implement management plans for upland areas already in public or non-profit ownership, including Calhoun Cut Ecological Preserve (approximately 1,000 acres), Rhode Island, etc.*

- *Develop and implement individual management plans for private agricultural properties and develop (or provide) funds to offset costs of voluntary implementation of such plans (plans could include flooding programs, enhanced levees and pumps to enhance flooding and drainage, recommend crop rotation cycles, size and location of permanent brood ponds, etc.).*

- *Develop and implement individual management plans for privately owned lands managed for wildlife habitat, such as duck clubs and upland hunting clubs, and develop (or provide) funds to offset costs of voluntary implementation of such plans.*

- *Control of stressors should be revised to avoid duplication with existing regulatory programs, such as existing dredging "windows," and the programs that are developed should respect the needs of existing land uses, such as water-oriented recreation. Where funds are needed to carry out specific programs, those funds should be made available to private land owners to implement CALFED programs.*

The Delta Protection Commission also suggested the approach for restoring a riparian corridor along the Delta portion of the Sacramento River should consider the ecological benefits of enlarging and enhancing a riparian corridor west of the Deep Water Ship Channel, within the Yolo Bypass. Such a waterway could connect to the main stem of the Sacramento River at either or both the Sutter Weir or the Sacramento Weir. There is an existing channel named the Tod Drain, which lies west of the Ship Channel. The Toe Drain is largely unvegetated by lies within the Yolo Bypass, where the lands are already subject to a flood easement purchased by the federal government to provide additional flood protection the city of Sacramento and the Delta area. While the Sacramento River can maintain flood flows of about 150,000 cfs, the Yolo Bypass can handle about three times as much flood flow (450,000 cfs). Locating an enhanced riparian corridor within the Yolo Bypass would also address the stranding of juvenile and adult fish when flood flows recede. Creating an enlarged channel would improve flood water conveyance capacity in the Yolo Bypass, which would then allow the introduction and maintenance of riparian vegetation into the flood bypass without reducing overall flow capacity during flood events.

The Delta Protection Commission also suggested that the South Fork of the Mokelumne River be considered for water conveyance and flood control, by dividing the flow of the Mokelumne River between its north and south forks. Both forks could be examined for additional habitat restoration opportunities as channel capacities are increased by dredging or construction of any necessary levee setbacks. There are significant flow constrictions in the upper reach of the South Fork Mokelumne, which if reduced, could provide important opportunities for flood control and habitat restoration. The Commission suggested that the Mokelumne River corridor must be multipurpose and provide water conveyance through the Delta, flood control for Sacramento and San Joaquin counties, and provide for a riparian corridor for aquatic and terrestrial species.

Table 4. Summary of ERPP Habitat Restoration Targets and Programmatic Actions for the Sacramento-San Joaquin Delta Ecological Management Zone.

Habitat Type	North Delta Acreage	East Delta Acreage	South Delta Acreage	Central and West Delta Acreage	Total Acreage
Tidal Perennial Aquatic	1,500	1,000	2,000	2,500	7,000
Shoal	0	0	0	500	500*
Nontidal Perennial Aquatic (deep open water)	0	200	200	100	500
Nontidal Perennial Aquatic (shallow open water)	1,000	300	300	500	2,100
Delta Sloughs (short-term)	10 miles	10 miles	25 miles	20 miles	65 miles*
Delta Sloughs (long-term)	Additional 20 miles	Additional 20 miles	Additional 25 miles	Additional 30 miles	Additional 95 miles*
Midchannel Islands	50 to 200	50 to 200	50 to 200	50 to 200	200 to 800*
Fresh Emergent Wetland (tidal)	TBD [to be determined]	TBD	TBD	TBD	30,000 to 45,000
Fresh Emergent Wetland (nontidal)	3,000	3,000	4,000	10,000	20,000
Seasonal Wetland	Improve: 1,000 Restore: 4,000	1,000 6,000	500 12,000	1,500 8,000	4,000 30,000
Riparian and Riverine Aquatic	10-15 miles plus 500 acres	8-15 miles	25-25 miles		43-55 miles plus 500 acres
Inland Dune Scrub	0	0	0	50 to 100	50 to 100*
Perennial Grassland	1,000	1,000	1,000 to 2,000	1,000 to 2,000	4,000 to 6,000
Wildlife Friendly Agricultural Land	TBD	TBD	TBD	TBD	40,000 to 75,000*
Total acres of all habitats to be restored include large acreages that will have minimal impacts on existing land uses such as wildlife friendly agricultural practices, shoal habitat, and inland dune scrub. The largest acreages are for shallow water habitats such as fresh emergent wetlands (tidal and nontidal) and tidal perennial aquatic habitats. Those three total 57,000-72,000 acres.					138,350 to 191,000
Total Delta Slough /Riparian and Riverine Aquatic Habitats includes miles of habitat to be improved and an expansion of Stone Lakes and Cosumnes River Preserve by 500 acres.					143-220 miles plus 500 acres

* Denotes acreages that have minimal impact to existing agricultural land uses and practices.

The Commission also provided information regarding wildlife friendly farming practices. In 1993-94, a Crop Shift Demonstration Project was conducted on Rindge Tract. The California Department of Fish and Game recommended specific measures to mitigate impacts to wildlife from the demonstration project. Most of the mitigation measures were implemented as part of the demonstration project, and project monitoring provided positive results. Based on this demonstration project, a wildlife friendly agricultural practices program should consider the following:

- *Extend availability of post-harvest flooded grain fields to more fully cover period of usage by migratory birds.*
- *Enhance food value of post-harvest flooded grain fields by intentionally leaving more grain in the fields either by modifying harvest practices or intentionally not harvesting portions of the fields to be harvested.*
- *Create fringe areas during important periods to enhance forage opportunities for species such as greater sandhill cranes and Swainson's hawks.*
- *Disperse the program throughout the Delta to discourage over-concentration of species in a single area.*
- *Maintain the existing agricultural economy of the region by using a voluntary program in which participants receive compensation equal to their cost or loss of income.*

Overall, the Delta Protection Commission has provided suggestions that will facilitate implementation of the long-term program. Although the recommended actions in this plan are still at the "Programmatic Level," near-term implementation plans and projects can incorporate these suggestions in order to develop actions that can be implemented with support of the Commission.

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce loss of important fish species at diversions (◆◆◆).

PROGRAMMATIC ACTION 1A: Consolidate and screen agricultural diversions in the Delta.

PROGRAMMATIC ACTION 1B: Replace or upgrade the screens at the SWP and CVP intakes with positive-barrier, fish bypass screens and state-of-the-art fish holding and transportation systems. *(Note: The ecological benefits of this action could be substantially improved by selection of an alternative that has a provision to relocate the intakes, screening those intakes, and providing for fish bypasses as needed.)*

PROGRAMMATIC ACTION 1C: Upgrade screens at Pacific Gas & Electric Company's Contra Costa power plant with fine-mesh, positive barrier, fish bypass screens.

RATIONALE: *Loss of juvenile fish in diversions is detrimental to fish species of special concern (Larkin 1979; Erkkila et al. 1950).*

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Increase shoreline and floodplain riparian habitat in the Delta by changing the vegetation maintenance practices on both the water and the land side of berms on 25 to 75 miles of the Sacramento, Mokelumne, and San Joaquin rivers, and on 25 to 100 miles of other Delta channels and sloughs confined by levees (◆◆).

PROGRAMMATIC ACTION 1A: Enter into agreements with willing levee reclamation districts to change levee and berm vegetation management practices that to establish and mature shoreline riparian vegetation. This will restore and maintain the health of Delta aquatic resources. Reimburse districts for any additional maintenance and inspection costs.

RATIONALE: *Restoring, improving, and protecting high-quality riparian woodland and willow scrub habitat will enhance nutrient cycling and the foodweb and provide habitat for terrestrial invertebrates that will sustain resident fish and juvenile anadromous fish. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, neotropical migrant songbirds, and the riparian brush rabbit. This action will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; and Knight and Bottorff 1983). Large-scale riparian restoration projects are needed to restore the variety of species and the sustainability and resilience of these habitats to support the ecological functions needed for aquatic resource restoration in the Bay-Delta. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994).*

DREDGING AND SEDIMENT DISPOSAL

TARGET 1: Limit dredging in channel zones that are not essential for flood conveyance or maintenance of industrial shipping pathways, and avoid dredging in shallow water areas (depths of less than 3 meters at mean high water) except where it is needed to restore flood conveyance capacity (◆◆◆).

PROGRAMMATIC ACTION 1A: Use alternate sources (rather than Delta in-channel sources) of levee maintenance material, such as:

- excavation of abandoned nonessential levees,
- excavation material from the restoration of secondary tidal channels,
- dry-side island interior borrow pits,
- upland borrow sites,
- Cache Creek settling basin and Yolo Bypass sediment deposits, and
- deep water dredging sites in the San Francisco Bay.

PROGRAMMATIC ACTION 1C: Restrict or minimize effects of dredging near existing Midchannel tule islands and shoals that are vulnerable to erosion and exhibit clear signs of area reduction from channel and bar incision (cutting).

TARGET 2: Avoid dredging during spawning and rearing periods for delta smelt and during rearing periods for winter-run chinook salmon (◆◆◆).

PROGRAMMATIC ACTION 1A: Follow DFG guidelines for dredging in the estuary.

PROGRAMMATIC ACTION 2D: Provide stockpiles of levee maintenance materials in three or more selected land-side areas to avoid the need to obtain material from Delta channels during restricted periods.

RATIONALE: *Soils for levee maintenance should not be taken from adjacent Delta waters because such dredging alters the physical and chemical characteristics of the aquatic habitat and disrupts aquatic organisms. Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These areas typically produce high levels of primary and secondary food species and support nutrient cycling that can sustain quality forage. These areas also provide high-quality forage for waterfowl that use submerge vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams in these areas (Fris and DeHaven 1993; Britain et al. 1993; Stuber 1984). Losses or impacts to this habitat should be avoided to restore the health of the estuary*

(Schlosser 1991; Sweetnam and Stevens 1993; Herbold 1994).

Impacts that could disrupt foraging and breeding activities of special-status estuarine fish should be avoided (Sweetnam and Stevens 1993; Moyle et al. 1992, Herbold 1994).

INVASIVE AQUATIC PLANTS

TARGET 1: Manage existing and restored dead-end and open-ended sloughs and channels within the Sacramento-San Joaquin Delta Ecological Management Zone so that the total surface area of these sloughs and channels covered by invasive non-native aquatic plants is reduced (◆).

PROGRAMMATIC ACTION 1A: Conduct large-scale, annual weed eradication programs throughout existing and restored dead-end and open-ended sloughs and channels within each of the Delta's Ecological Management Units. The goal is that less than 1% of the surface area of these sloughs and channels is to be covered by invasive non-native aquatic plants within 10 years.

PROGRAMMATIC ACTION 1B: Evaluate the feasibility of developing a program to commercially harvest and convert water hyacinth to methane (natural gas) and organic fertilizer.

TARGET 2: Reduce the potential for introducing non-native aquatic plant and animal species at border crossings (◆◆◆).

PROGRAMMATIC ACTION 2A: Provide funding to the California Department of Food and Agriculture to expand the current State border inspection process to include a comprehensive program of exclusion, detection, and management of invasive aquatic species such as purple loosestrife, and hydrilla.

RATIONALE: *Invasive aquatic plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those from competition for nutrients, light, and space. The prescribed action is primarily to enhance foodweb functions and improve habitat for resident, estuarine, and anadromous fish and neotropical migratory birds, in part, by reducing the areas inhabited by invasive non-native plants and by large-scale restoration of optimal nesting habitat (Dudley and D'Antonio 1994; Anderson 1990; Zedler 1992; Bay-Delta Oversight Council 1994).*

INVASIVE RIPARIAN AND SALT MARSH PLANTS

TARGET 1: Reduce surface area covered by non-native plants to less than 1% (◆).

PROGRAMMATIC ACTION 1A: Control non-native riparian plants.

TARGET 2: Reduce the area of invasive non-native woody species, such as Giant Reed (i.e., Arundo or false bamboo) and eucalyptus, that compete with native riparian vegetation, by reducing the area of non-natives by 50% throughout the Delta and by eradicating invasive woody plants from restoration areas (◆◆).

PROGRAMMATIC ACTION 2A: Implement a program throughout the Delta to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation by reducing the aerial extent of species such as False Bamboo, eucalyptus, and non-native cordgrass (Spartina spp.) by 50%.

PROGRAMMATIC ACTION 2B: Implement a program throughout the Delta that, before restoration actions, eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many* *fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat throughout the Delta (Dudley and D'Antonio 1994; Madrone and Assoc. 1980; Bay-Delta Oversight Council 1994; Cross and Fleming 1989; Zedler 1992). There have been extensive Spartina eradication efforts in Willapa Bay, Washington, that could provide guidance in designing and implementing a similar control program in the western Delta and north San Francisco Bay. In most cases, the removal of invasive plants will require the replanting of native vegetation to maintain adequate levels of herbaceous cover, canopy closure, habitat structure, and to limit exotic recolonization.*

INVASIVE AQUATIC ORGANISMS

TARGET 1: Reduce or eliminate the influx of non-native aquatic species in ship ballast water (◆◆◆).

PROGRAMMATIC ACTION 1A: Fund additional inspection staff to enforce existing regulations.

PROGRAMMATIC ACTION 1B: Help fund research on ballast water treatment techniques that could eliminate non-native species before ballast water is released.

TARGET 2: Reduce the potential for introducing non-native aquatic organisms at border crossings (◆◆◆).

PROGRAMMATIC ACTION 2A: Provide funding to the California Department of Food and Agriculture to expand the current State border inspection process to include a comprehensive program of exclusion, detection, and management of invasive aquatic species such as the zebra mussel.

RATIONALE: *Every reasonable effort should be made to reduce the introduction of non-native organisms in the ballast water of ships that enter the Delta. Such organisms have greatly altered the zooplankton of the Delta over the past several decades. Further alteration could reduce the capacity of the Delta to support native fishes.*

Every reasonable effort should be made to reduce the introduction of non-native organisms at overland entrances to California. Inspections at borders have already found Zebra mussels that if allowed to enter Bay-Delta waters could have devastating economic and ecological effects.

PREDATION AND COMPETITION

TARGET 1: Reduce loss of juvenile fish in Clifton Court Forebay to predation by 75% to 90% (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to reevaluate the need to remove predatory fish from Clifton Court Forebay.

PROGRAMMATIC ACTION 1B: Evaluate alternative methods to remove predator fish from Clifton Court Forebay with emphasis on predator removal near the fish facility.

PROGRAMMATIC ACTION 1C: Evaluate alternate operational strategies to reduce entrainment of juvenile fish into Clifton Court Forebay.

TARGET 2: Reduce in-channel predation loss of juvenile fish near structures such as bridge pilings and diversions (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to reevaluate opportunities to modify in-channel structures to eliminate predator habitat.

RATIONALE: *Diversions and other structures may provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern (Erkkila et al. 1950).*

Predation of juvenile fish in Clifton Court Forebay is a symptom of larger problems. These *are probably insufficient rearing habitat in the Central Delta, high channel velocities, and insufficient flows in the San Joaquin River. Short-term efforts in Clifton Court Forebay should include, at a minimum, a predator removal or control program near the fish facility and louver system. Additional focused research is needed on longer-term efforts to reduce predation and to improve the understanding of predator population growth. The longer-term solution to predation at this site lies in re-creating rearing and migration habitats throughout the Delta. Some of the water conveyance alternatives in the Delta could decrease the rates of predation by enlarging the forebay and closing the radial gates for longer periods.*

CONTAMINANTS

TARGET 1: Reduce loading, concentrations, and bioaccumulation of contaminants of concern to ecosystem health in the water, sediments, and tissues of fish and wildlife in the Sacramento-San Joaquin Delta Ecological Management Zone by 25 to 50% as measured against current average levels (◆◆).

PROGRAMMATIC ACTION 1A: Reduce the input of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife in the Delta by changing land management practices and chemical uses on 50,000 acres of urban and agricultural lands that drain untreated into Delta channels and sloughs. Actions will focus on modifying agricultural practices and urban land uses on a large scale. To reduce the concentration of pesticide residues, the amount applied will be reduced and the amount of pesticide load reaching the Delta's aquatic habitats will be further reduced by taking advantage of biological and chemical processes within wetland systems to help break down harmful pesticide residues.

PROGRAMMATIC ACTION 1B: Reduce levels of hydrocarbons and other contaminants entering the Delta foodweb from high releases into the estuary at oil refineries.

RATIONALE: *Reducing the concentrations and loads of contaminants including hydrocarbons, heavy metals, and other pollutants in the water and sediments of the Sacramento-San Joaquin Delta Ecological Management Zone will help ensure reduction of sublethal and chronic impacts of contaminants, whose impacts on population levels are hard to document. (Bay Delta Oversight Council 1994; Hall 1991; U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Sparks 1992; Diamond et al. 1993; Rost et al. 1989).*

Improved inchannel flows within the Delta from seasonal reductions in water use and improved flows attributed to enhanced supplies of environmental water will also contribute to reducing concentrations (Charbunneau and Resh 1992; U.S. Environmental Protection Agency 1993). Human health warnings associated with consuming fish and wildlife have been issued because of high levels of substances such as mercury and selenium. Large-scale restoration of aquatic and wetland habitats may contribute to reducing levels of hydrocarbons, heavy metals, and other pollutants. However, addressing point sources of concern such as the oil refineries on Suisun and San Francisco Bays and elevated releases of selenium as a result of refining oil from sources high in selenium can also help reduce these contaminants (Charbunneau and Resh 1992).

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal harvest of anadromous fish and wildlife in the Delta by increasing enforcement (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide additional funding to the DFG for additional enforcement.

PROGRAMMATIC ACTION 1B: Provide additional funding to local county sheriff's departments and local park agencies for additional enforcement.

PROGRAMMATIC ACTION 1C: Provide rewards for the arrest and conviction of poachers.

RATIONALE: *Actions to reduce illegal harvest of fish and wildlife are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake (U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Bay-Delta Oversight Council 1993; California Department of Fish and Game 1991).*

STRANDING

TARGET 1: Reduce or eliminate the stranding of juvenile chinook salmon on floodplains, shallow ponds, and levee borrow areas.

PROGRAMMATIC ACTION 1A: Conduct surveys of stranding in the Yolo Bypass under a range of flow conditions and develop recommendations to resolve the problem.

RATIONALE: *Under many flow conditions, stranding is likely in the Yolo Bypass and is a minimal problem. However, under conditions in which the Sacramento River reach high flows and flow is diverted into the flood bypasses, and then flow quickly recede, stranding is likely a serious problem. Timing also plays a important role in determining the severity of the problem. The California Department of Water Resources has been investigating stranding of juvenile fish in the Yolo Bypass and identified areas where remedial actions are probably appropriate to reduce the loss of juvenile fish. Further analysis is needed of the potential magnitude of the problem and additional options to reduce the potential severity of the problem need to be identified.*

DISTURBANCE

TARGET 1: Reduce boat traffic and boat speeds in areas where levees or channel islands and their associated shallow-water and riparian habitat may be damaged by wakes. This will protect important Delta habitats such as berm islands from erosion caused by boat wake (◆◆).

PROGRAMMATIC ACTION 1A: In the Central and West Delta Ecological Management Unit, establish and enforce no wake zones of 1 to 3 miles in Disappointment Slough, of 1 to 2 miles in White Slough, and of 3 to 4 miles in Middle and Old rivers in areas with remnant berms and midchannel islands.

PROGRAMMATIC ACTION 1B: In the East Delta Ecological Management Unit, establish and enforce no wake zones of 1 to 3 miles of the Mokelumne River, of 2 to 4 miles in Snodgrass Slough, and of 3 to 4 miles in Beaver, Hog, and Sycamore Sloughs in areas with remnant berms and midchannel islands.

TARGET 2: Reduce boat wakes near designated important California black rail nesting areas in the Delta from March to June to levels necessary to prevent destruction of nests. This will help in recovery of this listed species (◆◆).

PROGRAMMATIC ACTION 2A: Establish and enforce no wake zones within 50 yards of important California black rail nesting areas in the Delta from March to June.

PROGRAMMATIC ACTION 2B: Establish and enforce no motorized boating zones in 5 to 25 miles of existing dead-end channels in the Delta from March to June.

PROGRAMMATIC ACTION 2C: Establish and enforce no motorized boating zones in the small tidal channels created in restored tidal freshwater marshes and Delta floodplains of levee setbacks.

TARGET 3: Reduce boat wakes near important shallow water spawning areas in the Delta from March to June to levels necessary to protect successful spawning behavior and success. This will help in recovery of listed species (◆).

PROGRAMMATIC ACTION 2A: Identify important shallow water spawning areas and establish and enforce no wake zones within 50 yards of these important Delta habitats from March to June.

RATIONALE: *Protecting the highest quality and largest berm island complexes will advance the ERPP's strategy of protecting and restoring large areas of habitat rather than small fragmented areas (National Research Council 1992; Resource Agency 1976; San Francisco Estuary Project 1992a; San Joaquin County 1979; U.S. Fish and Wildlife Service 1992).*

Actions taken to restore ecological processes and functions, increase and improve habitats, and reduce stressors in this Ecological Management Zone are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as the black rail. (Madrone 1980; Schlosser 1991; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1978; Schlorff 1991).

Additional research is needed to identify important shallow water spawning areas and the potential adverse effects of boat traffic on the spawning success of native Delta fishes.

REFERENCES USED TO DEVELOP THE VISION FOR THE SACRAMENTO-SAN JOAQUIN DELTA ECOLOGICAL MANAGEMENT ZONE

Alevizon, W., J. Monroe, P. Fox, K. Levy, R. Bailey, R. Fujita, and C. Hanson. 1996. Habitat restoration in aquatic ecosystems. A review of the scientific literature related to the principles and practice of habitat restoration. Prepared for the CALFED Bay-Delta Program.

Anderson, L. W. J. 1990. Aquatic weed problems and management in North America. Pages 371-405 in H. Pieterse and K. J. Murphy (eds.). Oxford University Press. New York, NY.

Atwater and Belknap. 1980. Tidal-wetland deposits of the Sacramento-San Joaquin Delta, California. In: M.E. field, A.H. Bouma, I.P. Colburn, R.G. Douglas, and J.C. Ingle, Eds. Quaternary Depositional Environments of the Pacific Coast: Pacific Coast Paleogeography Symposium 4, Proceedings of the Society of Economic Paleontologists and Mineralogists, Los Angeles, CA.

Baltz, D. M., and P. B. Moyle. 1984. The influence of riparian vegetation on stream fish communities of California. Pages 183-187 in Richard E. Warner and Kathleen M. Hendrix (eds), California riparian systems: ecology, conservation, and productive management. University of California Press.

Bay-Delta Oversight Council. 1993. Draft briefing papers on biological resources of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

______________. 1994. Draft briefing paper on introduced fish, wildlife and plants in the San Francisco Bay/Sacramento- San Joaquin Delta Estuary.

Brostoff, W., and D. Clarke. 1992. Monitoring intertidal wetland establishment in the Pacific Northwest. Army Waterways Experiment Station, Wetlands Research Program Bulletin 2(3):1-4.

California Department of Fish and Game. 1991. Final program environmental document ocean sport fishing regulations (Section 27.00 - 30.10, Title 14, California Code of Regulations). California Resources Agency, Department of Fish and Game.

______________. 1993. Restoring Central Valley streams: a plan for action. November 1993.

California Resources Agency. 1976. Sacramento-San Joaquin Delta master recreation plan. Sacramento, CA.

Chadwick, H. K, and C. E. Von Geldern. 1964. The desirability of introducing white bass, Roccus chrysops, into California. (Report No. 64-11.) California Department of Fish and Game, Inland Fisheries Branch Administration.

Cross, D. H., and K. L. Fleming. 1989. Control of Phragmites or Common Reed. Fish and Wildlife Leaflet No. 13.4.12.

Cummins, K. W. 1974. Structure and function of stream ecosystems. BioScience 24(11): 631-641.

Diamond, J. M., W. Bower, et al. 1993. Use of man-made impoundment in mitigating acid mine drainage in the North Branch Potomac River. Environmental Management 17(2):225-238.

Dudley, T. L., and C. M. D'Antonio. 1994. Exotic species and sustainable ecosystem management. Page 307 in W. W. Covington, and L. F. DeBano (tech. coords.), Sustainable ecological systems: implementing an ecological approach to land management. 1993. Flagstaff, AZ. (Gen. Tech. Rep. RM-247.) U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO.

Erkkila, F., J. W. Moffett, O. B. Cope, B. R. Smith, and R. S. Nielson. 1950. Sacramento-San Joaquin Delta fishery resources: effects of Tracy pumping plant and Delta Cross Channel. (Special Scientific Report, Fisheries No. 56.) U.S. Fish and Wildlife Service.

Fahrig, L., and G. Merriam. 1985. Habitat patch connectivity and population survival. Ecology 66:762-1768.

Fris, M. B., and R. DeHaven. 1993. A community-based habitat suitability index model for SRA cover, selected reaches of the Sacramento River system. February. U.S. Fish and Wildlife Service, Ecological Services, Sacramento Field Office. Sacramento, CA.

Gaines, D. 1974. A new look at the nesting riparian avifauna of the Sacramento Valley, California. Western Birds 5:61-80.

______________. 1977. The valley riparian forests of California: their importance to bird populations. Pages 57-85 in A. Sands (ed.), Riparian forests of California: their ecology and conservation. Institute of Ecology, University of California, Davis, CA.

Hall, L. W., Jr. 1991. A synthesis of water quality and contaminants data on early life history stages of striped bass, Morone saxatilis. Reviews in Aquatic Science 4:261-288.

Herbold, B. 1994. Habitat requirements of delta smelt. Interagency Ecological Studies Program Newsletter, Winter 1994. California Department of Water Resources. Sacramento, CA.

Hudson, W. E. (ed.). 1991. Landscape linkages and biodiversity.

Hutto, R. L., S. Reel, and P. B. Landres. 1987. A critical evaluation of the species approach to biological conservation. Endangered Species Update 4(12):1-4.

Knight, A. W., and R. L. Bottorff. 1983. The importance of riparian vegetation to stream ecosystems. R. E. Warner and K. M. Hendrix (eds.), California riparian systems. University of California Press, Berkeley, CA.

Larkin, P. A. 1979. Predator-prey relations in fishes an overview of the theory. Pages 13-22 in Predator-prey systems in fisheries management. Sport Fishing Institute.

Lindberg, J. C., and C. Marzuola. 1993. Delta smelt in a newly-created, flooded island in the Sacramento-San Joaquin Estuary, spring 1993. BioSystems Analysis, Inc. (Report No. J-762.) State Department of Water Resources, Sacramento, CA.

Madrone Associates. 1980. Sacramento-San Joaquin Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and U.S. Fish and Wildlife Service.

Mahoney, D. L., and D. C. Erman. 1984. The role of streamside bufferstrips in the ecology of aquatic biota. Pages 168-176 in Richard E. Warner and Kathleen M. Hendrix (eds.), California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley, CA.

Motroni, R. S. 1981. Seasonal variation of bird numbers in a riparian forest, Sacramento Valley, California. In R. E. Warner and K. M. Hendrix (eds.), California riparian systems. University of California Press, Berkeley, CA.

Moyle. P.B. and J.P. Ellison. A conservation-oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

Moyle, P. B., B. Herbold, D. E. Stevens, and L. W. Miller. 1992. Life history and status of delta smelt the Sacramento-San Joaquin Estuary, California. Trans Am.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

National Research Council. 1992. Restoration of aquatic ecosystems. National Academy Press, Washington, DC.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1994. Endangered ecosystem of the United States: a preliminary assessment of loss and degradation. Biological Reports 28:1-28.

Noss, R. F., and L. D. Harris. 1986. Nodes networks, and MUMs: preserving diversity at all scales. Environmental Management 10:299-309.

Novick, H., and R. Hein. 1982. Bolsa Chica -- a coastal wetland restoration project. Page 101 in M. Josselyn (ed.), Wetland restoration and enhancement in California. (Report No. NOAA-83042503.) National Oceanic and Atmospheric Administration. Washington, DC.

Rost, R. A., J. C. Brand, et al. 1989. Water quality and restoration of the Lower Oconto River, Oconto County, WI. (Technical Bulletin No. 164.) Department of Natural Resources. Madison, WI.

San Francisco Estuary Project. 1992a. Status and trends report on wildlife of the San Francisco estuary. (Job No. CE-009519-01-0.) Prepared under cooperative agreement with Environmental Protection Agency, by the U.S. Fish and Wildlife Service.

_______________. 1992b. Status and trends report on aquatic resources in the San Francisco Estuary. Prepared under cooperative agreement with Environmental Protection Agency by B. H. Herbold, A. D. Jassby, and P. B. Moyle.

San Joaquin County Planning Department. 1979. A report on boating in the San Joaquin County.

Save Our Salmon. 1995. Wild salmon forever: a citizen's strategy to restore northwest salmon and watersheds. Report of the Save Our Wild Salmon Coalition, Seattle, WA.

Schlorff, R. 1991. Status of the Swainson's hawk. In 1991 annual report on the status of California State listed threatened and endangered animals and plants. California Resources Agency, Department of Fish and Game.

Schlosser, I. J. 1991. Stream fish ecology: a landscape perspective. BioScience 41(10):704-711.

Scott, J. M., B. Csuti, J. D. Jacobs, and J. E. Estes. 1987. Species richness: a geographic approach to protecting future biological diversity. BioScience 37:782-788.

Simenstad, C.A., and J. R. Cordell, et al. 1992. Ecological status of a created estuarine slough in the Chehalis River Estuary: assessment of created and natural estuarine sloughs, Jan-Dec 1991. (WA FRI-UW-9305.) Fisheries Research Institute, University of Washington, Seattle, WA.

Sparks, R. 1992. The Illinois River floodplain ecosystem. In National Research Council (ed.), Restoration of Aquatic ecosystems: science, technology, and public policy. National Academy Press, Washington, DC.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Stuber, R. J. 1984. Stemming the tide of coastal fish habitat loss: proceeding of a symposium on conservation of coastal fish habitat, Baltimore, MD, March 7-9. National Coalition for Marine Conservation, Savannah, GA.

Sweetnam, D. A., and D. E. Stevens. 1993. A status of the delta smelt (Hypomesus transpacificus) in California. (Candidate Species Report 93-DS.) Report to the Fish and Game Commission.

Toth, L. A. 1993. The ecological basis of the Kissimmee River restoration plan. Florida Scientist 56(1):25-51.

U.S. Environmental Protection Agency. 1993. San Francisco estuary project: comprehensive conservation and management plan.

U.S. Fish and Wildlife Service. 1978. Concept plan for waterfowl wintering habitat preservation, Central Valley, California. Region 1. Portland, OR.

______________. 1992a. EIS for Stone Lakes National Wildlife Refuge.

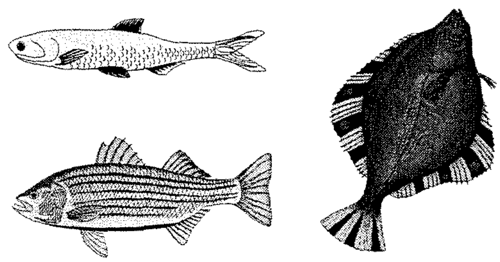
______________. 1992b. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin estuary. Annual report. U.S. Fish and Wildlife Service, Sacramento-San Joaquin Fishery Resource Office, Stockton, CA.

______________. 1997. Revised draft anadromous fish restoration plan: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

______________. 1996. Recovery plan for the Sacramento/San Joaquin San Joaquin Delta native fishes. U.S. Fish and Wildlife Service.

Zedler, J. B. 1992. Invasive exotic plants in coastal wetlands. Department of Biology, San Diego State University. San Diego, CA.

◆ SUISUN MARSH/NORTH SAN FRANCISCO BAY ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

Suisun Marsh and North San Francisco Bay are the portions of San Francisco Bay downstream of the Delta and upstream of Central San Francisco Bay. These areas include San Pablo and Suisun Bays, the adjacent Suisun Marsh, and the Contra Costa shoreline. North Bay was once bordered on the north by extensive marshes. Baylands alteration has now reduced the marshes to northern San Pablo Bay and Suisun Bay, including Petaluma, Napa, and Suisun marshes. Healthy marshes provide many ecological benefits including very high productivity, flood moderation and shoreline protection. Many of the tidal emergent marshes have been reclaimed for agriculture, salt production, duck clubs, and managed freshwater marshes. These lands are protected from flooding by hundreds of miles of levees. Remnants of the tidal salt marshes remain along the margins of San Pablo and Suisun Bay. The largest intact undiked wetlands remaining in Suisun Marsh are associated with Cutoff Slough and Hill Slough in north central Suisun Marsh.

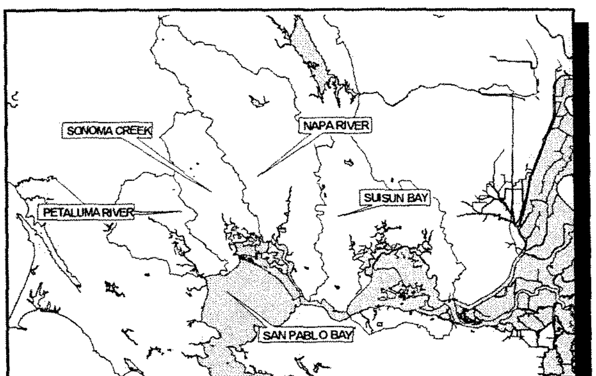
Suisun Marsh and North San Francisco Bay support many species of native and non-native fish, waterfowl, shorebirds, and other wildlife. This ecological management zone also supports many native plant communities including several significant rare and endangered plants which are dependent of wetland processes. All Central Valley anadromous fish migrate through the North Bay and depend on the North Bay and marshes for some critical part of their life cycle. Many Pacific Flyway waterfowl and shorebirds pass through or winter in the North Bay and marshes. The North Bay and adjacent marshes are important nursery grounds for many marine, estuarine and anadromous fish species. Four runs of chinook salmon, steelhead, green sturgeon, white sturgeon, striped bass, lamprey, and American shad migrate through the Delta on their journey between the Pacific Ocean and Central Valley spawning rivers. Young salmon may spend important weeks and months feeding in the North Bay and marshes before migrating to the ocean. Many sturgeon and striped bass spend much of their lives in the North Bay. Many marine (ocean) species depend on the North Bay as nursery area for young, including Pacific herring, northern anchovy, and Dungeness crab. Native resident fish, including longfin smelt, delta smelt, and splittail, spend much of their lives within the North Bay and marshes. Considerable areas of waterfowl and wildlife habitat occur on and along the margins of the North Bay and in the marshes.

Ecological factors having the greatest influence on North Bay and marsh fish and wildlife include freshwater inflow from rivers, wetlands, riparian vegetation, and aquatic habitat diversity. Stressors include water diversions, poor water quality, legal and illegal harvest, wave and wake erosion, and introduced non-native plant and animal species. Stressors to Suisun and North Bay saline emergent plant communities supporting sensitive plant and wildlife resources include freshwater discharges which are outside of the natural variability of seasonal runoff. For example, fresh wastewater treatment outfalls sustained outside of the normal runoff season have been proven detrimental to saline emergent wetlands. Stressors may also include water management activities which result in increased depth and duration of flooding in high marsh zone beyond the range of natural variability and seasonality.

DESCRIPTION OF THE MANAGEMENT ZONE

The Suisun Marsh/North San Francisco Bay Ecological Management Zone is the westernmost zone of the Ecosystem Restoration Program Plan (ERPP). Its eastern boundary is the Collinsville area, and to the west it is bounded by the western end of San Pablo Bay. The northern boundary follows the ridge tops of the Coast Ranges and includes the Petaluma River, Sonoma Creek, the Napa River, and San Pablo Bay. This Ecological Management Zone is composed of five Ecological Management Units:

- Suisun Bay and Marsh,
- Napa River,
- Sonoma Creek,
- Petaluma River, and
- San Pablo Bay.



Map of the Suisun Marsh/North San Francisco Bay Ecological Management Zone and Units.

The general structure of San Francisco Bay is that of a series of embayments, each containing a central expanse of open water overlying subtidal sediments, and ringed by intertidal wetlands, mudflats, and /or rocky shores. These different kinds of areas constitute the major distinctive habitat-types of the ecosystem. Hydrologically, the Bay may be divided into two broad subdivisions with differing ecological characteristics: a *southern reach* consisting of South Bay, and a *northern reach* composed of Central, San Pablo, and Suisun Bays. The southern reach receives little freshwater discharge, leading to high salinity and poor circulation. It also has more extreme tides. The northern reach (which this vision addresses) directly receives Delta outflow, is characterized by less extreme tides and a pronounced horizontal salinity gradient, ranging from near full marine conditions in Central Bay to near fresh water conditions in Suisun Bay. Central and Suisun Bays contain sizeable islands, features not present in San Pablo and South Bays.

Historically (ca 1800), San Francisco Bay included more than 242,000 acres of tidally influenced bayland habitats and about 90,000 acres of adjacent habitats (Goals Project 1999). Tidal marsh (190,000 acres) and tidal flats (50,000 acres) accounted for 98% of the bayland habitats. Today, only 70,000 acres remain. In the Suisun Bay and marsh, tidal marsh and tidal flat habitats have declined from 68,000 acres to about 15,000 acres. Similar declines have occurred in the North Bay region with tidal marsh and tidal flats declining from about 68,000 acres to about 25,000 acres (Goals Project 1999).

Today, the important habitat types in the Suisun Marsh/North San Francisco Bay Ecological Management Zone are tidal perennial aquatic habitat, tidal saline emergent wetland, seasonal wetland, perennial grassland, agricultural land, and riparian habitat. The separation of wetlands from tidal flows and the reclamation of emergent wetlands have altered ecological processes and functions in Suisun Marsh and the North Bay. Removing tidal action from the marsh and baylands soils has resulted in oxidation of the soil and, subsequently, subsidence (settling) of interior islands and adverse changes in wetland soils chemistry. Losing these processes and functions has reduced available habitat for native species of fish, plants, and wildlife; reduced water quality;

and decreased the area available for dispersing flood waters and depositing suspended silt.

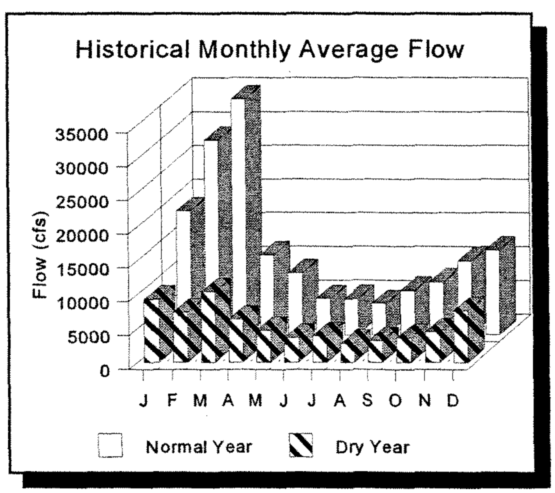
Species that have been affected include the salt marsh harvest mouse, California clapper rail, California black rail, waterfowl, shorebirds, Suisun shrew, and many other wildlife species. Many special-status plant species, including the soft-haired bird's beak, Suisun thistle, and Suisun aster, have also been adversely affected. Many species of native marine, estuarine, freshwater, and anadromous fish also depend on this habitat type for important parts of their life cycles. Fish species that continue to depend on tidal marshes and adjoining sloughs, mudflats and embayments include delta smelt, longfin smelt, chinook salmon, green sturgeon, white sturgeon, Pacific herring, starry flounder, splittail, and striped bass.

Submerged aquatic vegetation (SAV), especially seagrass, communities and habitats provide valuable habitat for fish and invertebrates in the San Pablo Bay and north San Francisco Bay and is an important foraging habitat for waterfowl. San Pablo Bay contains the greatest acreages of seagrass of any water body in the Bay-Delta system. The relative present-day rarity of seagrass beds suggests it could be considered a habitat of special concern in the system.

Ecological processes essential to a healthy Suisun Marsh and San Francisco Bay include freshwater inflow, flood and floodplain processes, and aquatic foodweb processes. The disruption of ecological processes in this zone, such as separating wetlands from tidal flows, has prevented the marshes from the accretion of bottom sediments necessary to keep up with sea level rise, reduced nutrient input to the zone, and reduced the output of other organics and fixed nutrients. Ecological processes essential to a healthy Suisun Marsh and San Francisco Bay include both freshwater inflow within natural (unimpaired) variability and also tidal inflow to deliver important ocean salts and maintain this brackish-saline system. In addition, rare events such as extreme pulse flow hydrographs associated with high outflow years and rare events such as extreme winter drought conditions which this system experienced historically may be equally important in maintaining the biological diversity of this mixed salinity zone.

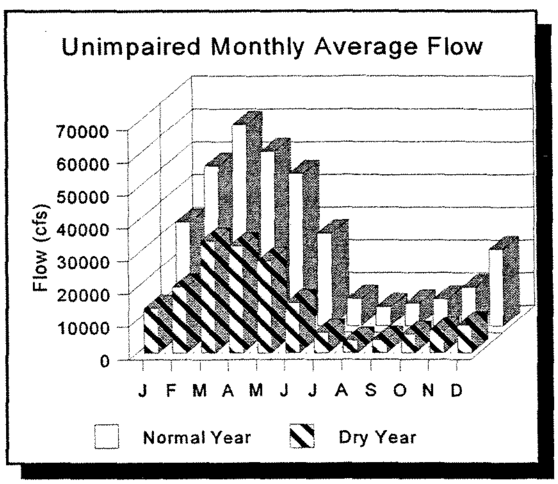
Hydrology is the physical process with the greatest influence on aquatic and wetland habitats, the many species of plants and animals that use the Bay, and the concentrations of pollutants in the marshes and North Bay. In areas downstream of the X2 isohaline (low salinity zone) which are well-mixed, ocean tides clearly dominate over and above freshwater inflow. The historical dominance of halophytic vegetation in Suisun Marsh also suggests that tidal hydrology may be more important to Suisun than freshwater inflows. The historical tidal prism prior to diking of the Suisun and North Bay marshes was also higher than present condition.

Freshwater inflow to the North Bay varies greatly from year to year. In 70 years of historical record, Bay inflow has ranged from a high of 50 million acre-feet (af) to a low of 8 million af, with an average of approximately 24 million af. During this period, freshwater inflow to the Bay has changed markedly because of upstream water storage in reservoirs and water-supply diversions developed in 1940s, 1950s, and 1960s. Spring freshwater inflows, which once averaged 20,000



Historical Delta Outflow, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

to 40,000 cubic feet per second (cfs) in dry years and 40,000 to 60,000 cfs in normal years, now average only 6,000 to 10,000 cfs in dry years and 15,000 to 30,000 cfs in normal years. In the driest years, spring freshwater inflows from the Delta were formerly 8,000 to 14,000 cfs; presently these flows average only 2,500 to 3,000 cfs. In dry and normal years, summer flows have remained in the range of 4,000 to 8,000 cfs, because channels carry irrigation water and Delta outflow needed to meet water quality criteria in the Delta. Winter freshwater inflows from the Delta in dry and normal years have been reduced from former levels of 15,000 to 60,000 cfs to current levels of 7,000 to 35,000 cfs because much of the runoff from winter rains and snowmelt is now stored in foothill reservoirs. Flows in highest rainfall years are relatively unchanged, although short-term peaks are reduced by flood-control storage in large foothill reservoirs.



Unimpaired Delta Outflow, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Freshwater inflows from the local watershed in the Vaca Mountains and Coast Range have also been modified from historic conditions. This influence, however, needs further review to clarify potential adverse downstream impacts.

Natural flood and floodplain processes are the periodic inundation of the floodplain during tidal cycles and peak flow events that would typically occur in late winter and spring during all but the driest years. Land reclamation and levee construction have eliminated much of the natural North Bay floodplain. This floodplain reduction forces water to rapidly exit the marshes and bays through confined channels and sloughs. While flows in most high rainfall years may be relatively unchanged, very large floods can devastate shoreline areas of the North Bay due to loss of floodplain and flood basin storage and other dampening effects of floods.

Aquatic foodweb productivity in the North Bay has declined over the past several decades due to several factors, including loss of tidal exchange, changes in freshwater inflow, Delta conditions, water diversions, water quality, and the introduction of exotic species. Foodweb productivity, beginning at the primary production level (i.e., plant cell production), is essential to maintaining important fish population. Primary productivity in the North Bay and adjacent marshes depends on spring freshwater flow events to bring in essential nutrients and recycle nutrients in the marshes. Primary productivity has been limited by heavy infestations of Asian clams that efficiently filter algae from the water column thus reducing the standing crop of phytoplankton.

With the reclamation of tidal marshes in the North Bay, there was an accompanying loss of shallow-water aquatic habitats on which many marine, estuarine resident and anadromous fish and estuarine invertebrates depend. Shallow-water habitats around the North Bay provide spawning and rearing habitat for many native resident Bay-Delta fishes and important rearing and migratory habitat for many Central Valley salmon and steelhead populations. Tidal perennial aquatic habitat benefits native waterfowl, wading and shorebirds, and other wildlife, as well as native plants that depend on such habitat.

Lakes and ponds (nontidal perennial aquatic habitats) found behind levees on reclaimed islands support simple invertebrate communities, riparian habitat, and wintering waterfowl. Such habitat within the North Bay also benefits waterfowl, as well as many plant and wildlife species.

After more than 100 years of land reclamation activities in the North Bay and marshes, many linear miles of natural sloughs have been lost. Sloughs are important spawning and rearing areas for many Bay-Delta fish species, as well as waterfowl and other wildlife. Of the natural sloughs that remain, most have severely degraded natural habitat values from loss of the tidal prism, dredging, levee confinement, riparian vegetation loss, high water flow, and poor water quality (i.e., from municipal, industrial, and agricultural drains).

Tidal marshes (including tidal perennial aquatic habitat, saline emergent wetlands, tidally influenced fresh emergent wetlands, and sloughs), once the most widespread habitat in the Bay-Delta, are now restricted to remnant patches. There have been extensive losses of saline emergent wetland habitat in the North Bay and adjacent marshes. Most of the remaining saline emergent wetlands lack adjacent upland transition habitat and other attributes of fully functioning saline emergent wetlands because of agricultural practices and urban and industrial development. Saline emergent wetlands provide important habitat for many plants, waterfowl, and other wildlife species. In addition, saline emergent wetlands contribute important plant detritus and nutrient recycling to the aquatic foodweb of the Bay-Delta estuary, as well as important habitat to some fish and aquatic invertebrate species.

Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats, such as managed duck clubs. Most of this habitat is located on levee-protected lands. Such habitats were once very abundant during the winter rainy season or after seasonal flooding. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many waterfowl, shorebird, and other wildlife species.

Upland habitats are found mainly on the outer edges of the North Bay and adjacent marshes. They consist primarily of grasslands and remnant oak woodland and oak savanna (intermittent woodland and grassland). Perennial grasslands are an important transition habitat for many wildlife species and are buffers to protect wetland and riparian habitats. Much of the grassland habitat associated with wetlands has been lost to agriculture (i.e., pasture, grain, vineyards, and orchards) and development (i.e., home construction, golf courses). Grasslands are important buffers for wetland habitat and provide habitat for many plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees, berms, berm islands, and in the interior of some islands. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide the shaded riverine aquatic habitat that many important fish and wildlife species depend on during some portion of their life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse habitat structure with low species diversity.

Riparian habitat is used by more wildlife than any other habitat type. From about 1850 to the turn of the century, most of the riparian forests in the Bay-Delta were cut down for fuelwood as a result of the Gold Rush, river navigation, and agricultural clearing. Remnant patches are found on levees, channel islands, and along the margins of the North Bay and adjacent marshes. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many fish and wildlife species.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors (soaring birds of prey, such as hawks and eagles). Nonflooded fields and pastures are also habitat for pheasants, quail, and doves. The North Bay and adjacent marshes support a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields, which support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations. The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Bay-Delta.

Water diversions in the North Bay and adjacent marshes divert freshwater inflow and brackish waters. Though diversions vary seasonally, relatively high rates can occur in any month of the year. Most water diverted from the North Bay and marshes is used locally. With many diversions unscreened or poorly screened, great numbers of fish and aquatic invertebrates are lost. In addition to organisms, diversions remove a disproportionately large portion of the nutrients and detrital (organic debris) load that drive the Bay-Delta foodweb. Losses of fish, invertebrates, and nutrients and organic debris limit the potential for the recovery of many fish species and improving Bay-Delta aquatic foodweb productivity. Lack of adequate screening and location of water diversions in sensitive areas contribute to the loss of important fish and aquatic foodweb organisms.

Levee construction and bank protection have led to the loss of wetland and shallow-water habitat throughout the North Bay and adjacent marshes. Habitat on levees and shorelines needs improvement to restore biodiversity and ecological functions needed for Bay-Delta aquatic and wildlife resources. Riparian habitats in this zone are found along the tributary streams in the upper reaches. Riparian habitat is not generally found in areas subject to reclamation by levee construction due to high salinity.

Dredging and disposal of dredge materials have contributed to the loss and degradation of important aquatic habitats such as tidal wetlands, mudflats, and sloughs in the North Bay and adjacent marshes.

Over the past several decades, the accidental introduction of many marine and estuarine organisms from the ballast waters of ships from the Far East has greatly changed the planktonic and benthic invertebrate fauna of the Bay-Delta, with further ramifications higher in the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta.

Toxins continue to enter the North Bay and adjacent marshes in large amounts from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of many important Bay-Delta fish and their foodweb organisms. Toxins in fish tissues are also a health risk to people who eat Bay-Delta fish. Continued reductions of toxins from discharges and releases from the sediment (e.g., disturbed by natural forces and dredging) are essential to the restoration program.

The legal and illegal fish harvest may limit recovery of some populations in the Bay-Delta and its watersheds. Sturgeon harvest in the North Bay and elsewhere may affect recovery of these populations.

Boat traffic in sloughs and channels contributes to the erosion of remaining shallow water, riparian, and wetland habitat. High boat speeds and traffic in channels where remnant or restored habitats are exposed to wave erosion jeopardize remnant habitat and limit the potential success of habitat restoration efforts. For example, an increase in jet ski use in Suisun Marsh following the improvement of local public launch facilities is also causing erosion and noise disturbance problems directly impacting sensitive channel side plant communities and nesting clapper rails in relict tidal marsh habitats.

The delta smelt population of the Bay-Delta estuary is a federally and state-listed threatened species. It depends on the North Bay and adjacent marshes for spawning and rearing habitat. It lives in fresh and brackish bays and sloughs of the Bay-Delta. Its decline is related to poor habitat conditions during drought periods. It benefits from high freshwater inflow, particularly during the late winter and spring of dry years, adequate slough and shallow water habitat, reduced effects of water diversions, and increased the aquatic foodweb productivity.

The longfin smelt populations of the Bay-Delta lives within the brackish water and saltwater of northern San Francisco Bay and migrates upstream into the Delta to spawn. The decline in the longfin smelt population has coincided with a number of changes in the estuary including: low flows in late winter and spring, reduced freshwater flows through the Delta and into Suisun Bay, water diversion (particularly in drier years), and contaminants.

Like delta smelt, splittail is a native resident species of the Bay that depends on the North Bay and adjacent marshes for much of its life cycle for spawning, rearing, and feeding. The splittail is a recently listed federal threatened species. The Bay-Delta population has declined, especially during recent droughts. Splittail depend primarily on shallow water habitats, including shorelines, sloughs, and aquatic habitats associated with wetlands and floodplain lands subject to seasonal inundation (e.g., the adjacent marshes of the North Bay). The splittail population benefits from wetland and slough habitat, a more productive aquatic foodweb, and higher late winter and spring freshwater flows during dry years. Losses to water diversions may also be a limiting factor.

White sturgeon and green sturgeon populations in the Central Valley use the North Bay for migrating, feeding, and as a nursery area for young and juveniles. Populations appear to be stable, but the green sturgeon is a California species of special concern due to low population size. Sturgeon benefit from high late winter and spring freshwater inflow, a productive aquatic foodweb, and bay habitat. Legal and illegal harvest and losses to water diversions may be limiting population abundance.

All four runs of chinook salmon in the Central Valley depend on the North Bay and adjacent marshes during at least a portion of their life cycle. The North Bay and adjacent marshes provide migratory and rearing habitat for salmon in all months. Many chinook salmon populations have declined in recent decades from a combination of ocean, river, and Bay-Delta factors. Freshwater flow reductions through the Bay-Delta and increases in water diversions have led to declines in salmon populations. Improving late winter and spring freshwater flows through the Bay-Delta and reducing losses to diversions are essential needs in salmon recovery.

Chinook salmon also benefit from lower water temperatures in spring and fall, as well as adequate aquatic habitats and high foodweb productivity. Tidal perennial marsh habitat and adjoining sloughs and aquatic habitats in the North Bay and adjacent marshes are important juvenile rearing habitat. Juvenile chinook salmon are lost to water diversions in North Bay and adjacent marshes.

Steelhead were historically present in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units, and are still present in most of these streams. The major factor limiting steelhead populations in these streams is agricultural development including water diversion, barriers due to diversion dams, high water temperatures and other water quality impacts from urban and agricultural runoff.

The striped bass population of San Francisco Bay and the Sacramento and San Joaquin rivers depends on the North Bay and adjacent marshes for much of its life cycle. The North Bay and adjacent marshes provide important feeding and juvenile rearing habitat for striped bass. Reduced freshwater flow and increased water diversions have resulted in a declining striped bass population over the past several decades. Poor Bay-Delta water quality may also be limiting survival of young and adults. Striped bass also benefit from high aquatic foodweb productivity. Loss of tidal perennial aquatic, wetland, and slough habitats may also limit striped bass production. Many striped bass young are lost in water diversions. Artificially rearing young striped bass salvaged at south Delta pumping plant fish facilities or supplementing production with hatchery reared fish may be necessary to sustain the population under present limiting factors.

American shad is an anadromous fish that spawns in the Sacramento River and its major tributaries. They pass through the Bay-Delta on their upstream spawning migration in spring, and in the fall, young fish pass through on their way to the ocean. A small portion of the population rears in North Bay waters. Though the population appears stable and healthy, low productivity in drought periods is a concern. American shad production is higher with higher late winter and spring freshwater flow through the Bay-Delta in dry and normal rainfall years, improved aquatic foodweb production, and lower relative rates of water diversions.

There are many native and non-native fish species resident to the Delta, like delta smelt and splittail, that will benefit from improved aquatic habitats and foodweb production in the Delta. Many native fish species have declined gradually over the past century from habitat loss and non-native fish introductions. More recently native resident (nonmigratory) species have further declined from changes in freshwater flow, water diversions, poor water quality, and further non-native species introductions and habitat degradation. For many of these species, improvements to their native habitats, including sloughs and tidal marshes, are essential in restoring these populations. Native residents will also benefit from more natural freshwater flow patterns, improved water quality, and reduced losses to water diversions.

Marine fishes include many species that are abundant and important ecologically in the Bay and coastal waters. Two ecologically valuable species are the Pacific herring and northern anchovy, whose young are important in the foodweb as prey of salmon, sturgeon, and striped bass, as well as other fish and waterfowl such as cormorants and terns. Pacific herring, Dungeness crab, and Bay shrimp also support commercial fisheries. Starry flounder contribute to the local Bay-Delta sport fishery. The Bay and Delta are essential spawning and nursery areas for many marine fish and invertebrates found in the Bay and coastal waters.

Factors that affect the survival and production of marine fish and invertebrates in the Bay-Delta include Delta outflow, water diversions, foodweb productivity, availability and quality of shallow water and wetland habitats, and water quality. In addition, the aquatic foodweb is linked to the transitional wetland foodweb which extends up into the high marshes and adjacent uplands. These are important ecological links which contribute to the detrital based portion of the aquatic foodweb.

Improvements in production and survival of marine and estuarine fishes in the Bay and Delta will provide ancillary benefits to important estuarine, anadromous, and resident fishes of the Bay-Delta.

Many marine species depend on the North Bay and adjacent marshes for spawning or as nursery areas. Pacific herring spawn in the Bay each winter, and their young are abundant in the North Bay into summer. Young northern anchovy spawned in the ocean enter the North Bay each summer to feed. Starry flounder, shiner perch, and many other marine-estuarine fish also use the Bay for spawning, rearing, and feeding. Dungeness crab use the North Bay as a nursery area. Several shrimp species are abundant in the North Bay.

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

Once possibly abundant, the giant garter snake and western pond turtle are now rare in the Bay-Delta. Improvements in wetland, riparian, and grassland habitats around the Delta margins could greatly benefit these species.

Once abundant in the Bay-Delta, Swainson's hawks are now rare. Improvements in agricultural, grasslands, and riparian habitats will aid in Swainson's hawk recovery.

The California clapper rail is State and federally listed as an endangered species. A long-term decline in tidal emergent wetlands has reduced the population in the Bay-Delta.

A long-term decline in emergent wetlands has reduced the California black rail population in the Delta. Restoring emergent wetlands in the Delta should aid in California black rail recovery.

The Suisun song sparrow lives only in the Suisun Bay marshes. It depends on brackish marsh and riparian habitats. Its population has declined with the loss of brackish marshes.

The salt marsh harvest mouse is a State and federally listed endangered species. It depends on tidal salt marshes and its population has declined with the loss of tidal salt marsh habitat.

Herons, egrets, and other shorebirds and wading birds breed and winter throughout the Central Valley, the North Bay, and adjacent marshes. Their populations depend on aquatic and wetland habitats. Shorebirds and wading birds will benefit from restoring wetland, riparian, aquatic, and agricultural habitats.

Many waterfowl species overwinter in the Bay-Delta and depend on high-quality foraging habitat to replenish their energy reserves. They depend on wetland, riparian, aquatic, and agricultural habitats. Many resident and migratory waterfowl species will benefit from improved aquatic, wetland, riparian, and agricultural habitats.

List of Species to Benefit from Restoration Actions in the Suisun Marsh/North San Francisco Bay Ecological Management Zone

- delta smelt
- longfin smelt
- splittail
- chinook salmon
- steelhead trout
- striped bass
- green sturgeon
- white sturgeon
- American shad
- native resident fishes
- Pacific herring
- marine fishes and shellfishes
- Bay-Delta foodweb organisms
- grass shrimp
- special status plants
- California freshwater shrimp
- giant garter snake
- western pond turtle
- Swainson's hawk
- California clapper rail
- California black rail
- Suisun song sparrow

- salt marsh harvest mouse
- San Pablo California vole
- Suisun ornate shrew
- shorebirds
- wading birds
- waterfowl
- Delta green ground beetle.

Descriptions of Ecological Management Units

Suisun Bay and Marsh Ecological Management Unit

The boundaries of the Suisun Bay and Marsh Ecological Management Unit are Collinsville on the east, the Contra Costa County shoreline to the south, the Richmond-San Rafael Bridge to the west, and the ridge tops of the Coast Ranges to the north. The marshland and bay are in a valley, bordered on the north and south by the Coast Ranges. The predominant habitat types in this zone are tidal perennial aquatic habitat, tidal brackish emergent wetland, seasonal nontidal wetland, and grassland. The marsh is primarily a managed wetland, with levees to control water level and seasonal flooding with fresh water.

Historically, the eastern portion of Suisun Marsh was predominantly tidal fresh and brackish water marsh. The western portion of the marsh was predominately fresh and brackish marshland with more saline marsh existing on the western edge. Within these broad marshes were sloughs, channels, ponds, and small bays. Except for parts of Suisun Bay, the segment had relatively few tidal flats. Large areas of moist grasslands connected the baylands with upland areas (Goals Project 1999).

An extensive network of sloughs conveys tidal flows and some freshwater flow into the marsh. Montezuma Slough, the largest of these, is connected to Suisun Bay at its eastern and western ends. The slough is an important nursery area for many fish, including chinook salmon, striped bass, splittail, and delta smelt. The Suisun Marsh Salinity Control Structure was constructed near the eastern slough entrance and began operation in the fall of 1988 to limit the tidal influx of saltwater from the Bay into Suisun Marsh. The salinity control structure operates from September through May by closing during flood tides and opening during ebb tides to keep salinity in the slough low throughout the managed wetland flooding season.

Efforts in the 1970s resulted in protecting the Suisun Marsh, the largest remaining brackish marsh in California. The marsh is an extremely important resource for migratory waterfowl, associated wildlife (including several threatened and endangered species), and many fish species. The marsh also harbors sensitive plant species and communities including several rare species. The Suisun thistle is a Suisun endemic and is found nowhere else in the world. The Suisun Marsh Protection Plan played a key role in reducing development pressure and other adverse impacts associated with human disturbance, such as accidental fires, careless application of pesticides and herbicides, and urban runoff.

Napa River Ecological Management Unit

The Napa River Ecological Management Unit is within the Napa River watershed and includes the river, an extensive marsh/slough complex, and the lower river estuary connecting to San Pablo Bay. Historically, this area was nearly all tidal salt marsh and tidal brackish marsh dominated by the flow patterns of the lower Napa River (Goals Project 1999). Currently, most of the baylands have been reclaimed for salt or agricultural production. A network of sloughs fringed by saline emergent marsh is also present. The sloughs have become silted as a result of lost tidal prism. The baylands are surrounded by uplands composed primarily of grasslands which are rapidly being converted to urban and agricultural (vineyard) uses. In the north, natural upper river watershed habitats have been reduced by agricultural and urban development and flood control measures. Vernal pools and other seasonal wetland habitats characteristic of the upper watershed have been almost entirely eliminated in the Napa River Ecological Management Unit.

The Napa River historically consisted of a fairly broad riparian corridor and programs to restore riparian and shaded riverine aquatic habitat will be an important component of the program, particularly in the upper Napa River area to provide habitat for wildlife and aquatic habitat for fish species. The tidal marshes of this area are of limited size and habitat quality due to past reclamation. Remaining tidal marshes are linear with little channel development. The larger sloughs have silted up due to a reduced tidal prism.

SONOMA CREEK ECOLOGICAL MANAGEMENT UNIT

The Sonoma Creek Ecological Management Unit is located southwest of the Napa River Ecological Management Unit. The main habitat types in the area are tidal and seasonal marsh, tidal sloughs, and upland areas, such as vernal pools, grassland, and savanna. Historically, this area was nearly all tidal salt marsh and tidal brackish marsh. Some areas of moist grasslands existed to the north and west along upper Sonoma Creek and in the drainages surrounding Lake Tolay (Goals Project 1999).

The lower portions of the unit are baylands, composed of tidal sloughs with fringing marshes, some diked managed wetlands, diked farm lands, mostly oat and hay, and surrounding uplands characterized by grasslands, vernal pools, and oak woodlands quickly being converted to vineyards. Tidal marshes and channels are reduced as a result of reclamation. Seasonal wetlands develop during the rainy season on reclaimed agricultural lands. Urban development along the upper river is associated with the city of Sonoma. Vineyards are the predominant land use in the upper watershed, particularly on the valley floor. The mountains of the watershed are characterized by oak woodlands, chaparral, and mixed conifer habitats. As in the Napa River Ecological Management Unit, much of the vernal pool, seasonal wetland and oak savanna habitat previously present on the valley floor has been eliminated as a result of agricultural and urban development.

PETALUMA RIVER ECOLOGICAL MANAGEMENT UNIT

The Petaluma River Ecological Management Unit is located west of the Sonoma Creek unit on the northwest margin of San Pablo Bay. The habitat types in this watershed are marsh wetlands and uplands, such as grassland. The lower portion of the watershed is composed of tidal marshes and sloughs, and diked seasonal wetlands and historic bayland which have been reclaimed for agriculture. Historically, tidal marsh was the dominant habitat type in this ecological management unit. Salt marsh existed near the mouth of the Petaluma River, and small tidal flats existed at the river mouth (Goals Project 1999).

The diked agricultural lands intermittently pond water during the rainy season which provided habitat for shorebirds and waterfowl. The surrounding uplands are characterized by open grasslands and oak savannas. This unit contains the largest extant natural tidal marsh on the west coast. The upper watershed is rapidly developing with Petaluma, the largest city. Agricultural uses include grazing, oat hay production, and vineyards.

SAN PABLO BAY ECOLOGICAL MANAGEMENT UNIT

The San Pablo Bay Ecological Management Unit includes San Pablo Bay and the adjacent mudflat and marsh baylands, both diked and non-diked. Habitat varies from deep bay marine habitat to edge mudflats and marsh/slough complexes. Bay habitat varies from nearly fresh water at its eastern end, during periods of high freshwater outflow, to nearly seawater salinity levels (32 parts per thousand) during the periods of lowest outflow at the western end of San Pablo Bay. Salinity in the bay is stratified (layered) during high outflow conditions, but is not stratified in dry periods/years. The mixing zone is upstream is San Pablo Bay in dry years.

Historically, this unit supported large tidal marshes that were bordered by extensive mudflats (Goals Project 1999). Although it is generally less productive than the less saline Suisun Bay to the east, San Pablo Bay is a productive estuary that has important spawning and rearing habitat for many marine, estuarine, and anadromous fish and marine-estuarine invertebrates (e.g., shrimp, crabs, and clams).

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone includes the concept of "whole marsh management." This vision embodies key parameters needed to successfully restore ecological processes, habitats, and to restore, maintain, or recover a wide diversity of fish, wildlife, and plant species.

The Goals Project (1999) proposed a series of key considerations in restoration of the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The considerations include:

- large, connected patches of tidal marsh habitat centered on existing populations of species concern (e.g., salt marsh harvest mouse, California clapper rail),
- placement of tidal marshes along the edge of the Bay an at the mouths of tributary streams to maximize benefits for aquatic organisms,
- incorporating natural features such as large tidal channels, marsh ponds, transitional pannes, and beaches to optimize habitats for many species of fishes, shorebirds, and waterfowl,
- utilize managed saline and seasonal ponds near mudflats to provide high-tide habitat for shorebirds,
- provide natural habitat transitions between bayland habitats and adjacent upland habitats to provide habitat required by many special status plant species,
- provide continuous corridors of riparian habitat along streams tributary to the Bay, and
- maintain upland buffers to protect all existing and restored wetland habitats from disturbance.

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone includes providing a more natural freshwater outflow pattern from the Delta in dry and normal rainfall years, restoring tidal and nontidal wetlands, restoring tidal perennial aquatic habitat, and screening unscreened and poorly screened diversions. These changes will assist in the recovery of special-status species and increase important fish, wildlife, and plant communities. Local and regional agency and stakeholder initiatives will help attain this vision.

The vision focuses on improving the natural freshwater inflow pattern to San Francisco Bay and restoring important, tidally influenced aquatic and wetland habitats and adjacent uplands. Other focal points are reducing stressors, such as non-native marine invertebrates in ship ballast water and contaminants in municipal, industrial, and agricultural discharges into the Bay, and reducing losses of juvenile fish and their food organisms at unscreened diversions. Habitat improvements will benefit the salt marsh harvest mouse, Suisun song sparrow, California clapper rail, and California black rail, as well as many native waterfowl and wildlife species living in and around the North

Bay. Improving freshwater inflow and habitat will benefit delta smelt, splittail, chinook salmon, striped bass, longfin smelt, and other anadromous and resident marine and estuarine fishes and larger marine invertebrates (e.g., shrimp, crabs, and clams) of the Bay, as well as the estuarine foodweb (e.g., algae and planktonic and bottom-dwelling animals) on which the fish depend. Separate visions have been prepared for many of these processes, stressors, habitats, and species. Volume I contains additional detail on the status and restoration needs of these resource elements and the specific restoration approach.

The vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone is closely tied to the vision for the Sacramento-San Joaquin Delta Ecological Management Zone. It is indirectly related to visions for the mainstem rivers and tributary watersheds. Flows and habitats in these areas are integrally linked. Many important anadromous fish and waterfowl species that use the Central Valley are affected by conditions in multiple Ecological Management Zones.

Restoring Suisun Marsh and North San Francisco Bay will improve the natural production of marine, estuarine, and anadromous fish; resident wildlife; migratory waterfowl; other winter migrants and neotropical birds; and special-status plants, plant communities, and associated terrestrial invertebrates. Several waterfowl species whose populations have declined in recent times, such as the canvasback and redhead, should also benefit.

Improving Suisun Marsh and North San Francisco Bay health will help to achieve the restoration goals set for the Sacramento-San Joaquin Delta Ecological Management Zone. Likewise, improving conditions in the Sacramento-San Joaquin River Delta (Delta) will benefit the Bay.

Goals for the Suisun Marsh/North San Francisco Bay Ecological Management Zone include protecting and enlarging remaining areas of native habitat and establishing connectivity among these areas. Enlarging the San Francisco Bay and San Pablo Bay National Wildlife Refuges and other State and local wildlife areas; expanding restoration efforts in the Napa Marsh area, Petaluma Marsh, and Sonoma baylands; and restoring connectivity among these features will help achieve the vision for this Ecological Management Zone. Expanding restoration efforts in the northeastern portion of Suisun Marsh and restoring connectivity with areas such as the Jepson Prairie Preserve in the Yolo Basin Ecological Management Zone and the Sacramento-San Joaquin Delta Ecological Management Zone will also contribute to this effort.

Potentially high-quality spawning, rearing, and migrating habitat will be restored to benefit important fish species that use Suisun Marsh and the Bay during at least a portion of their lives. This effort includes improving freshwater inflow patterns, particularly in dry and normal water years, and restoring extensive areas of tidal aquatic and wetland habitats in Suisun Marsh and the Bay.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

SUISUN BAY AND MARSH ECOLOGICAL MANAGEMENT UNIT

The vision for the Suisun Bay and Marsh Ecological Management Unit is to restore tidal marsh and to restore and enhance managed marsh, riparian forest, grassland, and other habitats.

Efforts and opportunities to restore tidal action to selected managed wetlands and promote natural riparian and wetland succession in Suisun Marsh will be expanded. Shallow-water, wetland, and riparian habitats within the marsh and along the shorelines of the Bay will be protected and improved, where possible. Upland habitats adjacent to riparian and wetland habitats will also be protected and improved. Efforts will focus on increasing the acreage open to tidal flows (e.g., by removing or opening levees) and providing connectivity among habitat areas to aid in the recovery of species, such as the salt marsh harvest mouse, clapper rail, and black rail. Those habitat areas will provide essential shelter and nesting cover during high tides. Improving marsh and slough habitats will benefit chinook salmon, striped bass, delta smelt, splittail, and other estuarine resident fish in the marsh and Suisun Bay.

Diverting water from Suisun Marsh channels for managed nontidal wetlands and controlling the salinity of water entering the marsh through Montezuma Slough will continue, but with consideration for maintaining the natural hydrologic regime and salinity levels of the slough and marsh. Efforts to screen diversions in the marsh will also continue to minimize the entrainment of juvenile fish. Water quality standards specified in the 1995 Water Quality Control Plan will be met in the eastern marsh and at several locations in the central marsh. Flows into the northwestern marsh will be improved.

Water diversions from Suisun Bay for cooling at the Pittsburg power plant will be conducted with minimal adverse effects on eggs, larvae, and juvenile fish. New fish screening technology or alternative sources of cooling water (such as cooling towers) will be considered.

Oil refinery operations in the Bay will be modified to reduce discharges of high levels of contaminants, such as selenium.

Suisun Marsh and Suisun Bay will function as high-quality spawning and rearing habitat and an effective fish migration corridor. A healthy Suisun Marsh-Bay ecosystem will be an important link in the estuary foodweb by improving primary and secondary productivity. Marsh and Bay productivity will improve as freshwater inflow events increase in dry and normal years and acreage of tidal wetlands and associated tidal perennial aquatic habitat increases.

Napa River Ecological Management Unit

The vision for the Napa River Ecological Management Unit is to restore large areas of tidal marsh to benefit salt marsh harvest mouse and California clapper rail, manage inactive salt ponds to benefit waterfowl; restore a continuous band of tidal marsh along the bayshore to benefit fish species; improve tidal circulation; manage diked wetlands and seasonal wetlands to improve seasonal ponding for shorebirds, wading birds and waterfowl; enhance riparian vegetation and marsh/upland transitional habitats; and provide upland buffers.

Restoration efforts will be focused in the Napa Marsh Wildlife Area, Cullinan Ranch, and Scagg Island. Habitats should be protected and natural expansion and succession should be supported to restore large, contiguous (connected) areas of tidal saline emergent wetland, riparian, and upland habitats. The existing habitat areas are sparse and low quality, because dikes and levees have disrupted the natural tidal flows and sediment supply that are essential to maintain marsh habitat. Restoring tidal action to additional portions of the marsh and improving water quality will enhance the health of the marsh. This, in turn, will aid in the recovery of species, such as the salt marsh harvest mouse and clapper rail in the southern part of the Ecological Management Unit. Fish species, such as chinook salmon, striped bass, splittail, and delta smelt, will benefit from the improved health of the marsh and associated improvements in the tidal slough complex and lower river estuary.

Sonoma Creek Ecological Management Unit

The vision for the Sonoma Creek Ecological Management Unit is to restore large patches of tidal marsh along the entire shoreline of San Pablo Bay; restore tidal marsh along Sonoma Creek;

establish managed mars or enhanced seasonal pond habitat for shorebirds; enhance riparian habitat along Sonoma Creek; and enhance marsh/upland transitional habitats.

Existing habitat will be maintained, and current and future restoration efforts in Napa/Sonoma Marsh will be expanded. The marsh is sparse and low quality, because dikes and levees have disrupted the natural sediment supply essential for maintaining marsh habitat. Leveed, historic marshland will be opened to tidal action, creating larger, more contiguous marsh areas. An expanded marsh/slough complex will support greater salt marsh harvest mouse and clapper rail populations, as well as splittail, delta smelt, juvenile chinook salmon, and striped bass. Restoration of existing managed marshlands may not be desirable as these lands support significant numbers of shorebirds and waterfowl. To achieve the restoration objective, acquisition and restoration of other diked baylands may be required.

PETALUMA RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Petaluma River Ecological Management Unit is to restore a continuous band of tidal marsh along the bayshore from Tolay Creek to the Petaluma River; restore tidal marsh along the Petaluma River; establish managed marsh or enhanced seasonal pond habitat on agricultural baylands not restored to tidal habitat; protect moist grasslands, and provide natural transitional habitat between marshes and upland areas.

Petaluma Marsh and its associated tidal slough network will be expanded. Outside of Petaluma Marsh, marsh habitat areas are sparse and low quality, because dikes and levees have disrupted the natural tidal flow and sediment supply essential for maintaining tidal emergent wetland habitat.

SAN PABLO BAY ECOLOGICAL MANAGEMENT UNIT

The vision for the San Pablo Bay Ecological Management Unit is to restore tidal marsh along the bayshore and to establish managed marshes or enhance seasonal pond habitat on agricultural baylands not restored to tidal action.

The ecological health of San Pablo Bay and its function as an important nursery area for marine, estuarine, and anadromous fish can be improved by increasing freshwater inflow in spring during years with low and normal freshwater outflow, protecting and expanding tidal marsh/slough habitat complexes along the margins of the bay, and reducing the input of pollutants into the bay. Removing dikes and levees along the bay's shoreline, where appropriate, will aid in the recovery and expansion of tidal emergent wetland habitat.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: A healthy pattern of freshwater inflow to Suisun Marsh and the North Bay would involve natural late-winter and spring flow events that support ecological processes and functions essential to the health of important Bay-Delta fish populations. Inflow to the Bay is impaired in dry and normal water years by storage and diversion of natural inflow to basin watersheds. The need for inflow to the Bay coincides with the need for natural flows in the mainstem rivers, their tributaries, and the Delta.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Expansion of the North Bay floodplain by setting back or removing levees would enhance floodwater and sediment retention and provide direct and indirect benefits to fish and wildlife that depend on natural floodplain inundation. Such floodplain expansion should also help to alleviate the flooding potential in other areas of the Bay-Delta.

BAY-DELTA AQUATIC FOODWEB: The aquatic foodweb of the Delta, which supports important resident and anadromous fish, has been severely impaired by drought, reductions in freshwater flow, water diversions, introductions of non-native species (e.g., Asiatic clams), and loss of shallow water and wetland habitats. Proposed improvements in spring flows, channel hydraulics, wetland habitats, and floodplain inundation should lead to a healthier and more productive aquatic foodweb. Improved water quality and greater sediment retention in wetland, riparian, and floodplain habitats will also increase foodweb productivity.

VISIONS FOR HABITATS

TIDAL PERENNIAL AQUATIC HABITAT: Aquatic habitat within and associated with tidal wetland habitat is important to fish populations that use the Bay. The area of such habitat has been substantially reduced over the past century by land reclamation. Large areas of tidal habitat have been diked and reclaimed for agriculture, salt production, industry, nontidal wetlands (e.g., duck clubs), and other uses. Restoring large areas of presently leveed land to tidal influence may increase important fish species production by providing more spawning, feeding, and migrating habitat and increasing foodweb production throughout the Bay.

NONTIDAL PERENNIAL AQUATIC HABITAT: Open water habitats in managed wetlands, such as ponds, provide valuable waterfowl and wildlife habitats. Such habitat should be included in restoration efforts involving nontidal saline emergent wetlands.

TIDAL SLOUGHS: Sloughs are an important native habitat for fish and wildlife. Many slough complexes in the wetlands along the North Bay have disappeared as a result of land reclamation and levee construction. Restoring tidal wetland-slough complexes will provide valuable habitat for fish, including chinook salmon, striped bass, delta smelt, and longfin smelt.

SALINE EMERGENT WETLANDS (TIDAL): Tidal saline emergent wetland habitat in the Bay has been drastically reduced as a result of land reclamation. Such habitat is essential to estuary functions and the health of many fish, waterfowl, and wildlife species. Wetlands also enhance water quality in the Bay by filtering out sediments and contaminants.

SEASONAL WETLANDS: Seasonal wetlands in Suisun Marsh provide valuable wetland habitat for waterfowl and shorebirds, as well as other wildlife.

VERNAL POOLS: Vernal pools provide habitat for many listed plant and invertebrate species. Vernal pool protection and restoration will be closely linked to other actions related to restoring wetland, riparian, and adjacent upland habitats.

RIPARIAN AND SHADED RIVERINE AQUATIC HABITAT: Riparian and shaded riverine aquatic (SRA) habitats have been greatly reduced as a result of development along streams in areas above the lower marshes, sloughs, and Bay shorelines. Such habitat has value to many special-status plant and animal species. In addition, SRA habitat is important for juvenile chinook salmon and many other resident and anadromous fish using the Bay.

ESSENTIAL FISH HABITAT: The Suisun Marsh/North San Francisco Bay Ecological Management Zone has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in this ecological management zone include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

PERENNIAL GRASSLANDS: Grasslands associated with wetland margins are important habitats for some special-status plant and wildlife species. Wetlands should be restored along with the associated aquatic and upland habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSION: Water diversions in North Bay watersheds, in Suisun Marsh, and upstream in the Delta and rivers affect freshwater flow in the Bay and remove fish and their foodweb organisms from the Bay. Unscreened diversions will be screened and poorly functioning screens will be improved to reduce fish loss. Where possible, diversions will be consolidated to reduce the number of diversions requiring screening. Most diversions in the Bay are confined to Suisun Marsh and Suisun Bay.

INVASIVE SPECIES: Over the past several decades, the inadvertent introduction of many marine and estuarine organisms from the Far East in the ballast water of ships has greatly changed the plankton and benthic invertebrate fauna of the Bay, with further consequences throughout the foodweb. Further changes can be expected if ballast water releases into the Bay are not restricted. Therefore, more stringent ballast water release restrictions are needed to reduce the influx of exotic species. Other invasive species such as exotic cordgrass (Spartina spp) are becoming established and control measures are needed to reduce future potential adverse affects.

NON-NATIVE WILDLIFE: Reducing the numbers of non-native species and therefore the effects these species have on native wildlife will require a coordinated approach that includes restoring ecosystem processes and functions where applicable and possible, restoring native habitats, reducing or eliminating other stressors that suppress native species, and efforts to control non-native species.

PREDATION AND COMPETITION: Millions of chinook salmon and striped bass have been stocked in North Bay waters to improve the survival of these species and their contributions to spawning populations. Although the presence of these fish in the Bay could be considered natural, the stocking of millions of hatchery smolts into small areas of the North Bay within a short period may affect the survival and production of important Bay species, such as longfin smelt.

CONTAMINANTS: Toxic contaminants continue to enter the Bay in large amounts as a result of municipal, industrial, and agricultural discharges. These toxins have had a demonstrated adverse effect on the health, survival, and reproduction of many important Bay fish species and their foodweb organisms. Toxins in fish tissues also pose a health risk to people who eat fish from the Bay. Continuing to reduce levels of toxic contaminants from discharges and releases of toxins from sediment (i.e., disturbed by natural forces and dredging) is an essential step in the restoration program. The level of toxins in the Bay is also closely tied to inputs upstream in the Delta and rivers; therefore, efforts to improve water quality should be coordinated throughout the basin.

HARVEST OF FISH AND WILDLIFE: Legal and illegal fish harvest may limit recovery of some populations in the Bay-Delta system and its watersheds. Striped bass, salmon, steelhead, and sturgeon harvest in the Bay may affect the recovery of these populations.

DISTURBANCE: Human activity, particularly boat wakes in sloughs and channels in tidal wetland areas, disturbs nesting waterfowl and erodes habitat. Disturbance to the endangered California clapper rail which also may occur includes boating and hunting. Restricting boat speeds and access by motorized boats in special areas will reduce these stresses.

VISIONS FOR SPECIES

DELTA SMELT: The vision for delta smelt is to recover this State-and federally listed threatened species in order to contribute to the overall species richness and diversity of the Bay-Delta. Recovery of the delta smelt population in the Bay-Delta will occur through improved freshwater inflow and Delta outflow patterns, greater foodweb productivity, increased areas and quality of aquatic habitats, and reduced effects of water diversions. Higher delta smelt production should be apparent in dry and normal water year types in response to improved flows, habitats, and foodweb, and reductions in stressors.

LONGFIN SMELT: The vision for longfin smelt is to recover this California species of special concern in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt.

SPLITTAIL: The vision for splittail is to recover of this federally listed threatened species. Recovery of the Bay-Delta splittail population will occur through improved floodplain inundation, higher late-winter Delta inflow, and improved tidal aquatic and wetland habitats. Greater production of young would be expected in dry and normal water year types.

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under the State or federal ESAs, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. Central Valley salmon populations will remain stable or increase with improved late-winter and spring flows into and through the Delta, increases in wetland and floodplain habitats, lower spring water temperatures, an improved aquatic foodweb, and reduced effects of water diversions. Survival rates through the Bay-Delta should increase. Numbers of young salmon rearing in the Bay-Delta should increase with improved winter-spring flows and wetland habitats.

STEELHEAD TROUT: The vision for Central Valley steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and the use fully existing and restored habitats. Steelhead will benefit from improved streamflows and riparian and shaded riverine aquatic habitat in the upper stream reaches. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring native species, to their 1960s level of abundance to support a sport fisher in the Bay, Delta, and tributary rivers. The striped bass population will benefit from increased freshwater inflow to the Bay-Delta in late winter and spring, an improved aquatic foodweb, and reduced effects of water diversions. Improvements in water quality and reducing summer losses to diversions may be important in the long-term recovery of striped bass. Given the high reproductive capacity of striped bass, improvements in young production rates should be readily apparent when improvements are made to flow and foodweb, and when stressors are reduced.

GREEN STURGEON: The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historical levels. Sturgeon populations should remain stable or increase with improved streamflows and aquatic foodwebs.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Sturgeon populations should remain stable or increase with improved streamflows and aquatic foodwebs.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Central Valley American shad populations will benefit from improved spring freshwater inflow to the Bay-Delta and an improved Bay-Delta aquatic foodweb. Populations would be expected to remain stable or increase. Increases would be expected in dry and normal rainfall years.

NATIVE RESIDENT FISH SPECIES: The vision for native resident fish species is to maintain and restore the distribution and abundance of native species to contribute to overall species richness and diversity. Many native and non-native fish species will benefit from improved aquatic habitats and foodweb. Population abundance rates remain stable or increase. The distribution of native resident fishes should increase with widespread habitat restoration. The locally extinct Sacramento perch could be restored to new habitats in Suisun Marsh.

PACIFIC HERRING: The vision for Pacific herring is to maintain self-sustaining populations in order to support commercial fishing. With improved freshwater inflow to the North Bay and Suisun Marsh and more tidal emergent wetland and associated tidal perennial aquatic habitat, marine and estuarine fish and invertebrate population abundance and distribution would increase. Pacific herring survival and production in the North Bay should increase with an improved aquatic foodweb.

BAY-DELTA FOODWEB ORGANISMS: The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and reducing loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Other elements include reducing losses to exports from the system and reducing the amount of toxic substances entering the system. Probably the best way to improve the aquatic foodweb is to restore tidal marshes and the connectivity to tidal flows in addition to the restoration of freshwater flows since and important part of the food web was probably driven by detritus originating from nearby marshes. A key to achieving this vision is expanded support of basic research to define and better understand the important links between the aquatic foodweb and adjacent terrestrial or transitional wetland foodweb.

GRASS SHRIMP: The vision for grass shrimp is to maintain self-sustaining populations in order to support recreational and commercial fisheries.

SPECIAL STATUS PLANT SPECIES: The vision for special status plant species is to contribute to their recovery by protecting and preserving important habitats sites within the Bay-Delta.

CALIFORNIA FRESHWATER SHRIMP: The vision for California freshwater shrimp is to maintain existing population distribution and abundance of the this federally listed endangered species.

GIANT GARTER SNAKE: The vision for giant garter snake is to contribute to the recovery of this State and federally listed threatened species. Restoring aquatic, riparian, and wetland habitats in the Bay-Delta will aid giant garter snake and western pond turtle recovery.

WESTERN POND TURTLE: The vision for western pond turtle is to maintain and restore their abundance and distribution in order to contribute to overall species richness and diversity. Restoring aquatic, riparian, and wetland habitats in the Bay-Delta will aid giant garter snake and western pond turtle recovery.

SWAINSON'S HAWK: The vision for Swainson's hawk it to contribute to the recovery of this State and federally listed threatened species. Improvements in riparian and agricultural wildlife habitats will aid in the Swainson's hawk recovery. Increased sightings and possibly increased nesting would be expected in the Bay-Delta.

CALIFORNIA CLAPPER RAIL: The vision for California clapper rail is to contribute to the recovery of this State and federally listed threatened species. Restoring emergent wetlands in the North Bay and adjoining marshes should aid California clapper rail recovery. Population abundance and distribution should increase in the North Bay and adjoining marshes.

CALIFORNIA BLACK RAIL: The vision for California black rail is to contribute to the recovery of this State-listed threatened species. Restoring emergent wetlands in the North Bay and adjoining marshes should aid in California black rail recovery. Population abundance and distribution should increase in the North Bay and adjoining marshes.

SUISUN SONG SPARROW: The vision for the Suisun song sparrow is to recover this species of special concern in Suisun Marsh and the western Delta. The Suisun song sparrow abundance and distribution in the Suisun Marsh should increase with new tidal wetlands and improved riparian habitat in the marshes.

ALAMEDA SONG SPARROW: The vision for the Alameda song sparrow is to maintain and restore the habitat of this species of special concern. The Alameda song sparrow abundance and distribution should increase with new tidal wetlands and improved riparian habitat in the marshes.

SALT MARSH HARVEST MOUSE: The vision for the salt marsh harvest mouse is to contribute to the recovery of this State and federally listed endangered species through restoring salt marsh habitat in San Pablo and Suisun bays and adjacent marshes. New and improved salt marsh habitat in the North Bay and adjoining marshes will help in salt marsh harvest mouse recovery.

SAN PABLO CALIFORNIA VOLE: The vision for the San Pablo California vole is to contribute to the recovery of the species of special concern to contribute to overall species richness and diversity.

SUISUN ORNATE SHREW: The vision for the Suisun ornate shrew is to recover this California species of special concern to contribute to overall species richness and diversity.

SHOREBIRDS AND WADING BIRDS: The vision for the shorebird and wading bird guilds is to maintain and restore healthy populations through habitat protection and restoration, and reduction is stressors. Shorebirds and wading birds will benefit from wetland, riparian, aquatic, and agricultural habitats restoration. Seasonal use of the North Bay and adjoining marshes by these birds should increase.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and North American Waterfowl Management Plan. Many resident and migratory waterfowl species will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the North Bay and adjoining marshes and, possibly, increases in some populations would be expected.

DELTA GREEN GROUND BEETLE: The vision for the Delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing their populations and abundance through habitat restoration.

Integration With Other Restoration Programs

Changing freshwater inflow patterns to the Bay, the major ecosystem process in the plan for the Delta, is a longstanding need; however, without developed supplies, the prescribed spring flow events and minimum freshwater inflows may not be available in all water-year types. In the short term, efforts will focus on providing the needed flows with available water supplies from the Central Valley Project (CVP) facilities at Shasta, Folsom, and New Melones Reservoirs using water prescribed by the Central Valley Project Improvement Act (CVPIA) and water purchased from willing sellers. The effectiveness of the water releases would be maximized through the use of tools such as water transfers. Property acquisitions with water rights from willing sellers are also a tool for acquiring water. In the long term, additional water supplies may be needed to meet remaining environmental needs.

Much of the infrastructure to implement the vision for the marsh and bay already exists. Restoration will be implemented through these existing programs. In areas where no cooperative agency and stakeholder efforts are underway, such organizations can be developed to help implement the program. To be successful, the restoration program must help to coordinate existing restoration programs being undertaken by State and federal resource agencies.

The recommendations in this plan will coincide with numerous programs and projects to protect and restore the Bay-Delta estuary. These programs are described below.

San Francisco Bay Area Wetlands Ecosystem Goals Project

The San Francisco Bay Area Wetlands Ecosystem Goals Project is a comprehensive, science-based program which had developed recommendations regarding where and how much of the various types of wetland should be restored in the Suisun Bay and San Francisco Bay areas. Many of the goals that have been presented are consistent or enhance the ERPP prescriptions to improve the ecological health of processes, habitats, and species in this ecological management zone.

San Francisco Estuary Project

The San Francisco Estuary Project has four goals to restore the physical, chemical, and biological integrity of the San Francisco Bay-Delta Estuary:

- protect existing wetlands,
- restore and enhance the ecological productivity and habitat values of wetlands,
- expedite a significant increase in the quantity and quality of wetlands, and
- educate the public about the values of wetland resources.

Central Valley Project Improvement Act

Restoring and maintaining ecological processes and functions in the Suisun Marsh and North Bay Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. With the CVPIA program, the Anadromous Fish Restoration Program (AFRP) of the U.S. Fish and Wildlife Service (USFWS 1997) has a goal to double the natural anadromous fish production in the system over the average production during 1967 through 1991. CVPIA authorized dedicating and managing 800,000 af of CVP yield annually to implement the fish, wildlife, and habitat restoration purposes and measures that include water purchased for inflow to and outflow from the Delta. The CVPIA AFRP includes provisions for restoring habitat and reducing stressors, such as unscreened water diversions.

Recovery Plan for Sacramento-San Joaquin Delta Native Fishes

The scope of the plan includes San Francisco Bay and the Delta. The intent is to promote conservation of the ecosystems on which the native fishes, such as chinook salmon, delta smelt, longfin smelt, splittail, and Sacramento perch, depend. The plan outlines a strategy for restoration, including actions, The goals, strategies for recovery, and programmatic actions presented in the plan have been adopted by the ERPP. The plan includes targets for populations, habitat restoration, structural changes, and Delta outflow to the Bay that have been included in the ERPP. Important recovery actions in this plan include placing the 2 parts per thousand isohaline (X2 SWRCB standard) at Roe Island, Chipps Island, or at the confluence of the Sacramento-San Joaquin rivers at Collinsville. Suitable placement of the 2 parts per thousand isohaline is key to providing adequate shallow water habitat for delta smelt, longfin smelt, and splittail.

Recovery Plan for Salt Marsh Harvest Mouse and California Clapper Rail

The recovery plan for the salt marsh harvest mouse and clapper rail focuses on protecting existing marshes, creating new marsh habitat with unrestricted tidal sloughs, pickleweed habitat for mice, and suitable nesting habitat for the rail. This recovery plan, prepared and approved in 1984, is being revised by the USFWS. The goals and objectives that are being developed in the revised recovery plan may lead to corresponding adjustments in ERPP targets and programmatic actions.

Suisun Marsh Management and Protection Plans

The Suisun Marsh Management Plan was mandated by the Suisun Marsh Preservation Act of 1977. Its goal is to maximize waterfowl food production while maintaining a diverse marsh flora capable of supporting the present wide variety of wildlife in the marsh. The plans were developed to mitigate (avoid, reduce, or compensate for) the effects on the marsh of the federal Central Valley Project and State Water Project. Though the plan's focus is to manage diked wetlands, plan elements are consistent with ERPP objectives and targets. A primary management area, consisting of 58,000 acres of tidal and managed wetlands, and secondary management areas of 28,000 acres of grasslands, have been identified for management and protection. Restoring tidal wetlands and sloughs in Suisun Marsh will be consistent with Suisun Marsh Management Plan goals.

Interagency Ecological Program Suisun Ecological Workgroup

The Suisun Ecological Workgroup (SEW) was convened at the request of the State Water Resources Control Board as a component of the "Program of Implementation" in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. SEW is and ad hoc multi-agency/organization work group whose goal is to review the scientific basis for the current salinity standards in Suisun Marsh and make recommendations for comprehensive brackish marsh standards. The primary goals of the SEW are: (1) characterize the brackish water ecosystem for Suisun Marsh, (2) evaluate the effects of existing Western Suisun Marsh water quality standards on beneficial uses, (3) determine and recommend appropriate resource-specific standards, (4) recommend narrative standards for tidal wetlands, (5) assess impacts of implementing appropriate resources-specific standards on other resources, (6) develop appropriate multi-resource (ecosystem) water quality standards, (7) consider alternative models, and (8) recommend future studies and compliance monitoring programs.

Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture is a component of the USFWS's North American Waterfowl Management Plan, with funding and cooperative project participation by federal, State, and private agencies. New funding sources including CALFED restoration funds, are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes Suisun Marsh. Objectives include protecting wetlands by acquiring fee-title or conservation easements and enhancing waterfowl habitat in wetlands and agricultural lands. Joint Venture objectives and targets have been adopted by the ERPP.

Recovery Plan for the Sacramento River Winter-Run Chinook Salmon

The winter-run recovery plan is being prepared and will be implemented by the Nation Marine Fisheries Service (NMFS). The draft plan includes recommendations for improving riparian and tidal marsh habitats in the Bay and Delta. ERPP objectives and targets are consistent with those of the recovery plan.

San Francisco Estuary Project Comprehensive Conservation and Management Plan

The San Francisco Estuary project's (SFEP's) purpose is to promote effective management of the Bay-Delta estuary and restore and maintain the estuary's water quality and natural resources. There are eleven programs within the management plan, including wetland management and habitat restoration in the North Bay stream watersheds. Programs include protecting remnant stream habitats and restoring shaded riverine aquatic habitats. Objectives include restoring and creating habitats, including tidal saltmarsh and adjacent upland habitats. A plan is being developed for managing the San Francisco Bay National Wildlife Refuge. Many SFEP and CCMP objectives and targets are included in the ERPP.

Agreement on San Joaquin River Protection

In an effort to resolve issues brought forth in the State Water Resources Control Board's 1995 Water Quality Control Plan for the Bay/Delta, the San Joaquin River Tributaries Association, San Joaquin River Exchange Contractors Water Authority, Friant Water Users Authority, and the San Francisco Public Utilities Commission collaborated to identify feasible, voluntary actions to protect the San Joaquin River's fish resources. In spring 1996, these parties agreed on a "Letter of Intent to Resolve San Joaquin River Issues." This agreement, when finalized, has the potential of providing the following:

- higher minimum base flows,
- significantly increased pulse flows,
- installation and operation of a new fish barrier on the mainstem San Joaquin River,
- set up a new biological monitoring program, and
- set aside federal restoration funds to cover costs associated with these measures.

One of the important components of the Agreement is the development of the Vernalis Adaptive Management Program (VAMP) to improve environmental conditions on the San Joaquin River. Elements of this potential adaptive management program include a range of flow and non-flow habitat improvement actions throughout the watershed, and an experimental program designed to collect data needed to develop scientifically sound fishery management options for the future.

CALFED Bay-Delta Program

CALFED has funded seven ecosystem restoration projects in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Two projects screen diversions for managed wetlands on the Suisun Marsh and three restore habitat. A project by the Central Costa County Sanitary District discourages pesticide use by encouraging homeowners to use integrated pest management techniques.

Linkage to Other Ecological Management Zones

Restoration efforts in all Ecological Management Zones upstream of the Suisun Marsh and North San Francisco Bay will contribute to the health and recovery of this zone. Likewise, efforts in this zone will contribute to the health of the Delta and salmon and steelhead population recovery in the Sacramento and San Joaquin River basins.

Successfully realizing the vision for this Ecological Management Zone depends, in part, on achieving targets in the Sacramento-San Joaquin Delta, Sacramento River, Eastside Delta Tributaries, and San Joaquin River Ecological Management Zones. These include targets associated with restoring streamflow processes, reducing contaminants, and improving and increasing riparian and wetland habitats. Efforts toward achieving targets in these zones should interact to restore important rearing habitat, reduce the introduction of contaminants, and control the introduction of non-native aquatic species. For example, essential for meeting the Bay freshwater inflow prescriptions are efforts to meet the individual flow prescriptions for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers. Aquatic, riparian, and wetland corridors in the Delta are also directly linked and integral to habitat corridors in Suisun and San Pablo Bays.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflow (Freshwater Inflow)

Target 1: More closely emulate the natural seasonal freshwater inflow pattern to North San Francisco Bay to:

- transport sediments,
- allow upstream and downstream fish passage,
- contribute to riparian vegetation succession,
- permit transport of larval fish to the entrapment zone,
- maintain the low salinity zone in Suisun Bay, and
- provide adequate attraction flows for upstream, through-Bay migrating salmon.

Delta outflow in dry and normal years will be improved by coordinating releases and natural flows in the Sacramento River Basin to provide a March flow event of at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal years, and at least 40,000 cfs for 10 days in above-normal years. The existing smaller, late-April and early-May flow event will be improved with additional water releases from San Joaquin River and Delta tributaries to provide flows of magnitudes and durations similar to those prescribed for March (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to provide target flows in dry and normal years by allowing inflows to major storage reservoirs, prescribed in the visions of upstream Ecological Management Zones, to pass downstream into and through the Delta. (This action would result from an accumulation of recommendations for spring flow events and minimum flows from upstream Ecological Management Zones.)

RATIONALE: *Restoring freshwater flows into Suisun Marsh/North San Francisco Bay Ecological Management Zone consistent with natural hydrologic conditions in the Bay-Delta watershed will help restore fundamental ecosystem processes and functions for the North Bay's aquatic and wetland resources. Increasing spring freshwater inflows will benefit the Bay and help move outmigrating juvenile chinook salmon and steelhead through the Bay toward the ocean. Spring plankton blooms in the North Bay, stimulated by freshwater outflow, support the North Bay's functions as a primary nursery ground for many important fish and crustacean species. These include chinook salmon, striped bass, delta smelt, splittail, Pacific herring, starry flounder, northern anchovy, Dungeness crab, several species of Bay shrimp, and many species of planktonic and benthic invertebrates that make up the Bay's foodweb. Spring freshwater flows also stimulate tidal emergent marsh productivity by providing necessary nutrients and sediments. Freshwater inflows of 20,000 to 40,000 cfs in dry and normal years, compared to the existing 10,000 to 30,000 cfs, would ensure that the low salinity zone of the estuary and X2 would be located well downstream in Suisun Bay, especially in dry years, and allow some fresh water to reach San Pablo Bay through tidal circulation and mixing. (Note: the location of X2 is the distance from the Golden Gate Bridge to the point at which the daily average salinity is 2 parts per thousand (ppt) at the bottom.)*

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Expand the floodplain area in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units by putting approximately 10% of leveed lands into the active floodplain (◆◆◆).

PROGRAMMATIC ACTION 1A: Convert leveed lands to tidal wetland/slough complexes.

RATIONALE: *Restoring approximately 10% of existing leveed lands to tidal action and floodflows will greatly enhance the floodwater and sediment retention capacity of the area and contribute nutrients for the aquatic foodweb.*

BAY-DELTA AQUATIC FOODWEB

TARGET 1: Increase primary and secondary nutrient productivity in the Suisun Marsh/North San Francisco Bay to levels historically observed in the 1960s and early 1970s (◆◆).

PROGRAMMATIC ACTION 1A: Actions described to restore streamflow, floodplains, tidal wetlands and sloughs, and riparian habitat would increase primary and secondary productivity in the Suisun and North San Francisco Bay areas.

PROGRAMMATIC ACTION 1B: Implement an expanded aquatic foodweb research program to better understand the linkage of adjacent and transitional wetland habitats and the aquatic foodweb.

RATIONALE: *Increasing the area of tidal wetland/slough habitat will increase primary and secondary productivity. More flooding of floodplains will provide more nutrients and organic carbon inputs.*

HABITATS

GENERAL RATIONALE

Restoring tidally influenced wetlands are an essential focus of restoration efforts in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Habitats of particular interest include tidal perennial aquatic habitat, saline emergent wetlands, and tidal slough habitat. Restoration of these habitats will require a mosaic of habitats including adjacent habitats that need to be comprised of seasonal wetlands, non-tidal perennial aquatic habitats, perennial grasslands, and riparian habitats. Restoration targets were set with the realization of the difficulty in locating lands for restoration. In the Suisun Marsh, for example, the restoration of tidally influenced habitats will likely require the conversion of existing managed wetlands. The conversion of these existing freshwater wetlands will be offset to the extent possible by restoring existing degraded wetland habitats and by improvement to existing unmanaged wetlands. Likewise, in the San Pablo Bay Ecological Management Unit, restoration of habitat will be constrained by the fact that the area is characterized by open bay and intertidal flats with very limited opportunities for restoration of other shallow water habitat types.

TIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Restore 1,500 acres of shallow-water habitat in the Suisun Marsh/North San Francisco Bay Ecological Management Zone (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire and restore 1,500 acres of shallow-water habitat in the Suisun Bay and Marsh Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to evaluate the feasibility of restoring shallow-water habitat in the San Pablo Bay Ecological Management Unit.

RATIONALE: *Restoring, improving, and protecting high-quality, shallow-water habitat will provide foraging habitat for juvenile fish in this Ecological Management Zone. These areas typically provide high primary and secondary productivity and support nutrient-cycling functions that can sustain high-quality foraging conditions. Opening new areas to tidal flows will also help restore a more natural tidal action to the Bay-Delta. These tide-influenced areas also provide high-quality foraging habitat for waterfowl that use mudflat or submergent vegetation growing in shallow water and diving ducks, such as canvasback and scaup, that consume clams in these areas (Fris and DeHaven 1993, Brittain et al. 1993, Stuber 1984, Schlosser 1991, Sweetnam and Stevens 1993, San Francisco Estuary Project 1992a, U.S. Fish and Wildlife Service 1996, and Lindberg and Marzuola 1993).*

Restoration of shallow water habitat in the San Pablo Bay Ecological Management Unit may not be possible as the unit is characterized by open bay and intertidal flats. No lands may be available for restoration.

Development of shallow water habitats in the North Bay will require large-scale tidal restoration to expand and maintain third through fifth order slough channels. Larger sloughs provided the shallow water habitat which existed under historic conditions in the North Bay. Acquiring and restoring diked subsided lands will create shallow water habitats in the short-term. Sedimentation will occur over the long-term and the area will develop into a saline emergent marsh. This objective is probably only achievable in the Napa River, Sonoma Creek, and Petaluma River Ecological Management Units.

NONTIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Develop 1,600 acres of deeper (3-6 feet deep) open-water areas to provide resting habitat for water birds, foraging habitat for diving ducks and other water birds that feed in deep water (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire and develop 400 acres of deeper open-water areas adjacent to restored saline emergent wetland habitats in the Suisun Bay and Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to acquire and develop 400 acres of deeper open-water areas adjacent to restored saline emergent wetland habitats in each the Napa River, Sonoma Creek and Petaluma River Ecological Management Units (1,200 acres total).

RATIONALE: *Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife species will increase the overwinter survival rate of these populations. Other water-associated wildlife species will also benefit (Madrone Associates 1980).*

TIDAL SLOUGHS

TARGET 1: Restore slough habitat for fish and associated wildlife species. Restore 5 miles of slough habitat in the near-term, and 10 miles in the long-term, in the Suisun Bay and Marsh Ecological Management Unit. Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Napa River Ecological Management Units. Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Sonoma Creek Ecological Management Units. Restore 10 miles of slough habitat in the near-term, and 20 miles in the long-term, in the Petaluma River Ecological Management Units (◆◆).

PROGRAMMATIC ACTION 1A: In association with wetland/marsh restoration efforts, construct sloughs in marsh/slough complexes by acquiring land and purchasing easements.

RATIONALE: *Restoring, improving, and protecting slough habitat in the units of the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help sustain high-quality shallow-water habitat that provides spawning habitat for native fish and foraging habitat for rearing juvenile fish. Restoring sloughs, along with tidally influenced freshwater areas and saline emergent marsh, will provide spawning habitat for native fish and foraging habitat for rearing juvenile fish; contribute to high levels of primary and secondary productivity; and support nutrient-cycling functions that can sustain high-quality foraging conditions. These sloughs can also provide resting sites for waterfowl and habitat for the western pond turtle (Simenstad et al. 1992, Lindberg and Marzuola 1993, and Madrone Associates 1980). Tidal sloughs can also provide important loafing sites for waterfowl, particularly diving ducks in the North Bay. The miles of targeted sloughs represent a reasonable restoration level as indicated by maps available from the early 1900s and existing configurations in the Ecological Management Units.*

In general, tidal slough restoration should be associated by tidal marsh restoration. Sloughs are a function of the marshes they traverse. The acreage of marsh and soils, sediments, hydrodynamics will limit the amount of tidal marsh that can be restored. These sloughs can also provide loafing sites for waterfowl, particularly diving ducks in the North Bay.

SALINE EMERGENT WETLANDS

TARGET 1: Restore tidal action to 5,000 to 7,000 acres in the Suisun Bay and Marsh Ecological Management Unit; 1,000 to 2,000 acres in the Napa River Ecological Management Unit; 500 to 1,000 acres each in the Sonoma Creek, Petaluma River, and San Pablo Bay Ecological Management Units (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire, in fee-title or through a conservation easement, the land needed for tidal restoration, and complete the needed steps to restore the wetlands to tidal action.

TARGET 2: Protect 6,200 acres of existing saline emergent wetlands in the Suisun Bay and Marsh Ecological Management Zone.

PROGRAMMATIC ACTION 2A: Develop a cooperative program to acquire, in fee-title or through a conservation easement, existing wetlands subject to tidal action.

TARGET 3: Restore full tidal action to muted marsh areas along the north shore of the Contra Costa shoreline.

PROGRAMMATIC ACTION 3A: Develop a cooperative program to evaluate, acquire, in fee-title or through a conservation easement, and restore existing muted wetlands to full tidal action.

RATIONALE: *Restoring tidally influenced saline marsh in this Ecological Management Zone will contribute to increasing levels of primary and secondary productivity and support nutrient-cycling functions that can sustain high-quality foraging conditions (Lindberg and Marzuola 1993, Miller 1993, Simenstad et al. 1992). Increasing the area occupied by saline tidal marsh in each Ecological Management Unit will help support the proper aquatic habitat conditions for rearing and outmigrating juvenile chinook salmon, steelhead, and sturgeon and rearing delta smelt, striped bass, and splittail. Restoring high-quality saline marshes, both tidal and nontidal, will contribute to nutrient cycling, maintaining the foodweb, and supporting enhanced levels of primary and secondary production. Increasing the area occupied by nontidal saline marsh will contribute to subsidence control and island accretion (growth) efforts. Permanent saline marsh can help arrest and, in some cases, reverse subsidence where peat oxidation has lowered land elevations to more than 15 feet below sea level. Increasing the area occupied by saline marsh will contribute to an ecosystem that can accommodate sea-level rise and provide a more natural tidal pattern and associated benefits to the foodweb and water quality of the Bay and Delta. Habitat conditions for wetland-associated wildlife will be improved.*

The targets for saline emergent wetlands will probably be achieved or even exceeded by several ongoing programs. These include activities to restore saline emergent wetlands which are contained within land acquisition programs by the U.S. Fish and Wildlife Service and Department of Fish and Game.

SEASONAL WETLANDS

TARGET 1: Assist in protecting and enhancing 40,000 to 50,000 acres of existing degraded seasonal wetland habitat in the Suisun Bay and Marsh Ecological Management Unit per the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. (◆◆◆).

PROGRAMMATIC ACTION 1A: Support the cooperative program to improve management of up to 26,000 acres of degraded seasonal wetland habitat in the of the Suisun Bay and Marsh Ecological Management Unit.

PROGRAMMATIC ACTION 1B: Support the development of a cooperative program to improve management of up to 32,000 acres of existing seasonal wetland habitat in the Suisun Bay and Marsh Ecological Management Unit.

TARGET 2: Acquire and convert 1,000 to 1,5000 acres of existing farmed baylands in the Suisun Marsh to seasonal wetlands.

PROGRAMMATIC ACTION 2A: Develop a cooperative program to acquire, in fee-title or through a conservation easement, existing farmed baylands and restore tidal action.

RATIONALE: *Restoring wetland and riparian habitats in association with aquatic habitats is an essential restoration strategy element for this*

Ecological Management Zone. This restoration is fundamental to supporting the foodweb and enhancing conditions for rearing chinook salmon, steelhead, sturgeon, juvenile delta smelt, striped bass, and splittail. Foodweb support functions for wildlife will also benefit (Cummins 1974, Brostoff and Clark 1992).

Seasonal wetlands can help reduce concentrations and loads of pesticide residues in water and sediments, which help to reduce sublethal and long-term impacts of specific contaminants for which it is difficult to conclusively document population-level impacts. Modifying agricultural practices and land uses on a large scale will reduce the concentrations of pesticide residues through a combined approach. This approach involves reducing the amount of pesticide applied and the amount reaching aquatic Suisun Marsh and San Francisco Bay habitats. This will be done by biological and chemical processes in wetland systems that break down harmful pesticide residues. Improved inchannel flows in this Ecological Management Unit resulting from seasonal reductions in water use and enhanced environmental water supplies will also help to reduce contaminant concentrations (San Francisco Estuary Project 1992a).

Restoring high-quality freshwater marsh and brackish marsh, both seasonal and permanent, will increase the production and availability of natural forage for waterfowl and other wildlife. It will increase the overwinter survival rates of wildlife populations in this Ecological Management Zone and improve their body condition before they migrate. As a result, breeding success will be improved. Managing these habitats will also reduce the amount and concentrations of contaminants that could, upon entering the sloughs, interfere with efforts to restore aquatic ecosystem health.

Target 1 "enhance 40,000 to 50,000 acres of degraded seasonal wetland habitat" is consistent with the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. Programmatic Action 1A "enhance 26,000 acres of degraded seasonal wetland habitat" is already being implemented by Ducks Unlimited as part of a grant through the North American Wetlands Conservation fund. The intent of the ERPP is to remove the levees of some managed wetlands to allow the restoration of tidally influenced habitats and expand the acreages of wet meadows or pastures. The greatest need to restore where possible, tidal wetland areas. This may result in a need to replace any losses of managed wetlands by creating additional wetland areas. However, there may not be area for any additional acres of managed wetlands as the majority of agricultural lands have already been converted to managed wetlands. For example, the following figures provided by the Suisun Resource Conservation District display the possible difficulty in creating additional managed wetlands.

Existing Land Use	*Existing Acreage*
managed wetlands	*52,000 acres*
unmanaged tidal wetlands	*6,300 acres*
bays and sloughs	*30,000 acres*
uplands and grasslands	*27,700 acres*

VERNAL POOL

TARGET 1: Protect and manage vernal pools in the Suisun Bay and Marsh Ecological Management Unit that provide suitable habitat for listed fairy shrimp species, the Delta green ground beetle, and special-status plant species to assist in these species' recovery (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire and manage 100 acres of vernal pools and 500 to 1,000 acres of adjacent buffer areas

TARGET 2: Restore vernal pools that have been degraded by agricultural activities to provide suitable habitat for special-status invertebrates and plants and amphibian, such as the spadefoot toad, to assist in the recovery of these populations (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore the quality of vernal pools and their adjacent habitats.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential restoration strategy element for the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Restoring this habitat mosaic on a large scale will help restore ecosystem processes and functions and provide additional protection to listed species associated with this habitat type.*

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Restore 10 to 15 linear miles of riparian habitat along riparian scrub and shrub vegetation corridors in each Ecological Management Unit. In this restored habitat, 60% should be more than 15 yards wide, and 25% should be no less than 5 yards wide and 1 mile long (◆◆◆).

PROGRAMMATIC ACTION 1A: Coordinate with landowners and managers to restore and maintain 10 to 15 linear miles of riparian habitat along corridors of riparian scrub and shrub vegetation in each Ecological Management Unit. Of this, 60% should be more than 15 yards wide, and 25% should be no less than 5 yards wide and 1 mile long.

RATIONALE: *Many wildlife species, including several species listed as threatened or endangered under the State and federal Endangered Species Acts (ESAs) and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian scrub and shrub will help provide needed escape cover for these species during high-flow periods. Riparian vegetation in the western portion of the Suisun Marsh/North San Francisco Bay Ecological Management Zone is limited by water salinity. Riparian restoration will most likely occur in the upper reaches of the Ecological Management Units in areas that may be tidally influenced but which have low salinity.*

ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Delta ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of rivers and streams and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

PERENNIAL GRASSLANDS

TARGET 1: Restore 1,000 acres of perennial grasses in each Ecological Management Unit associated with existing or proposed wetlands (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore perennial grasslands by acquiring conservation easements or purchasing land from willing sellers.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential restoration strategy element for this Ecological Management Zone. Eliminating fragmentation and restoring connectivity will enhance habitat conditions for special-status species, such as the Suisun song*

Table 5: Summary of ERPP Habitat Restoration Targets and Programmatic Actions for the Suisun Marsh/ North San Francisco Bay Ecological Management Zone.

Habitat Type	Suisun Bay and Marsh	Napa River	Sonoma Creek	Petaluma River	San Pablo Bay	Total
Tidal Perennial Aquatic	1,500	0	0	0	Feasibility study	1,500 acres
Nontidal Perennial Aquatic (deep, open water)	400	400	400	400	0	1,600 acres
Tidal Sloughs (short-term)	5 miles	10 miles	10 miles	10 miles	0	35 miles
Tidal Sloughs (long-term)	Additional 5 miles	Additional 10 miles	Additional 10 miles	Additional 10 miles	0	35 miles
Saline Emergent Wetland (restore)	5,000-7,000	1,000-2,000	500-1,000	500-1,000	500-1,000	7,500 -12,000 acres
Saline Emergent Wetland (protect)	to be determined (TBD)	TBD	TBD	TBD	TBD	6,200 acres
Seasonal Wetland (Protect existing)	40,000-50,000	0	0	0	0	40,000-50,000 acres
Seasonal Wetland (Restore)	1,000-1,500	0	0	0	0	1,000-1,500 acres
Vernal Pools	100	0	0	0	0	100 acres
Vernal Pool Buffer Area	500-1,000	0	0	0	0	500-1,000 acres
Riparian and Riverine Aquatic	10-15 miles	10-15 miles	10-15 miles	10-15 miles	10-15 miles	50-75 miles
Perennial Grassland	1,000	1,000	1,000	1,000	1,000	5,000 acres
Total acres of all habitats to be restored include tidal perennial, nontidal perennial saline emergent wetland, seasonal wetland, vernal pool and vernal pool buffer, and perennial grassland.						17,200-22,700 acres
Total acres of existing habitats to be protected and enhanced						46,200-56,200 acres
Total miles of tidal sloughs to be restored						70 miles
Total miles of riparian and riverine aquatic habitat to be restored						50-75 miles

sparrow, California black rail, and salt marsh harvest mouse. For instance, the habitats for these species have been degraded by the loss of adjacent, suitable escape cover that is needed by the salt marsh harvest mouse during periods of high flows or high tides. Fragmentation has also interfered with daily and seasonal migratory movements and genetic interchange within the population (Novick and Hein 1982).

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce entrainment losses of juvenile fish at diversions by 25 to 50% by installing positive-barrier fish screens on large diversion structures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to consolidate, screen, or eliminate diversions in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

RATIONALE: *Large diversions on the main channels of Suisun and San Pablo Bays and adjoining marsh/slough complexes entrain juvenile and small adult fish at rates that could be detrimental to the survival of species of special concern (Chadwick and Von Geldern 1964, 1974; Larkin 1979; and Erkkila et al. 1950). The reduction target reflects preliminary data indicating that entrainment through the smallest diversions on small channels might not pose a significant threat to the successful restoration of Bay-Delta health. The success of screening in the estuarine zone is difficult and dependent on critical protective operations and facilities. For example, bypass flows or bypass systems are needed to move target species away from the zone of influence and into areas safe from entrainment.*

INVASIVE AQUATIC PLANTS

TARGET 1: Manage existing and restored dead-end and open-end sloughs and channels within the Ecological Management Zone so that less than 1% of the surface area of these sloughs and channels is covered by invasive non-native aquatic plants (◆◆).

PROGRAMMATIC ACTION 1A: Conduct large-scale, annual weed eradication programs throughout existing and restored dead-end and open-end sloughs and channels in each Ecological Management Unit so that less than 1% of the surface area of these sloughs and channels is covered by invasive non-native aquatic plants within 10 years.

RATIONALE: *Invasive aquatic plants have altered ecosystem processes, functions, and habitats by modifying the foodweb and competing for nutrients, light, and space. Nesting birds are particularly vulnerable to increased predation from non-native ground-dwelling predators and competition from non-native nest parasites. Actions taken in the Suisun Marsh/North San Francisco Bay Ecological Management Zone to address this objective are prescribed primarily to enhance foodweb functions and improve habitat conditions for resident, estuarine, and anadromous fish and neotropical migratory birds. This can be accomplished, in part, by reducing the area inhabited by invasive non-native plants and by restoring large areas of optimal nesting habitat (Dudley and D'Antonio 1994, Anderson 1990, Zedler 1992, and Bay-Delta Oversight Council 1994).*

INVASIVE AQUATIC ORGANISMS

TARGET 1: Reduce or eliminate the influx of non-native aquatic species in ship ballast water (◆◆◆).

PROGRAMMATIC ACTION 1A: Fund additional inspection staff to enforce existing regulations.

PROGRAMMATIC ACTION 1B: Help fund research on ballast water treatment techniques that could eliminate non-native species before ballast water is released.

TARGET 2: Reduce the potential for influx of non-native aquatic plant and animal species at border crossings (◆◆◆).

PROGRAMMATIC ACTION 2A: Provide funding to the California Department of Food and Agriculture to expand or establish, as appropriate, a comprehensive program to exclude, detect, and manage invasive aquatic species, such as zebra mussel.

RATIONALE: *Every reasonable effort should be made to reduce the introduction of non-native organisms in the ballast water of ships that enter the Delta. Such organisms have greatly altered the zooplankton of the Delta over the past several decades. Further alteration could reduce the capacity of the Delta to support native fishes.*

Every reasonable effort should be made to reduce the introduction of non-native organisms at border crossings into California. Border inspections have already found zebra mussels, which, if allowed to enter Bay-Delta waters, could have devastating economic and ecological effects.

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce by 50% the area covered by invasive non-native woody species, such as giant reed and eucalyptus, that compete with native riparian vegetation, and eradicate invasive woody plants from restoration areas (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to remove and suppress invasive non-native plants that compete with native riparian vegetation by reducing the area occupied by these species (such as giant reed and eucalyptus) by 50%.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to eliminate invasive woody plants from restoration sites to protect native riparian vegetation.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to develop control measures for perennial pepperweed.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats by modifying the foodweb and competing for nutrients, light, and space (Dudley and D'Antonio 1994, Madrone Associates 1980, Bay-Delta Oversight Council 1994, Cross and Fleming 1989, and Zedler 1992).*

NON-NATIVE WILDLIFE

TARGET 1: Reduce red fox and feral cat populations in and adjacent to habitat areas suitable for California clapper rail, California black rail, and salt marsh harvest mouse.

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate means to reduce red fox and feral cat populations through trapping, relocation, fertility control, or other suitable measures.

PROGRAMMATIC ACTION 1B: Develop and implement a public education program that emphasizes the ecological value of maintain coyote populations.

RATIONALE: *The large-scale restoration of emergent wetlands, riparian habitat, and adjacent perennial grasslands will be the main focus of a strategy to reduce the adverse impacts of non-native wildlife on the health of the Bay-Delta ecosystem. The goal is a restored Bay-Delta and watershed where the quality, quantity, and structure of the restored habitat discourage colonization by non-native wildlife, provide a competitive advantage to native wildlife, and reduce the vulnerability of native species from predation by species such as the red fox and feral* *cat. A public education program to inform duck club owners of the ecological importance of native coyotes in the Suisun region may help prevent the potentially devastating spread of red fox further into the Suisun Marsh and Delta region. Coyotes are native to the region and tend to keep foxes from increasing their range.*

One of the most serious environmental problems facing California is the explosive invasion of non-native pest plants and animals. Non-native plants, wildlife, fish, and aquatic invertebrates can greatly alter the ecosystem processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife.

Many of these invasive species spread rapidly and form dense populations primarily by out-competing native species as a result of large-scale habitat changes that tend to favor non-native species and a lack of natural controls (e.g., natural predators). These non-native species usually have a competitive advantage because of their location in hospitable environments where the normal controls of disease and natural enemies are missing. As populations of non-native species grow, they can disrupt the ecosystem and population dynamics of native species. In some cases, habitat changes have eliminated connectivity of habitats that harbor the native predators that could help to limit populations of harmful non-native species.

PREDATION AND COMPETITION

TARGET 1: Limit striped bass supplementation to life stages that minimize predation on juvenile anadromous and estuarine fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide sufficient equipment, support staff, and operation and maintenance funds to hold juvenile striped bass longer so they can be planted at 2 years of age instead of 1 year.

PROGRAMMATIC ACTION 1B: Cooperatively develop an ecologically based approach to limit striped bass and chinook salmon stocking in the Bay to areas and periods that will not increase predation on special-status species, such as longfin smelt and delta smelt, and other native fishes.

RATIONALE: *Actions taken in this Ecological Management Zone are prescribed to protect populations of aquatic species, such as longfin smelt and delta smelt, from excessive predation rates caused by large concentrations of stocked hatchery-reared fish. Limited studies have shown that two-year-old striped bass have less of an impact on anadromous and estuarine fish than one-year-old striped bass.*

CONTAMINANTS

TARGET 1: Reduce the input of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife in the Suisun Marsh/North San Francisco Bay Ecological Management Zone (◆).

PROGRAMMATIC ACTION 1A: Support programs already in place to regulate the discharge of pollutants or reduce pollutant toxicity in Bay waters.

RATIONALE: *Reducing the concentrations and loads of contaminants, including hydrocarbons, heavy metals, and other pollutants, in the water and sediments of the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help reduce sublethal and long-term impacts of specific contaminants for which it is difficult to conclusively document population-level impacts. Reducing loading in urban runoff and modifying agricultural practices and land uses on a large scale will reduce pesticide residue concentrations through a combined approach. This approach involves reducing the amount of pesticide applied and the amount reaching the Bay's aquatic habitats. This will be done by biological and chemical processes in wetland systems that break down harmful pesticide residues. (Bay Delta Oversight Council 1994, Hall 1991, U.S. Fish and Wildlife Service 1996, San*

Francisco Estuary Project 1992b, Resources Agency 1976, Sparks 1992, Diamond et al. 1993, and Rost et al. 1989).

Improved inchannel flows in the Delta resulting from seasonal reductions in water use and enhanced environmental water supplies will also help to reduce concentrations (San Francisco Estuary Project 1992a). Health warnings have been issued regarding human consumption of fish and wildlife because of elevated levels of substances, such as mercury and selenium. Large-scale aquatic and wetland habitats restoration may help to resolve concerns about hydrocarbons, heavy metals, and other pollutants. Addressing point sources of concern, such as the oil refineries in Suisun and San Francisco Bays, and elevated releases of selenium resulting from refining oil from sources high in selenium, can be effective elements of a strategy to achieve the desired reductions.

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal anadromous fish and waterfowl harvest in Suisun Marsh and San Francisco Bay by increasing enforcement and public education (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide additional funding to California Department of Fish and Game (DFG) for additional enforcement.

PROGRAMMATIC ACTION 1B: Provide additional funding to county sheriff's departments and State and local park agencies to support additional enforcement efforts.

PROGRAMMATIC ACTION 1C: Provide rewards for the arrest and conviction of poachers.

PROGRAMMATIC ACTION 1D: Develop and implement a public outreach/education program regarding the illegal harvest.

RATIONALE: *Actions taken to reduce stressors in this Ecological Management Zone are prescribed primarily to contribute to the recovery of aquatic species, such as winter-, spring-, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. These actions will also contribute to the recovery of species, such as Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake (U.S. Fish and Wildlife Service 1996, San Francisco Estuary Project 1992b, Bay-Delta Oversight Council 1993, and California Department of Fish and Game 1991).*

DISTURBANCE

TARGET 1: Reduce boat wakes near California clapper and black rail nesting areas in Suisun Marsh and San Francisco Bay from March to June to prevent destruction of nests and assist in the recovery of this listed species (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program with local agencies to establish and enforce zones prohibiting boat wakes within 50 yards of California black rail nesting areas in Suisun Marsh and San Francisco Bay from March to June.

PROGRAMMATIC ACTION 1B: Develop a cooperative program with local agencies to establish and enforce zones prohibiting motorized boats in 5 miles of dead-end channels in Suisun Marsh and San Francisco Bay from March to June.

PROGRAMMATIC ACTION 1C: Develop a cooperative program with local agencies to establish and enforce zones prohibiting motorized boats in new, small channels in restored tidal fresh emergent wetlands.

RATIONALE: *Clapper rail are particularly sensitive to disturbance and efforts to reduce jet ski traffic in critical areas for the rail would contribute to their recovery. Other actions taken to restore ecological processes and functions, increase and improve habitats, and reduce stressors in this Ecological Management Zone are* *prescribed primarily to contribute to the recovery of aquatic species, such as winter-, spring-, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. These actions will also contribute to the recovery of species, such as the black rail (Madrone Associates 1980, Schlosser 1991, San Francisco Estuary Project 1992a, U.S. Fish and Wildlife Service 1978, Schlorff 1991, and Resources Agency 1976).*

References Used to Develop the Vision for the Suisun Marsh/North San Francisco Bay Ecological Management Zone

Anderson, L. W. J. 1990. Aquatic weed problems and management in North America. Pages 371-405 in H. Pieterse and K. J. Murphy (eds.). Oxford University Press. New York, NY.

Bay-Delta Oversight Council. 1993. Draft briefing papers on biological resources of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

____________________. 1994. Draft briefing paper on introduced fish, wildlife and plants in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

____________________. 1994. Plant and wildlife resources, technical advisory committee. November.

Brostoff, W., and D. Clarke. 1992. Monitoring intertidal wetland establishment in the Pacific Northwest. Army Waterways Experiment Station. Wetlands Research Program Bulletin 2(3): 1-4.

California Department of Fish and Game. 1991. Final program environmental document: ocean sport fishing regulations (14 CCR 27.00-30.10).

Chadwick, H. K, and C. E. Von Geldern. 1964. The desirability of introducing white bass, *Roccus chrysops,* into California. (Administrative Report 64-11.) Inland Fisheries Branch.

____________________. 1974. Entrainment and thermal effects on mysid shrimp and striped bass in the Sacramento-San Joaquin Delta. In L. D. Jensen (ed.), Proceedings of Second Entrainment and Intake Screening Workshop. Cooling Water Research Project, John Hopkins University. Baltimore, MD.

Cummins, K. W. 1974. Structure and function of stream ecosystems. BioScience 24(11): 631-641.

Diamond, J. M., W. Bower, et al. 1993. Use of man-made impoundment in mitigating acid mine drainage in the North Branch Potomac River. Environmental Management 17(2): 225-238.

Dudley, T. L., and C. M. D'Antonio. 1994. Exotic species and sustainable ecosystem management. Page 307 in W. W. Covington and L. F. DeBano (technical coordinators), Sustainable ecological systems: implementing an ecological approach to land management. July 12-15, 1993. Flagstaff, AZ. (General Technical Report RM-247.) U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO.

Erkkila, L. F., J. W. Moffett, O. B. Cope, B. R. Smith, and R. S. Nielson. 1950. Sacramento-San Joaquin Delta fishery resources: effects of Tracy pumping plant and Delta Cross Channel. (Special Scientific Report, Fisheries No. 56.) U.S. Fish and Wildlife Service.

Fris, M. B., and R. DeHaven. A community-based Habitat Suitability Index model for shaded riverine aquatic cover, selected reaches of the Sacramento River system. February. U.S. Fish and Wildlife Service, Ecological Services, Sacramento Field Office.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

Hall, L. W., Jr. 1991. A synthesis of water quality and contaminants data on early life history stages of striped bass, *Morone saxatilis*. Reviews in Aquat. Sci. 4:261-288.

Larkin, P. A. 1979. Predator-prey relations in fishes: an overview of the theory. Pages 13-22 in Predator-prey systems in fisheries management. Sport Fishing Institute.

Lindberg, J. C., and C. Marzuola. 1993. Delta smelt in a newly-created, flooded island in the Sacramento-San Joaquin Estuary, Spring 1993. California Department of Water Resources. Sacramento, CA. Prepared by BioSystems Analysis (J-762).

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and U.S. Fish and Wildlife Service. December.

Novick, H., and R. Hein. 1982. Bolsa Chica—a coastal wetland restoration project. In M. Josselyn (ed.), Wetland restoration and enhancement in California. (NOAA-83042503). National Oceanic and Atmospheric Administration. Washington, DC.

Resources Agency. 1976. Sacramento-San Joaquin Delta master recreation plan. Sacramento, CA.

Rost, R. A., J. C. Brand, et al. 1989. Water quality and restoration of the Lower Oconto River, Oconto County, WI. (Technical Bulletin No. 164.) Wisconsin Department of Natural Resources. Madison, WI.

San Francisco Estuary Project. 1992a. Status and trends report on wildlife of the San Francisco Estuary. Prepared under cooperative agreement with U.S. Environmental Protection Agency (Job No. CE-009519-01-0) by the U.S. Fish and Wildlife Service.

_________________. 1992b. Status and trends report on aquatic resources in the San Francisco Estuary. Prepared under cooperative agreement with U.S. Environmental Protection Agency by B. H. Herbold, A. D. Jassby, and P.B. Moyle.

_________________. 1993. Comprehensive conservation and management plan. Prepared under cooperative agreement with the U.S. Environmental Protection Agency by the Association of Bay Area Governments.

Schlorff, R. 1991. Status of the Swainson's hawk. In 1991 annual report on the status of California state listed threatened and endangered animals and plants. California Department of Fish and Game.

Schlosser, I. J. 1991. Stream fish ecology: a landscape perspective. BioScience 41(10): 704-711.

Simenstad, C. A., J. R. Cordell, et al. 1992. Ecological status of a created estuarine slough in the Chehalis River Estuary: assessment of created and natural estuarine sloughs, Jan-Dec 1991. (WA FRI-UW-9305.) Fisheries Research Institute, University of Washington, Seattle.

Sparks, R. 1992. The Illinois River floodplain ecosystem. In National Research Council (ed.), Restoration of aquatic ecosystems:

science, technology, and public policy. National Academy Press. Washington, DC.

Stuber, R. J. 1984. Stemming the tide of coastal fish habitat loss: proceeding of a symposium on conservation of coastal fish habitat, Baltimore, Maryland, Mar 7-9. National Coalition for Marine Conservation. Savannah, GA.

Sweetnam, D. A., and D. E. Stevens. 1993. A status of the delta smelt *(Hypomesus transpacificus)* in California. Report to the Fish and Game Commission. Candidate Species Report 93-DS.

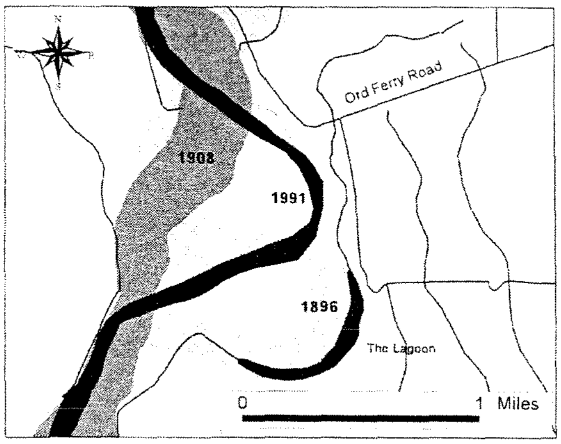
U.S. Fish and Wildlife Service. 1978. Concept plan for waterfowl wintering habitat preservation. Central Valley, California. Region 1. Portland, OR.

______________. 1996. Recovery plan for the Sacramento/San Joaquin Delta native fishes.

______________. 1997. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase the natural production of anadromous fish in the Central Valley of California. May 30, 1997.

Zedler, J. B. 1992. Invasive exotic plants in coastal wetlands. Biology Department, San Diego State University. San Diego, CA.

◆ Sacramento River Ecological Management Zone



Sacramento River channel south of Ord Ferry Bridge in 1896, 1908, and 1991 (Sacramento River Advisory Council, 1998).

Introduction

The health of the Sacramento-San Joaquin Delta is dependent on the rivers and streams that compose its watershed. They provide inflow, sediments, nutrients, spawning and rearing areas for many aquatic species, and riparian corridors that support neotropical bird and other terrestrial wildlife, such as western yellow-billed cuckoo and bank swallow, and invertebrate species. Many estuarine fish species and their foodweb depend on the input from the Sacramento River. The Sacramento River is the largest element of the Delta's watershed, providing about 80% of the inflow to the Delta.

The Sacramento River is also an essential spawning, rearing, and migratory pathway for many anadromous fish populations, such as winter-run, fall-run, late-fall-run, and spring-run chinook salmon, steelhead, white sturgeon, green sturgeon, lamprey, striped bass, and American shad. All of these populations must pass through the Delta and Bay during portions of their life cycle as they migrate to the ocean as juveniles and return as adults to spawn.

Ecological factors having the greatest influence on the anadromous fish in the Sacramento River include streamflow, coarse sediment supply (including gravel for fish spawning and invertebrate production), stream channel dynamics (meander), and riparian and riverine aquatic habitat. Stressors, including dams, legal and illegal harvest, high water temperature during salmon spawning and egg incubation, toxins from mine drainage, hatchery stocking of anadromous fish, and unscreened or poorly screened irrigation diversions, have affected the health of anadromous fish populations.

Description of the Management Zone

The Sacramento River flows more than 300 miles from Lake Shasta to Collinsville in the Delta, where it joins the San Joaquin River. It is a major river of the western United States and the largest and most important riverine ecosystem in the State of California. The river corridor encompasses more than 250,000 acres of natural, agricultural, and urban lands upstream of Sacramento. Various cropland habitats occur on flat and gently rolling terrain adjacent to most of this zone. Irrigated crops are mostly rice, grains, alfalfa, and orchard crops. Most of this cropland is irrigated with water diverted from the Sacramento River or its tributaries. Four National Wildlife Refuges (Sacramento, Delevan, Colusa and Sutter) are located either adjacent to or within 5 miles of the Sacramento River.

The Sacramento River Ecological Management Zone includes 242 miles of the mainstem Sacramento River from Keswick Dam near Redding to the American River at Sacramento. (The remaining 60 miles of the lower river downstream of Sacramento are included in the North Delta Ecological Management Unit.) The mainstem river planning area includes the river channel, gravel bars and vegetated terraces, the 100-year river floodplain, and the geologically defined band of historic and potential river migration (i.e., the meander belt). In the artificially narrow, leveed reach downstream of Colusa and extending to Sacramento, an approximately 1-mile-wide band of river alluvium and historic and potential forest land that borders the levees is also included in this Ecological Management Zone.

This Ecological Management Zone encompasses five Ecological Management Units:

- Keswick to Red Bluff Diversion Dam,
- Red Bluff Diversion Dam to Chico Landing,
- Chico Landing to Colusa,
- Colusa to Verona, and
- Verona to Sacramento.

The National Marine Fisheries Service (NMFS) has determined that critical habitat for the endangered Sacramento winter-run chinook salmon includes the entire Sacramento River from Keswick Dam, river mile (RM) 302 to the Golden Gate Bridge (NMFS 1993). The NMFS has also proposed that all Central Valley stream reaches that are accessible to steelhead be designated as critical habitat, except for the San Joaquin River and tributaries upstream of the Merced River confluence.

Other fish dependent on the Sacramento River Ecological Management Zone include spring-run chinook salmon, late-fall-run chinook salmon, fall-run chinook salmon, steelhead, lamprey, green sturgeon, white sturgeon, American shad, striped bass, American shad and a resident native fish community, including the Sacramento splittail. Due to declining populations sizes, many of these are species of special concern or listed under provisions of the state of federal endangered species acts. One of the important attributes of the zone is its riparian forest, which supports a variety of neotropical migrant bird species, the valley elderberry longhorn beetle, and many other

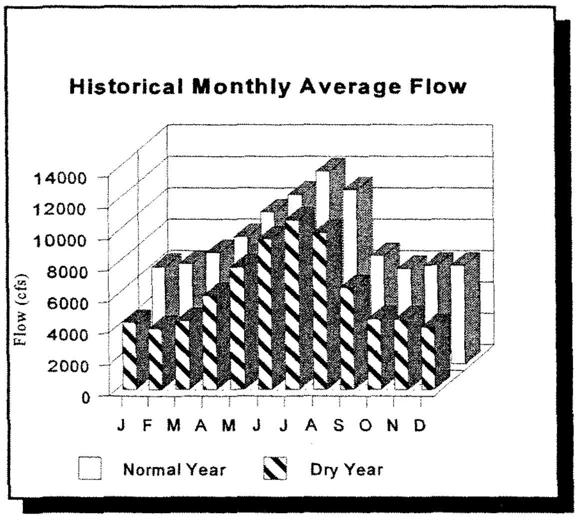
Listing Status of Sacramento River Species

Species	Status of Listing
Winter-run chinook	ESA: endangered CESA: endangered
Spring-run chinook	ESA: proposed endangered CESA: threatened
Late-fall chinook	ESA: proposed threatened
Fall-run chinook	ESA: proposed threatened
Steelhead	ESA: threatened
Green sturgeon	Species of Special Concern
Splittail	ESA: threatened
Bank swallow	CESA: threatened
Western yellow-billed cuckoo	CESA: endangered
Valley elderberry longhorn beetle	ESA: threatened

terrestrial species. The riparian vegetation is a significant contributor to the food web and large riparian forests effectively moderate air temperatures.

Sacramento River flow is controlled during much of the year by water releases at Keswick and Shasta dams. Tributaries, including many with no major storage dam, provide a significant quantity of flow accretion, particularly through winter and spring months. Prior to the construction of Shasta Dam, the river flows near Redding had a typical winter and spring high-flow period and a summer low-flow period. Dry-year flows typically reached a peak near a monthly average of 10,000 cubic feet per second (cfs) in March. In more normal years, peak flows reached approximately 20,000 cfs in March. Low summer flows averaged less than 5,000 cfs in dry and normal years.

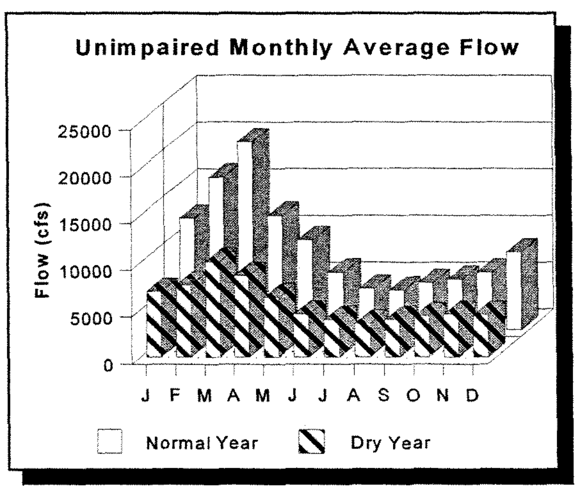
Since completion of Shasta and Trinity dams, streamflows in the Sacramento River have changed markedly. Late-winter and spring flows in dry and normal years are stored in reservoirs and released during the late-spring through fall irrigation season. In addition to flows released for irrigation in recent years, flows in excess of 10,000 cfs have been augmented to assist in controlling temperature for survival of winter-, spring, and fall-run chinook salmon spawning, egg incubation, and early rearing in the upper river.



Historical Streamflow below Keswick Dam, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Several water development and flood control projects have dramatically altered the river's natural flow regime, sediment transport capabilities, and riparian and riverine habitats. These projects include the Central Valley Project (CVP), which consists of Shasta, Keswick, and Whiskeytown dams and Red Bluff Diversion Dam (RBDD). They also include the Sacramento River Flood Control Project, which extends 180 miles south from Chico Landing and consists of a series of levees, weirs, and overflow areas, and the Chico Landing to Red Bluff Comprehensive Bank Stabilization Project, which is designed to control lateral river channel migration. This project is about 54% complete but has not been worked on since 1984. The State Water Project (SWP), consisting of Oroville Dam and the associated diversion works, has altered the flow regime below the confluence with the Feather River.

Natural sediments include fine suspended material that causes elevated turbidity to coarser materials that include gravel and cobbles. Bedload sediments also contribute to ecological health by absorbing energy of water and dampen the intensity of flood effects. Gravel recruitment is limited by dams blocking downstream gravel transport, bank protection, and gravel mining on tributaries. Deficiency in spawning gravels reduces the productive capacity of the river. This is especially true in the 15- to 20-mile river reach below Keswick Dam. Spawning gravel may be adequate to support present salmon and steelhead populations. As fish populations increase, gravel replenishment will be necessary. Natural gravel recruitment from tributary streams, particularly from Cottonwood Creek, needs to be protected to ensure that the gravel deficit does not increase. Spawning gravel needs protection from degradation caused by excessive silt entering the river from the tributaries. Watershed protection and comprehensive watershed management plans are needed in all the tributaries to reduce erosion of silts and sands that impair the quality of spawning gravels.



Unimpaired Streamflows below Keswick Dam, 1972-1992 (Dry year is the 20th percentile year; normal is the 50th percentile or median year.)

The Sacramento River and its tributaries above Shasta Dam have a cold temperature regime suitable for year round salmon spawning.

Although the salmon cannot access this reach of the ecosystem, the cold water can be managed using the reservoir and dam to replace the inaccessible upper portions of the watershed. Water temperature in the river is influenced by water releases from Shasta and Keswick dams in drought and consecutive dry or critically dry years. Low flows, combined with warmwater releases, cause the loss of many adult salmon and eggs spawned in the river.

Sacramento River temperature control and power generation requires the installation of a multilevel outlet structure on Shasta Dam and a minimum fall carryover storage in the reservoir of about 2 million acre-feet (MAF). Water temperature in the Sacramento River near Knights Landing can be improved by redirecting the Colusa Basin drain and other agriculture return water to a receiving water other than the Sacramento River or by reuse.

The Colusa Basin drain originates north of Willows in Glenn County. The drain captures waters from the two major diverters located on the west side of the Sacramento River, the Tehama-Colusa and Glenn-Colusa Irrigation districts in Glenn, Colusa, and Yolo counties. Much of the water conveyed through the drain is recaptured and reused before being discharged into the Sacramento River at Knights Landing near RM 90. The combined volume of the water delivered by the two districts can exceed 5,000 cfs during the peak of the irrigation season.

Water temperature is also affected by overhanging vegetation, which shades and moderates heat gain by the water. This shaded riverine aquatic (SRA) habitat has been significantly altered by bank protection and flood control projects. Reestablishing this edge vegetation would significantly improve SRA habitat, woody debris, and other riparian habitat along the Sacramento River, which, in turn, should improve production and survival of salmon and steelhead.

Historically, the riparian forest corridor along the river averaged 4 to 5 miles wide and encompassed a significantly large area. Today only 5% of the forests remain. One-third of the river length has natural banks and floodplain terraces; the other two-thirds have been modified and confined by levees, riprap, and flood control projects. These structures limit the dynamic forces that promote natural habitat succession and regeneration along the river. Channelization and bank protection between Red Bluff and the Delta eliminate and degrade many habitats by increasing the depth and velocity of flow and reducing the hydraulic and substrate diversity associated with more natural or undeveloped river systems. Bank protection also reduces the amount of fresh gravel and shaded riverine aquatic habitat normally available to the river through bank erosion.

Between Colusa and Red Bluff, natural riparian vegetation associated with the existing stream meander corridor plays a part in the natural floodplain process. In turn, the diversity of streamside vegetation and its overall condition are dependent on these same dynamic river processes. Riparian vegetation effectively creates a buffer to decrease local flood flow velocities. This increases deposits of suspended materials derived from eroding banks. This erosion-deposition process builds the midterrace and eventually the high-terrace lands that support climax forest and agriculture. Overbank flooding is essential for the continued health of the riparian system. As silt and seeds are deposited during these overbank water flow events, the native vegetation is rejuvenated.

The fragmentation of the remaining riparian habitat greatly diminishes its ability to support viable wildlife populations. This remaining habitat is being further degraded by human activity and adverse land uses. The combined loss, fragmentation, and deterioration of riparian habitat has caused, or is leading to, the extinction or elimination of several wildlife species. The drastic decline of the Swainson's hawk, once one of California's most abundant raptors, is in part a result of the loss of riparian nesting areas. In 1987, surveys documented such a low number of yellow-billed cuckoos, that the species appeared to be in danger of immediate extirpation. The elimination of the bank swallow appears likely if bank protection work continues and if mitigation measures are unsuccessful. Various other animal species and some plant species, including the Rose mallow, have population viability problems as a result of adverse human impacts on riparian habitat.

Reestablishing a viable riparian ecosystem along the upper Sacramento River region will increase the acreage and variety of riparian habitats and reverse the decline in wildlife, fishery, and human use values. The U.S. Fish and Wildlife Service (USFWS), the Wildlife Conservation Board (WCB), the National Audubon Society, The Nature Conservancy (TNC), and other private conservation groups are actively seeking to acquire conservation easements or fee ownership of high-priority riparian lands along the Sacramento River as a means to permanently save these lands.

More than 100 miles of the Sacramento River between Red Bluff and Colusa are wholly or partially intact as a dynamic alluvial river meander belt. Although about 20% of its banks are armored by riprap that protects levees and orchards, the river continues to erode its banks naturally and form new banks from gravel and sediment deposits on point bars and terraces. These fluvial geomorphic features support a time-dependent succession of young- and old-growth forest and wildlife habitat that requires 65 to 100 years to reach full maturity (climax succession to valley oak woodland). New sediment and gravel that sustain this process are supplied by a combination of eroding banks along the mainstem river and input from unregulated upstream tributaries. New fish habitat is continually created by migrating gravel riffles and deeper pools formed at bendways, and by mature trees and roots that overhang or topple into the channel as the river naturally erodes through older alluvial deposits supporting climax vegetation.

Improvements in the riparian and stream meander corridors along the Sacramento River are needed to improve spawning and early rearing habitat of splittail. Late-winter and early-spring streamflow improvements are needed to provide attraction flows for spawning adults and increased spawning habitat. Increasing flows in early spring also assists in successful migration of juvenile chinook salmon and steelhead.

Improved peak flows in late winter and early spring are needed to benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon.

All four races of chinook salmon require improved streamflows, gravel recruitment, water temperatures, riparian and riverine aquatic habitat, and stream meander corridors, and reduction in the adverse effects of stressors, such as high water temperatures, unscreened diversions, contaminants, and harvest.

Steelhead require improved streamflows and gravel recruitment in the upper river and improved water temperature and riverine habitat in the upper, middle, and lower reaches of the river. Restoring and maintaining natural flow patterns will benefit chinook salmon, but steelhead will benefit only if the natural flows also provide suitably cold water to support year round rearing of juvenile fish. Because of the placement of impassable dams on all major tributaries, approximately 82% to 95% of historical Central Valley steelhead habitat is now inaccessible (Yoshiyama et al. 1996) hence natural populations are mostly relegated to spawning and rearing in low elevation habitats that were historically used mostly as migration corridors. Because of increased summer and fall hypolimnetic releases from reservoirs, flow and temperature conditions in the late summer and fall periods in these reaches can be more beneficial to steelhead than before the dams were built, and small numbers of natural steelhead are able to sustain themselves in these tailwater habitats because of this. Inhospitable conditions in the lower reaches in the pre-dam years was not an overriding impact to steelhead because they had access to the cooler water habitats of the mid and high elevation tributaries.

Striped bass spawning in the Sacramento River is controlled by water temperatures. Fertilized striped bass eggs require sufficient stream flows and velocities to maintain the eggs in suspension.

Improvements in late-winter and spring streamflows and stream meander corridors are needed to benefit American shad spawning and rearing in the Sacramento River.

The yellow-billed cuckoo along the Sacramento River above the Delta is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be improved by improvements in riparian habitat areas that result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Sacramento River Ecological Management Zone, sustaining the river meander belt, and increasing the coarse sediment supply to support meander and riparian regeneration.

Specific restoration projects are not proposed for the bank swallow populations along the Sacramento River above the Delta. Potential habitat for bank swallows will be improved by sustaining the river meander belt, and increasing the coarse sediment supply to support meander and coarse sediment erosion and deposition processes.

Other problems in the Sacramento River affecting anadromous fish include poorly screened diversions, seasonal dams installed in rivers, small unscreened diversions, and a limited number of large diversions (>250 cfs). Two diversion dams operate on the river seasonally: Anderson-Cottonwood Irrigation District's (ACID) flashboard dam in Redding that diverts approximately 400 cfs and partially impairs the upstream and downstream migration of salmon and steelhead, and RBDD, the gates of which are in place from mid-May to mid-September to allow diversions up to 3,000 cfs into the Corning Canal and Tehama Colusa Canal. Both the dams and diversions have fish passage facilities and fish screens. Fish passage facilities are inadequate at both facilities, and the screen system at the ACID diversion is not adequate. Although predation problems associated with the dams have been lessened, they still occur.

All other water diversions along the river are shoreline diversions. The largest is GCID's Hamilton City Pumping Plant on an oxbow off of the Sacramento River. It diverts up to 3,000 cfs of water into the Glenn-Colusa Canal. Although many improvements have been made to its screening system, fish protection remains inadequate and improvement efforts continue. An environmental impact report is being prepared to describe actions involved in resolving the problem. In addition, hundreds of unscreened diversions located along the river operate primarily in the spring-through-fall irrigation season. Approximately 20 of these are large (>250 cfs). Efforts are presently being made in cooperation with the irrigators and resource agencies to screen these larger diversions.

The damage to fisheries and the riparian system associated with each of the problems in the upper river varies according to the type of water-year and water delivery operations. The diverse and cumulative nature of these variables requires a holistic remedy to achieve ecosystem restoration in the Sacramento River. The most important factors causing mortality are being addressed in various ways with interim or emergency actions. Fish passage over the 80-year-old ACID diversion dam must be improved. A feasibility study is being conducted to identify alternatives to achieve this goal. ACID canal operations need to be standardized to protect Sacramento River chinook salmon. This involves draining canal water through waste gates only on channels with fish barriers at their confluence with the river, limiting waste-gate releases to 5 or 10 cfs to minimize attraction of salmon from the river, and providing total containment of canal waters when toxic herbicides are present.

Fish passage at RBDD is a longstanding problem that has been partially solved through reoperation. This interim fix has constrained water diversion, and the longer term resolution needs to incorporate fish passage and survival and water delivery. There is the potential that the U.S. Bureau of Reclamation (Reclamation) research pumping facility at RBDD will allow "gates up" operation at RBDD from mid-September through mid-May and allow Reclamation to fulfill its water contract commitments. With the gates raised, fewer squawfish congregate below the dam, thereby reducing predation on juvenile salmon as they pass under the dam gates. This also provides unimpaired upstream and downstream migration for all anadromous fish in the river. During the period when the gates are open, the gravels in the reach immediately above the dam are available for chinook salmon and steelhead spawning, thereby, avoiding the need to compensate for its loss. Fish losses and delayed migration, however, will still occur during the 4 months the dam gates are lowered.

Natural stream meander, river and floodplain interactions, and riparian plant communities have been damaged by levees, bridges, bank protection, and other types of inchannel structures. Where feasible, natural stream meander should be allowed. To enhance this process, it is likely that riprap would be removed in specific areas formerly subject to bank protection activities. Bridge piers and abutments restrict stream channel processes. Long-term remediation of this problem might include future redesign to accommodate river meander when bridges across the Sacramento River are replaced.

Unnatural levels of predation typically occur in the Sacramento River near instream structures, such as diversion dams, bridge piers and pilings, and support structures for diversion pumps. These provide structure and shade which attract predators. This problem can be reduced in the long term by redesigning, removing, or reoperating these structures to minimize the creation of predator habitat, and by providing escape cover in the form of shaded riverine aquatic habitat.

Competition is primarily between naturally and hatchery produced fish and is typically for food and rearing area. The extent of adverse effects of the interaction between hatchery and natural fish has not been adequately investigated in the Central Valley, although Hallock (1987) reported that yearling steelhead released into Battle Creek consumed large numbers of naturally produced chinook salmon fry. Competition may be a suitable subject for focused research and adaptive management. In the interim, hatchery release strategies and schedules should be evaluated to determine opportunities to reduce or eliminate the potential for competition. Although the potential adverse effects of hatchery fish on wild stocks of salmon and steelhead have not been adequately investigated, there is every reason to expect adverse impacts in addition to competition including predation, interference with reproduction, increased fishing mortality due to mixing in the ocean fishery, disease introduction, loss of local adaptations, and genetic introgression. Hatchery operations should be evaluated and changed to minimize all these potential problems.

Harvest will remain an important element that influences the abundance of Central Valley anadromous fish populations. Harvest strategies need to emphasize the protection of naturally produced stocks with a focus on improving spawner returns for winter-run and spring-run chinook salmon and steelhead. Harvest has been severely restricted in recent years to maximize the return of winter-run chinook spawners, at a high economic cost to fishermen in terms of lost opportunities to harvest abundant fall-run chinook.

Improved management of anadromous fish populations, particularly chinook salmon and steelhead, requires the development and implementation of a comprehensive coded-wire tagging and recovery program for hatchery stocks. Data derived from these marking programs are important to assess the contributions of hatchery fish to the fisheries and escapements. Experimental studies can be designed to evaluate the interaction of hatchery and wild fish to that future management direction can be established.

In the interim, the annual production levels of each hatchery should be evaluated to ensure that the hatchery goals are consistent with ecosystem restoration and the recovery of listed species. In the longer-term, hatcheries should not produce fish at levels which exceed the mitigation requirements and other production goals.

Toxins from mine drainage on Spring Creek, enter the river by way of Keswick Dam and threaten survival of salmon and steelhead when sufficient dilution flows are not available from Shasta Lake. Recurrent non-point discharges of agricultural pesticides and herbicides occur, which may also adversely affect juvenile fish populations, other aquatic organisms, and riparian and riverine aquatic vegetation.

List of Species to Benefit from Restoration Action in the Sacramento River Ecological Management Zone

- splittail
- green sturgeon
- white sturgeon
- chinook salmon
- steelhead trout
- striped bass
- American shad
- western yellow-billed cuckoo
- bank swallow

Descriptions of Ecological Management Units

Keswick Dam to Red Bluff Diversion Dam Ecological Management Unit

The Keswick Dam to Red Bluff Diversion Dam reach (59 miles from RM 302 to RM 243) includes the mouths of Ash, Bear, Cow, Inks, Stillwater, Anderson, Battle, and Paynes creeks draining Mount Lassen, and of Spring, Clear, and Cottonwood creeks draining the Coast Range and Klamath Mountains. Much of the river in this reach flows through confined canyons, although portions have a broader floodplain. About 4 miles below Keswick Dam, the river widens to about 500 feet before entering the alluvial plains of the Sacramento Valley below Red Bluff. This reach includes much urbanized and residential river frontage, but is not contained by levees as is common on the downstream reach. More than 75% of naturally spawning chinook salmon in the Sacramento River use this reach, while the remaining spawners use the reach from RBDD to Princeton, near Colusa.

Red Bluff Diversion Dam to Chico Landing Ecological Management Unit

The Red Bluff Diversion Dam to Chico Landing Reach (49 miles from RM 243 to RM 194) includes the mouths of eastside tributaries of the Sacramento River that drain Mount Lassen and the northern Sierra Nevada, including Antelope, Mill, Deer, Pine, Rock, and Big Chico creeks. Westside streams that drain the upper valley and parts of the Coast Range include Elder and Thomes creeks. South of Red Bluff, the river meanders over a broad alluvial floodplain confined by older, more consolidated geologic formations (i.e., more cohesive deposits resistant to bank erosion). The extent of river floodplain and active channel meander belt from Red Bluff to Chico Landing has remained relatively unchanged and includes a significant amount of riparian forest and wildlife.

Chico Landing to Colusa Ecological Management Unit

The Chico Landing to Colusa reach (51 miles from RM 194 to RM 143) includes the mouth of Stony Creek and no other major tributaries. In this reach, most of the high flow during storm runoff events leaves the river along the east bank and enters the expansive floodplain of Butte Basin through three major flood relief outfalls at M&T Ranch, 3B's, and Parrot Ranch, and farther downstream through the Moulton and Colusa weirs near Colusa. Much of the river downstream of Chico Landing has been subject to flood control with an extensive system of setback levees, basin and bypass outflows, and streambank protective measures, such as riprap. However, considerable riparian forest remains within the levees along the active channel. Levees in this reach are 0.25 to 1.0 mile apart.

In the Butte Basin overflow segment, more extensive bank revetment projects installed during the past 30 years by landowners and the U.S. Army Corps of Engineers (Corps) attempt to halt natural channel migration by fixing the river in a static position. It was believed that natural channel migration and meander cutoff might alter flow splits that divert a major portion of river floodflow over three major weirs into Butte Basin, where flooding volumes pose less risk to levee overtopping. Recent hydraulic simulation studies of this reach appear to indicate that the river is somewhat self-adjusting to maintain similar Butte Basin overflow volumes despite specific meander cutoffs that may occur. However, bridge structures (e.g., Ord Ferry Bridge) may be more at risk to major adjustments of the channel position within the floodplain.

Colusa to Verona Ecological Management Unit

The Colusa to Verona reach (63 miles from RM 143 to RM 80) includes the mouth of Butte Creek at the Butte Slough outfall gate, but no significant tributary inflow until the Colusa Basin drain enters the river near Knights Landing at RM 90. In past years outflow at the Colusa Basin Drain has contributed to attraction of adult chinook salmon from their normal migratory pathway of the Sacramento River. Fish that stray into the Colusa Basin Drain are subject to stranding and loss from the spawning population. High flows leave the river by way of the Colusa and Tisdale weirs. Farther downstream, most flow from the Sutter Bypass/Butte Slough and Sacramento River leaves the river again at the 3-mile-long Fremont weir and flows down the Yolo Bypass to the Delta at Rio Vista. Most of the levees in this reach are built close to the main river channel, and little riparian forest or shaded riverine aquatic (SRA) habitat remains. Leveed banks are steep, with extensive riprap and routine removal of volunteer vegetation by local reclamation districts to maintain levee stability on the confined river channel. At the turn of the century, levees were built close to the banks to help move sediment down the river to prevent natural shoals that obstructed commercial river navigation reaching Colusa and Red Bluff. This unit is the most important spawning area for striped bass, and appropriate flow velocities and water temperatures are required for successful striped bass reproduction.

Verona to Sacramento Ecological Management Unit

The Verona to Sacramento Ecological Management Unit (20 miles from RM 80 to RM 60) includes important tributary inflow from the Feather River (and from Sutter Bypass and Butte Creek during high flows) at RM 80 and from the American River at RM 60. High-flow outfall from the rivers and Sutter Bypass enters the Yolo Bypass via the Fremont Weir. As with the upstream reach, most of the levees in this reach are built close to the main river channel, and little riparian forest or SRA habitat remains.

Vision for the Ecological Management Zone

The vision for the Sacramento River Ecological Management Zone is to improve, restore, and maintain the health and integrity of the Sacramento River riverine-riparian and tributary ecosystems to provide healthy conditions for sustainable fish and wildlife populations and the plant communities on which they depend.

The pathway to this vision is through preservation and restoration of erosional and depositional channel and floodplain forming processes, riparian and wetland habitats, spawning gravel recruitment, and reducing the extent and influence of stressors. It also includes managing streamflow and flow regime in ways that benefit ecosystem health. Restoring the health and integrity of the Sacramento River Ecological Management Zone will provide a productive and resilient foundation for the recovery of the Bay-Delta estuary and the associated fish, wildlife, and plant resources.

The main stem Sacramento River above Verona may be the most important sturgeon spawning and rearing habitat in the Central Valley, particularly in view of recent information regarding green sturgeon spawning in the river above Hamilton City.

In addition to the vision for the Sacramento River Ecological Management Zone, individual visions have been developed for ecological processes, habitats, stressors, species, and Ecological Management Units. These visions follow.

Visions for Ecological Management Units

Vision for the Keswick to RBDD Ecological Management Unit

The vision for the Keswick Dam to Red Bluff Diversion Dam Ecological Management Unit is to protect ecological processes where still intact; allow riparian forests to reach maturity; restore physical and successional processes; and protect and restore freshwater fish habitats that provide for migration, spawning, and rearing for chinook salmon and steelhead.

The potential activities include maintaining a flow pattern that emulates the seasonal hydrologic regime and provides adequate temperatures for rearing steelhead and winter-run chinook salmon to the extent possible while conserving the cool water pool in Shasta Reservoir. This must be done in consideration of the high level of development of water and flood storage in the upper section. Additional activities include cooperative efforts to restore some aspects of the natural hydrologic conditions of the upper Sacramento River. The Anadromous Fish Restoration Plan's (AFRP's) targets of 3,250 to 5,500 cfs from October 1 to April 30 are similar to the rates of unimpaired average flows. In addition to the AFRP base flow minimums, reservoir inflows should be released to the river to provide 8,000 to 10,000 cfs and 15,000 to 20,000 cfs flow events for approximately 10 days in March of dry and below normal years, respectively. Such flow events would support natural processes in the upper river, such as erosion, sediment transport and sediment deposition, and stream channel meander, that depend on natural flow regimes. In addition, this reach contains important year-round spawning and incubation habitat for anadromous salmonids.

The vision highlights the restoration of ecological processes that naturally create and sustain habitats needed to support and restore the endangered Sacramento winter-run chinook salmon, the threatened Central Valley steelhead, the threatened spring-run chinook populations; and species of special concern such as fall-run chinook, late-fall-run chinook, and green sturgeon. Important ecological functions of flow include maintaining and supplementing the natural stream meander and gravel recruitment processes, transporting and depositing sediment, protecting the limited riparian corridor, providing cool water for all species of fish, and preventing potential catastrophic fish losses resulting from an uncontrolled spill of toxic materials from Iron Mountain Mine (IMM) and Spring Creek debris dam overflows.

Because this Ecological Management Unit encompasses a significant portion of critical holding, spawning, and nursery area required by the endangered winter-run chinook salmon, most of the water diversions in this reach require positive-barrier fish screens installed to protect juvenile salmon and steelhead. A primary concern in this Ecological Management Unit is protecting and enhancing instream gravel resources supplied to the mainstem river by the tributaries.

Nursery areas for juvenile salmon would be improved by restoring or enhancing riparian and riverine aquatic vegetation throughout this unit, particularly in areas immediately up- and downstream of the mouths of some of the tributaries described above.

VISION FOR THE RED BLUFF TO CHICO LANDING ECOLOGICAL MANAGEMENT UNIT

The vision for the Red Bluff Diversion Dam to Chico Landing Ecological Management Unit is to protect and expand the quantity and quality of the stream meander corridor; protect the associated riparian forest and allow it to reach maturity; install positive barrier fish screens to protect young fish; maintain flows that emulate the natural hydrology to the extent possible; and recover or contribute to the recovery of threatened, endangered, and special concern species.

The existing meander belt should be protected and improved to sustain the riparian and riverine aquatic habitat component that is important habitat for winter-run chinook salmon and steelhead, other anadromous fish species, riparian forest dependent species, such as yellow-billed cuckoo, other neotropical migrant bird species, and the valley elderberry longhorn beetle. This reach also provides important spawning habitat for anadromous salmonids, particularly fall-run chinook salmon.

Restoring endangered species and species of special concern requires that water management activities be consistent with maintaining ecological processes. These include flows that emulate the natural hydrologic regime to the extent possible and are compatible with the high level of development of water in the upper section. Important considerations include flows needed to maintain natural stream meander processes, gravel recruitment, transport, deposition, and establishment and growth of riparian vegetation.

Because this Ecological Management Unit encompasses an important portion of critical nursery and emigration area required by the endangered winter-run chinook salmon, water diversions in the section will require positive-barrier fish screens to protect juvenile fish. In addition, recent research on non-natal rearing in secondary and ephemeral tributaries indicates that these streams are important rearing habitat and refuges for young chinook salmon and steelhead in the Sacramento River system.

The broad riparian corridors throughout the unit should be connected and should not be fragmented. These corridors connect larger blocks of riparian habitat, typically greater than 50 acres. The riparian corridors should generally be greater than 100 yards wide and would support increased populations of neotropical migrants, such as the yellow-billed cuckoo, and unique furbearers, such as the ring-tail and river otter. Species such as the bank swallow will benefit from the restoration of processes that create and maintain habitat within this unit.

Nursery areas for juvenile salmon should be improved through the restoration of waterside emergent and riparian vegetation throughout the unit and particularly up- and downstream of the mouths of some of the tributaries described above.

Vision for the Chico Landing to Colusa Ecological Management Unit

The vision for the Chico Landing to Colusa Ecological Management Unit is to improve habitat and increase survival of many important fish and wildlife resources by preserving, managing and restoring a functioning ecosystem that provides a mosaic of varying riparian forest age classes and canopy structure; maintaining a diversity of habitat types, including forest and willow scrub, cut banks and clean gravel bars, oxbow lakes and backwater swales with marshes, and floodplain valley oak/sycamore woodlands with grassland understory; maintaining uninterrupted gravel transport and deposition; supporting a complexity of shaded and nearshore aquatic substrate and habitats with well-distributed instream woody cover and organic debris; setting back levees; and the installing positive barrier fish screens.

Restoring endangered species and species of special concern requires that water management activities be consistent with maintaining ecological processes. These include flows that emulate seasonal patterns typical of the natural hydrologic regime, consistent with the high level of water development in the upper section. Important considerations include flows needed to maintain natural stream meander processes and gravel recruitment, transport and deposition, and maintenance of the limited riparian corridor in this section. A long-term goal would be to set back levees in this section consistent with flood control requirements. This important concept should be integrated into any future flood control planning efforts.

Closing gaps in the shoreline riparian vegetation and nearshore aquatic habitat will be accomplished by several means. These include natural colonization or active restoration of expanded floodplain along channels; reduction of vegetation management by local reclamation districts (consistent with flood control requirements); and enhancement of channel banks by modifying levees and berms to incorporate habitat structures, such as fish groins and low waterside berms that support natural growth and woody debris. However, in the long-term, it may be more beneficial and more cost effective to construct set back levees.

Important elements needed to attain the vision for this unit include specific processes that maintain high-quality habitat for chinook salmon and steelhead, as well as the other anadromous fish species. The continuance of the natural river migration within its meander zone is essential to create and maintain most of these habitats. A mix of solutions will be employed to reduce the need for future additional bank protection or separation of the channel from its floodplain. Floodplain management and detention measures that expand flood protection for valley residents by reducing peak flood stage within the leveed channel will also permit more undisturbed habitat to thrive within the river corridor. Measures will most likely include strategic levee setbacks, expanding flood basin outflow capacity, and new flood easements in basin lands that detain additional flood flows, thereby reducing river stage.

In this unit, broad riparian corridors should be interconnected with narrower corridors that are not subject to fragmentation. These corridors should connect larger blocks of riparian habitat, typically larger than 50 acres. These blocks should be large enough to support the natural cooling of the river by convection currents of air flowing from the cool, humid forests and across the river water. The wider riparian corridors should generally be greater than 100 yards wide to better support neotropical migrants, such as the yellow-billed cuckoo. Cavity-nesting species, such as the wood duck, and special-status species, such as the bank swallow, will benefit from restoring the processes that create and maintain habitat within this unit. The narrower corridors would be 10 to 25 yards wide.

Nursery areas for juvenile salmon should be improved by restoring waterside emergent and riparian vegetation throughout this unit.

Because this Ecological Management Unit encompasses a significant portion of the critical migration habitat required by the endangered winter-run chinook salmon, positive-barrier fish screens should be used at water diversions in this section to protect juvenile fish.

VISION FOR THE COLUSA TO VERONA ECOLOGICAL MANAGEMENT UNIT

The vision for the Colusa to Verona Ecological Management Unit is to improve habitat and increase survival of many important fish and wildlife resources; set back levees to improve conditions for riparian vegetation and limited stream meander; provide flows that emulate the natural flow patterns; and install positive barrier fish screens to protect young fish.

Important elements needed to attain the vision for this unit include specific processes that allow the recovery of riparian forest and nearshore aquatic habitats and maintain high-quality habitat for chinook salmon and steelhead and other anadromous fish species. Because this reach is an important seasonal component of the critical migration habitat required by the endangered winter-run chinook salmon, positive-barrier fish screens should be used at water diversions in this section to protect juvenile fish. Adverse environmental effects of the Colusa Basin Drain will be eliminated so that there are no future problems with high water temperatures, contaminants, or fish stranding.

The lack of channel capacity and proximity of levees to the river in the lower two units in this zone are the primary reasons that many habitats are degraded, discontinuous, or absent from this part of the river. There is simply no more room to restore large habitat nodes or corridors without contributing to the flood risk. This is an area where flood control, the potential for set back levees, and ecosystem restoration requirements must be carefully evaluated and integrated. While the potential for meander restoration is less feasible here than on other sections of the river, some degree of restoration is possible.

VISION FOR THE VERONA TO SACRAMENTO ECOLOGICAL MANAGEMENT UNIT

The vision for the Verona to Sacramento Ecological Management Unit is to recover, contribute to the recovery, or maintain many important fish and wildlife resources that depend on partially operational ecological processes and functions. Elements of this vision include actions to maintain a natural flow pattern; maintain high-quality nursery and migration habitat for adult and juvenile winter-run chinook salmon and steelhead and other anadromous fish species; emulate the natural hydrologic regime to the extent possible; maintain natural stream meander processes and gravel recruitment and deposition; maintain a limited but continuous riparian corridor; provide water temperatures suitable to support chinook salmon, steelhead, and other anadromous fish; reducing potential fish losses resulting from toxic residues from agricultural tailwater; and install positive barrier fish screens to protect young fish.

Closing gaps in the shoreline riparian vegetation and nearshore aquatic habitat will be accomplished (consistent with flood control requirements) by reducing vegetation management by local reclamation districts and by enhancing channelbanks. The letter entails modifying levees and berms that incorporate habitat structures (such as fish groins and low waterside berms), which support natural growth and woody debris. This section presents the greatest potential for adding oxbows and arms back into the river system. These modification would enhance valley-wide flood control because an increased floodplain would disperse and carry more water. Nursery areas for juvenile salmon would be improved by restoring waterside emergent and riparian vegetation nodes throughout this unit, particularly in areas immediately downstream of the mouth of the American River.

In this unit, narrower riparian corridors should be connected and should not be fragmented. These corridors would connect larger blocks of riparian habitat, typically greater than 50 acres. These blocks would be large enough to support the natural convection currents of air flowing from the forests across the river, causing evaporative cooling of the river. The riparian corridors would generally be 10 to 25 yards wide and would support cavity-nesting species, such as the wood duck, and provide perch and nest sites for raptors, such as the Swainson's hawk. Significant expansion of riparian habitat is only possible if lower river peak floodflow can be reduced, or where levees can be set back several hundred feet at constricted bends to create expanded floodplain nodes within the levees.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Healthy streamflows are natural seasonal patterns in late winter and spring, which include peak flow events that support many ecological processes and functions essential to the health of the anadromous fish populations. The Sacramento River has only a marginally healthy streamflow, because storage reservoirs in the upper watershed reduce flood peaks during the winter and spring, releasing the stored water during the summer months. The vision for these flow patterns can be attained by supplemental short-term releases from the major storage reservoirs to provide flows that emulate natural peak flow events.

COARSE SEDIMENT SUPPLY: The supply of sediments, including gravel, on the Sacramento River is severely impaired by reduced inputs from tributaries and blockage of upstream sources by Shasta Dam and Keswick Dam. Spawning habitat of salmon and steelhead and the production of aquatic invertebrates are dependent on the amount of suitable gravel in the river. Two major sources of sediments include Cottonwood Creek and natural bank erosion. The vision is to use natural processes to provide sediments to the system and to supplement sediment introductions to the extent necessary to emulate natural conditions.

STREAM MEANDER: The meandering river process in the Sacramento River provides much of the habitat required by anadromous fish populations that depend on the river for spawning, rearing, and migration. The meander belt of the upper portion of the river above Chico Landing is reasonably healthy and functioning, while the meander belt of the lower reaches of the river has been greatly limited by river channelization, by a network of confining levees, and associated development in the river floodplain. The vision is to maintain and preserve existing areas of meander and to reactivate meander in other areas that are impaired by bank protection activities.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Natural floodplains above Chico Landing are present, but much of the floodplains below are no longer accessible due to levee construction. Maintaining existing and restoring inaccessible floodplains are important ecological components needed to improve the health of the Sacramento River and the Delta. Actions proposed for protecting the natural stream meander corridor along the Sacramento River will contribute to improved connectivity of the river with its floodplain. The vision is to maintain existing areas where the Sacramento River seasonally inundates its floodplain and to reestablish this seasonal inundation in smaller areas that will be subject to adaptive management and focused research.

CENTRAL VALLEY STREAM TEMPERATURES: High summer and fall water temperatures continue to threaten the health of anadromous fish populations in the river. Although actions have been taken to reduce high water temperatures, low flows and the release of warm water from reservoirs in drought years remain as very serious threats to the anadromous fish populations of the Sacramento River. The vision is that stream temperatures will be manipulated to the extent possible to meet the biological requirements of aquatic organisms and that a healthy riparian and riverine aquatic corridor will contribute to shading and moderating temperatures gains in the river. Summer and fall stream temperatures are more critical for steelhead than they are for most races of chinook salmon because steelhead juveniles must rear for more than one year in fresh water, hence the vision is also to provide adequate water temperatures year-round.

VISION FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: The vision is to maintain and restore extensive areas of riparian and riverine aquatic habitats. The primary area for this is along the Sacramento River above Colusa. However, contiguous riparian habitats are extremely important to fish and wildlife throughout all reaches of the Sacramento River, including the 143 miles below Colusa.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper sections of the Sacramento is a fall chinook salmon spawning stream of low gradient while the remainder is a valley floor low elevation stream (Moyle and Ellison 1991). The vision is that the quality of freshwater fish habitat in the Sacramento River will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Sacramento River has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision for EFH is to maintain or restore substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions ranging from several cfs to several thousand cfs lead to the loss of millions of juvenile anadromous and resident fish. Significant progress has been made in screening the larger diversions, but screens are needed on the remaining unscreened largest, many medium-sized, and small diversions. Losses at these diversions continue to threaten the health of the anadromous fish populations. The vision is to consolidate, relocate, and screen diversions along the Sacramento River to the extent that they no longer impair other efforts to restore anadromous and resident fishes.

DAMS AND OTHER STRUCTURES: Diversion dams and other structures in the Sacramento River directly and indirectly impair the survival of adult and juvenile anadromous fish. Structures delay or prevent the upstream migration of adult fish during their spawning run, which lowers the reproductive success and viability of the entire population. These diversion structures can injure young fish as they migrate downstream or cause disorientation, making them more susceptible to predation. Predator fish that are not able to migrate upstream may congregate below these structures during times when prey species are abundant. The vision is to modify, remove, or reoperate structures in a manner that greatly lessens adverse affects on aquatic organisms.

LEVEES, BRIDGES, AND BANK PROTECTION: Most of the biological productivity in large river ecosystems occurs in the floodplain. Levees tend to sever the river from its floodplain and thereby reduce this productivity. Bridges and bank protection limit the lateral migration of the river channel. The vision is to modify or remove structures in a manner that greatly lessens adverse affects on ecological processes, habitats and aquatic organisms.

PREDATION AND COMPETITION: Predation and competition are natural ecological functions. For example, Sacramento squawfish are a large native predatory minnow which evolved along with other fishes in the Sacramento River system. Predation by this species under natural environmental conditions is a natural ecological function. However, large-scale alterations of habitat, streamflow, and the construction of instream structures has provided an advantage to predatory species by eliminating escape cover for young fish and providing types of habitat that harbor predatory fish. Unnatural levels of predation or competition can result in adverse effects to important sport and commercial fisheries and species of concern. The vision is that predation and competition will be lessened by removing, redesigning, or reoperating inwater structures and diversion dams, altering hatchery practices, and restoring riparian and riverine aquatic habitats.

CONTAMINANTS: Heavy metals from Spring Creek are a continuing problem for fish in the upper Sacramento River, as well as non-point sources of contaminants in the lower river reaches, such as agricultural return flow at Knights Landing. The vision is that contaminant effects will be reduced to levels that will not impair efforts to restore anadromous and resident fish populations and other aquatic and terrestrial species.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of anadromous fish within the river, estuary, and ocean constrains recovery of wild populations of anadromous fish in the Sacramento River. Reducing the fraction of the wild population harvested will most likely be necessary to allow recovery of populations to a healthy condition. The vision is that harvest strategies will complement efforts to rebuild anadromous fish populations.

ARTIFICIAL PROPAGATION OF FISH: Stocking hatchery-reared salmon and steelhead in the Sacramento River and some of its tributaries supports important sport and commercial fisheries and mitigates loss of chinook salmon and steelhead from the construction of large dams and reservoirs. Hatchery fish also supplement the numbers of naturally spawning chinook salmon and steelhead in the river. However, hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for food and space. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers. Improvements in hatchery practices are necessary to ensure recovery of wild salmon and steelhead populations. The vision is to operate hatcheries in a manner that is fully integrated into ecosystem management and restoration of naturally spawning anadromous fish.

STRANDING: Chinook salmon and other fish species remain susceptible to stranding as a result of entering the lower end of the Colusa Basin Drain. The vision is to provide a long-term remedy to prevent adult fish, particularly chinook salmon, from entering the drain.

VISIONS FOR SPECIES

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species. Improvements in the riparian and stream meander corridors along the Sacramento River will improve spawning and early rearing habitat of splittail. Late-winter and early-spring streamflow improvements will provide attraction flows for spawning adults and increased spawning habitat. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger splittail population.

Splittail are presently restricted to a fraction of their historic range. Restoring splittail to their former range outside the Delta is in an important element for this species. Generally, restoration of the species refers primarily to restoration of the reduced Delta populations. Nonetheless, some actions that may assist in restoration of this native species to a portion of its previous upstream range include: creation of meander belts along the Sacramento River by levee setbacks, creation of floodable wetlands in the lower San Joaquin, Tuolumne, and Stanislaus rivers, marsh restoration in the Delta and Suisun Marsh, managing bypasses for fish, and removal of upstream barriers to migration.

Because of its distribution, restoration actions implemented in the following Ecological Management Zones will contribute to the recovery of splittail: Sacramento River, East San Joaquin, San Joaquin River, Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, Colusa Basin, Feather River/Sutter Basin, American River Basin, and Yolo Basin. Many of the related actions include restoring ecological processes linked to natural floodplains and flood processes.

WHITE STURGEON AND GREEN STURGEON: The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historic levels. The vision for white sturgeon is to maintain and restore population distribution and abundance to historic levels to support a sport fishery. Improved peak flows in late winter and early spring will benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger sturgeon populations.

Green sturgeon is a legal sport fish in California, Oregon, and Washington. The Bay-Delta system constitutes the southernmost reproducing populations of green sturgeon. There is no direct evidence that green sturgeon have declined in the Sacramento River, but the population is quite small, and a collapse could occur under some conditions. Green sturgeon require additional focused research on life history, distribution and abundance.

Similar to restoration actions for white sturgeon, actions that will contribute to the protection and restoration of green sturgeon will occur in the Sacramento River, Feather River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

The success of the Department of Fish and Game's white sturgeon management program is clearly indicated by comparison of present day annual numbers of fish harvested, which consistently is nearly 70% of the average commercial catch from 1875 to 1899, about 374,000 pounds. The early unregulated fishery nearly wiped out the populations in a short period of time, while the present managed sport fishery promises to yield continuous returns. The present population goals for white sturgeon are to double the white sturgeon abundance of the average 1967 to 1991 population estimates of fish older than 15 years and to maintain a population that includes at least 100,000 fish that are greater than 102 cm in length.

Although the California Department of Fish and Game and USFWS have set population and harvest goals, actions to accomplish the Ecosystem Restoration Program Plan (ERPP) target will be achieved by restoration actions undertaken and completed in the Sacramento

River, Feather River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and use fully existing and restored habitat.

Four races of chinook salmon will benefit from improved streamflows, gravel recruitment, water temperatures, riparian and riverine aquatic habitat, and stream meander corridors. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger chinook salmon populations.

Presently, late-fall-run chinook salmon have no special protection. The great majority of late-fall-run chinook appear to spawn in the mainstem Sacramento River during January, February, and March. Late-fall-run chinook abundance has declined due to passage problems at Red Bluff Diversion Dam, loss of habitat, poor survival of emigrating smolts, sport and commercial harvest, and other factors, such as disease and pollutants.

Sacramento River late-fall-run chinook salmon populations will be regarded as healthy when the average number of spawners in the Sacramento River basin exceeds 15,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry (USFWS 1996).

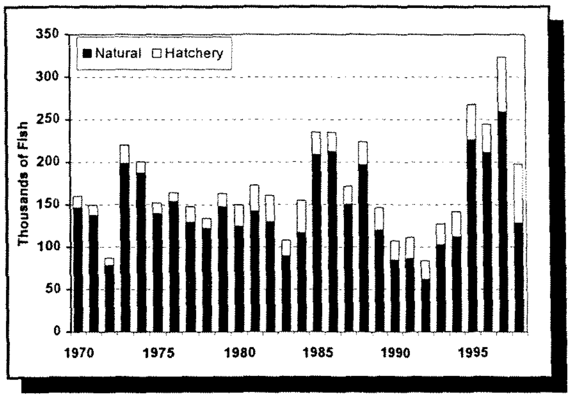
The recovery of the winter-run chinook salmon requires actions to increase their abundance and improve their habitat to the point that the probability of extinction will be very low. Although artificially produced fish may be used to rebuild the population to a level that can satisfy these criteria, direct satisfaction of the criteria will depend on natural reproduction.

The population criteria proposed to determine when winter-run chinook salmon are recovered require that mean annual spawning abundance over any 13 consecutive years shall be 10,000 females. The geometric mean of the cohort replacement rate (CRR) over the same 13 years shall be greater than 1.0. The variability in cohort replacement rate is assumed to be the same as or less than the current variability. The recovery goal also includes a provision to ensure that the population estimates are sound. The estimation criterion is that there must be a system in place for estimating spawning run abundance with a standard error of less than 25% of the estimate. If this level of precision cannot be achieved, then the sampling period over which the geometric mean of the Cohort Replacement Rate is estimated must be increased by one additional year for each 10% of additional error above 25%.

With respect to the recovery of the Sacramento River winter-run chinook salmon, there are two genetic issues of concern: (1) the effects of past and present reductions in population size on population fitness and population growth rate and (2) the genetic consequences of meeting the delisting criteria.

Programmatic actions that will contribute to the recovery of the winter-run chinook salmon will be implemented in the following Ecological Management Zones: Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay.

Because of their life-history requirements, typical of all Pacific salmon, Central Valley chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are successfully maintained to varying degrees by existing ecological processes. Even though the quality and accessibility of the habitats have been diminished by human-caused actions, these habitats can be restored through a comprehensive program that strives to restore or reactivate ecological processes, functions, and habitat elements on a systematic basis, while reducing or eliminating known sources of mortality and other stressors that impair the survival of chinook salmon.



Sacramento Valley chinook Salmon Spawning Population Abundances with Proportion of Estimated from Natural Spawning and Hatchery Production, PFMC 1999.

There are three major programs to restore chinook salmon populations in the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (PL 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1996). The California Department of Fish and Game is required under state legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993).

Each of the major chinook salmon restoration /recovery programs has developed specific goals for Central Valley chinook salmon stocks. ERPP embraces each of the restoration/recovery goals and will contribute to each agency's program by restoring critical ecological processes, functions, and habitats, and by reducing or eliminating stressors. ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERPP will contribute to maintaining a cohort replacement rate of 1.0.

Spring-run chinook salmon are a threatened species under the California Endangered Species Act and is considered a sensitive species by the U.S. Forest Service. Because of their life history patterns, spring-run chinook enter the Sacramento River early in the year and ascend to tributaries where they oversummer to spawn during the following fall. Young fish may rear for a year or longer in the tributaries before entering the Sacramento River during their seaward migration.

The status of a spring-run chinook salmon in the mainstem Sacramento River is uncertain, however, evidence suggests that there may be a significant introgression with fall-run chinook. The role of the Sacramento River in sustaining spring-run chinook salmon is primarily to provide adult fish passage to the tributary streams and to provide rearing and emigration habitat for juveniles during their seaward migration.

Spring-run chinook salmon populations will be considered healthy when the average number of spawners in tributary streams to the Sacramento River exceeds 5,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry. The average number of natural, wild spawners over the 15-year period must not be fewer than 8,000 fish (USFWS 1996).

STEELHEAD TROUT: The vision for steelhead trout is to recover this species listed as threatened under ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats.

Steelhead will benefit from improved streamflows and gravel recruitment in the upper river and improved water temperature and riverine habitat in the upper, middle, and lower reaches of the river. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

NMFS has identified steelhead populations in the Central Valley as composing a single evolutionary significant unit (ESU) based on a variety of physical and biological data. These data include the physical environment (geology, soil type, air temperature, precipitation, riverflow patterns, water temperature, and vegetation); biogeography (marine, estuarine, and freshwater fish distributions); life history traits (age at smolting, age at spawning, river entry timing, spawning timing), and genetic uniqueness.

The Central Valley steelhead ESU encompasses the Sacramento and San Joaquin Rivers and their tributaries. Recent data from genetic studies show that samples of steelhead from Deer and Mill Creeks and Coleman National Fish Hatchery on Battle Creek are well differentiated from all other samples of steelhead from California.

Within the broad context of ecosystem restoration, steelhead restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes, or that are nonspecific to steelhead trout. For example, restoration of riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetation/successional processes. These will be extremely important in providing shaded riverine aquatic habitat, woody debris, and other necessary habitats required by lower trophic organisms and juvenile and adult steelhead populations.

Operation of the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout.

STRIPED BASS: The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission striped bass policy. This will support a sport fishery in the Bay, Delta, and tributary rivers and reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta. Striped bass spawning in the Sacramento River is controlled by water temperatures. Fertilized striped bass eggs require sufficient stream flows and velocities to maintain the eggs in suspension. Striped bass will benefit from management of streamflow, water velocities, and water temperatures. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger striped bass population.

Most of the broader restoration actions for striped bass are centered in the Delta. However, the Sacramento River near Colusa is the primary spawning area for adult striped bass. A water temperature of 61°F is required to trigger striped bass spawning in the spring. Therefore, in some years it may be possible to manipulate water temperatures to reach the threshold for spawning. Striped bass eggs require sufficient flow velocity to keep the eggs suspended for two to three days before they hatch. Typically, flow velocity in the Sacramento River is more than adequate to maintain egg suspension.

Very young fish (larvae and fry) are susceptible to entrainment at diversions and are not protected by positive barrier fish screens designed to protect young salmon.

AMERICAN SHAD: The vision for American shad is to maintain an naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Improvements in late-winter and spring streamflows and stream meander corridors will benefit American shad spawning and rearing in the Sacramento River. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger American shad population.

Although American shad is an introduced species, it supports a highly seasonal and popular sport fishery in the Sacramento, Feather, Yuba, and American Rivers. This species will benefit from actions implemented to restore and maintain ecological processes related to streamflow, floodplain processes, and improved nearshore habitat and cover provided by shaded riverine aquatic and woody debris. These actions are being developed throughout the Central Valley and will provide benefits to numerous species and species communities.

WESTERN YELLOW-BILLED CUCKOO: The vision for the yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. The yellow-billed cuckoo along the Sacramento River above the Delta is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be expanded by improvements in riparian habitat areas. These improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Sacramento River Ecological Management Zone, thus sustaining the river meander belt, and increasing the coarse sediment supply to support meander and riparian regeneration.

Yellow-billed cuckoos inhabit extensive deciduous riparian thickets or forests with dense, low-level or understory foliage that abuts rivers, backwaters, or seeps. This species is found in the American River Basin, Colusa Basin, Sutter Basin, Butte Basin, and North Sacramento Valley Ecological Management Zones. Overall, the decline of the cuckoo has resulted from the loss of dense riparian habitat along the lower floodplains of larger streams, including those found within the Sacramento-San Joaquin Delta. Conversion of land to agriculture, urbanization, and flood control projects have caused the loss of habitat.

The yellow-billed cuckoo is listed as endangered by the State of California. This listing charges the state with the responsibility to conserve, protect, restore, and enhance the species as well as to acquire lands for its habitat.

Rebuilding the yellow-billed cuckoo population to a healthy state will require a coordinated approach to restoring ecosystem processes and functions, restoring habitat, and reducing or eliminating stressors. Within the broad context of ecosystem restoration, restoration of the cuckoo populations will include a wide variety of efforts, many of which are being implemented for other ecological purposes or which are nonspecific to the cuckoo. For example, restoration of riparian woodlands along the Sacramento River will focus on natural stream meander, flow, and natural revegetational/successional process. These will be extremely important to providing shaded riverine aquatic habitat, woody debris, and other habitat values that contribute to the health of yellow-billed cuckoo populations.

BANK SWALLOW: The vision for the bank swallow is to contribute to the recovery of this State-listed threatened species. Potential habitat for bank swallows will be improved by sustaining the river meander belt and increasing the coarse sediment supply to support meander and natural sediment erosion and deposition processes.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Sacramento River Ecological Management Zone requires near-term funding and implementing actions to achieve the targets. This includes managing water project operations, purchasing title or easements of land from willing sellers, cooperatively developing and implementing a phased fish screening program, acquiring and placing gravel, and performing engineering studies to improve fish passage at diversions and dams. Significant areas of the Sacramento River between Red Bluff and Colusa actively meander. Management actions should aim to protect this functioning process where it is intact, in addition to restoring channel migration within the meander belt.

Several major restoration efforts are either being developed or implemented by state and federal agencies. They will greatly contribute to the success of effort to restore ecological health to the Sacramento River.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoration of habitats and species and elimination of many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment, fish passage, water temperature control in the reach between Keswick Dam and RBDD, water acquisition, and other measures that will contribute to health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

The vision for the Sacramento River Ecological Management Zone will contribute to and benefit from the Anadromous Fish Restoration Program, which strives to double the natural production of anadromous fish in the system over the average production from 1967 through 1991.

In addition to the Anadromous Fish Restoration and Anadromous Fish Screening programs, the CVPIA requires the Secretary of the Interior to implement a wide variety of Central Valley Project (CVP) operation modifications and structural repairs in the Central Valley for the benefit of the anadromous fish resources. Sections 3406(b)(1) through (21) of the CVPIA authorize and direct the Secretary, in consultation with other state and federal agencies, Indian tribes, and affected interests to take the following actions, all of which will 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.

- Modify CVP operations to protect and restore natural channel and riparian values
- Modify CVP operation based on recommendations of the USFWS after consultation with the CDFG.
- Manage 800,000 acre-feet of CVP yield for fish, wildlife, and habitat restoration purposes after consultation with USBR and CDWR and in cooperation with the CDFG.
- Acquire water to supplement the quantity of water dedicated for fish and wildlife water needs including modifications of CVP operations; water banking; conservation; transfers; conjunctive use; and temporary and permanent land fallowing, including purchase, lease, and option of water, water rights, and associated agricultural land.
- Mitigate for Tracy Pumping Plant operations.

- Mitigate for Contra Costa Pumping Plant operations.
- Install temperature control device at Shasta Dam.
- Meet flow standards that apply to CVP.
- Use pulse flows to increase migratory fish survival.
- Eliminate fish losses due to flow fluctuations of the CVP.
- Minimize fish passage problems at Red Bluff Diversion Dam.
- Implement Coleman National Fish Hatchery Plan and modify Keswick Dam Fish Trap.
- Provide increased flows and improve fish passage and restore habitat in Clear Creek.
- Replenish spawning gravel and restore riparian habitat below Shasta Reservoir.
- Install new control structures at the Delta Cross Channel and Georgiana Slough.
- Construct, in cooperation with the State and in consultation with local interests, a seasonally operated barrier at the head of Old River.
- In cooperation with independent entities and the State, monitor fish and wildlife resources in the Central Valley.
- Resolve fish passage and stranding problems at Anderson-Cottonwood Irrigation District Diversion Dam.
- Reevaluate carryover storage criteria for reservoirs on the Sacramento and Trinity rivers
- Participate with the State and other federal agencies in the implementation of the on-going program to mitigate for the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant.
- Assist the State in efforts to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions.

In addition to the aforementioned CVPIA actions, Section 3406(e)(1 through 6) directs the Secretary to investigate and provide recommendations on the feasibility, cost, and desirability of implementing the actions listed below. When completed, these actions will provide additional understanding of the overall ecosystem problems and provide additional measures which will benefit anadromous fish.

- Measures to maintain suitable temperatures for anadromous fish survival by controlling or relocating the discharge of irrigation return flows and sewage effluent, and by restoring riparian forests.
- Opportunities for additional hatchery production to mitigate the impacts of water development and operations on, or enhance efforts to increase Central Valley fisheries: PROVIDED, that additional hatchery production shall only be used to supplement or to re-establish natural production while avoiding adverse effects on remaining wild stocks.
- Measures to eliminate barriers to upstream and downstream migration of salmonids.
- Installation and operation of temperature control devices at Trinity Dam and Reservoir.
- Measures to assist in the successful migration of anadromous fish at the Delta Cross Channel and Georgiana Slough.
- Other measures to protect, restore, and enhance natural production of salmon and

steelhead in tributary streams of the Sacramento River.

Section 3406(g) of the CVPIA directs the Secretary to develop models and data to evaluate the ecologic and hydrologic effects of existing and alternate operations of public and private water facilities and systems to improve scientific understanding and enable the Secretary to fulfill requirements of the CVPIA.

Upper Sacramento River Fisheries and Riparian Habitat Advisory Council

Established in 1986 by Senate Bill 1086, this council has develop a restoration plan and undertaken efforts to eliminate structural problems related to fish passage and entrainment (Resources Agency 1989). The present focus of the Council is to develop and implement a program to protect and preserve the stream meander corridor and establish a riparian conservation area from Keswick Dam to Verona.

The vision for this important Ecological Management Zone will assist the Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 committee) as it progresses with its plan to restore a naturally sustained riparian corridor, including a designated meander belt and extensive forests, between Keswick Dam and Verona.

Sacramento and San Joaquin Basins Comprehensive Study

As a result of State and Federal legislation, the U.S. Army Corps of Engineers and The Reclamation Board of California are conducting the Sacramento and San Joaquin River Basins Comprehensive Study. The Study will identify and evaluate measures to correct system deficiencies and will formulate a Master Strategy for Flood Damage Reduction and Environmental Restoration. This Master Strategy will identify immediate and staged implementation objectives for resolving flooding and interrelated ecosystem problems in the two basins. A cornerstone of this study is a system-wide evaluation to determine the existing capabilities of the flood management systems with an assessment of ecosystem functions intricately linked with the flood conveyance functions of the river systems.

Endangered Species Recovery Plan Implementation

The ERPP will be an important, if not major, component in the successful implementation of recovery measures for species listed under either the State or Federal ESAs. For example, many of the targets and programmatic actions listed later in this section are derived from existing recovery plan. Two plans that have had major influences on the development of programmatic actions include the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) and the NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997).

Because the ERPP addresses endangered species from a broader ecosystem perspective, many restoration actions will benefit broad species communities and the habitats upon which they depend. These include actions to benefit aquatic and terrestrial fish and wildlife species as well as special plants and plant communities.

State and federal agencies responsible for flood control and natural river resources should collaborate with local jurisdictions, landowners, and river conservation organizations to seek systemize solutions, particularly those that emphasize non-structural solutions to flood control and floodplain protection and restoration. In particular, the U.S. Army Corps of Engineers (Corps) should develop a physical model of the river system and its floodplain (similar to the Butte Basin study, but on a larger scale) to test hypotheses for complex rerouting, detention, and bypassing of floodwater. A Sacramento Valley hydraulic and sediment transport model will be integrated with an evaluation of ecological functions dependent on these physical processes and on the interaction of elements of the ecosystem recovery and land use with floodway capacity.

Completion of studies and subsequent implementation of the U.S. Environmental Protection Agency (EPA) remedies for the IMM Superfund site are needed to attain the safe metal concentrations identified in the basin plan. Pollution control remedies are required at the IMM portal for discharges of remaining sulfide ore deposits inside the mountain, the discharges from tailing piles, and the metal sludge in Keswick Reservoir.

In reaching the vision for this Ecological Management Zone, many cooperative programs need to be developed with federal, state, and local agencies, as well as local interests, such as watershed groups and individual landowners. The cooperative approach also applies to efforts to redirect some industries, such as the aggregate resource industry, to areas outside the active stream channel. These efforts require support from the industry and counties to undertake new programs.

CALFED BAY-DELTA PROGRAM

CALFED has funded nearly 20 ecosystem restoration projects along the Sacramento River. Most projects screen diversions for irrigated agriculture. Four projects acquire and restore riparian habitat, in conjunction with the SB1086 program. Three projects plan, design, and will construct a new fish ladder at the Anderson-Cottonwood diversion to improve access for winter-run chinook salmon to spawning habitat upstream of the dam.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

The Sacramento River Ecological Management Zone is dependent on virtually all of its adjacent Ecological Management Zones, which cumulatively contribute to the maintenance of important ecological processes and functions, particularly water, sediments, and nutrients. However, many large, westside streams no longer provide significant sediment and gravel to the mainstem river because of the placement of large reservoirs or sediment control basins, and instream gravel mining that depletes gravel sources in the channel for downstream transport.

Restoring and maintaining ecological processes and functions in the Sacramento River Ecological Management Zone are highly dependent on actions and conditions in adjacent zones. For example, maintaining the riparian forests and stream meander quality of the Sacramento River above Chico Landing is dependent on input of largely unregulated flow and sediments from Cottonwood Creek and several undammed tributaries draining Mount Lassen and the northern Sierra Nevada. Therefore, restoring and maintaining important ecological processes in Cottonwood Creek and other nonregulated tributaries is absolutely essential to maintaining the ecosystem health of the Sacramento River.

Cottonwood Creek is the most important watershed component in the upper river downstream of Shasta Reservoir and controls and supports the maintenance of ecological processes and functions in the upper Sacramento River. The Cottonwood Creek Ecological Management Zone is discussed separately, but its importance to the ecological health of the upper Sacramento River is emphasized here, because it is the largest remaining undammed tributary with natural hydrologic conditions and sediment characteristics. In the winter 1986 flood, more than half the flow (and presumably gravel and sediment) in the Sacramento River originated in Cottonwood Creek, greater than the volume represented by all other north-valley streams combined.

Likewise, some fish species depend exclusively on the Sacramento River for migration, spawning, and nursery habitat, while some species that use other Ecological Management Zones for spawning use the Sacramento River as primary migration, nursery, and emigration habitat. Other important Ecological Management Zones dependent on the resources of the Sacramento River include the Sacramento-San Joaquin Delta Ecological Management Zone and the Suisun Marsh/San Francisco Bay Ecological Management Zone. These zones, in turn, provide essential foodweb prey species and critical rearing habitat for outmigrating anadromous fish that spawn in the Sacramento River and its major tributaries.

Additionally, stressors important to fish and wildlife species using the Sacramento River during at least part of their life cycle occur outside the identified Ecological Management Zones. For example, ocean recreational and commercial salmon fisheries remove a large portion of the potential spawning adults from the population each year. New harvest management strategies for the ocean fisheries will be needed to augment improvement to inland ecological processes and functions that maintain key habitats for salmon. Water quality of agricultural tailwater throughout the Colusa Basin that reenters the Sacramento River at Knights Landing or Prospect Slough (Yolo Bypass) affects the health and survival of juvenile fish and prey species in the river, depending on the temperature, toxicity level, dilution ratios, and contaminant concentrations and presence of loadings.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: More closely emulate the seasonal streamflow patterns in dry and normal year- types by allowing a late-winter or early-spring flow event of approximately 8,000 to 10,000 cfs in dry years and 15,000 to 20,000 cfs in below normal water-years to occur below Keswick Dam (◆◆).

PROGRAMMATIC ACTION 1A: Provide a flow event by supplementing normal operating flows from Shasta and Keswick Dams in March during years when no flow event has occurred during winter or is expected to occur. Flow events would be provided only when sufficient inflow to Lake Shasta is available to sustain the prescribed releases. This action can be refined by evaluating its indirect costs and the overall effectiveness of achieving objectives.

TARGET 2: Maintain base flows of 6,000 to 8,000 cfs during fall (◆).

PROGRAMMATIC ACTION 2A: Provide flow releases from Shasta Lake and Keswick Dam when necessary to provide the target base flows. Releases would be made only when inflows equal or exceed prescribed releases.

RATIONALE: *Increasing releases from Shasta Reservoir are the only means of maintaining base flows in the upper river. Late-winter or early-spring flow events of sufficient magnitude attract and sustain adult salmon, steelhead, sturgeon, and American shad; improve transport of juvenile fish downstream; sustain riparian habitat; and sustain gravel recruitment, transport, and cleansing processes. The target flows are consistent with historic and unimpaired flows for the Sacramento*

River in dry and normal years. These flows may not occur in some years under the present level of project development and operation. Implementing the target level of the flow event must necessarily be on a conservative basis because of the potential cost to water supply. The fall flow pattern needs to be carefully evaluated to ensure protection for incubating chinook salmon eggs. The chinook salmon that spawn in the fall have eggs in the river that incubate into the winter season. Incubating eggs can be severely damaged when wintertime releases from Keswick Dam are dropped below the fall release levels. Other concerns include maintaining high base flows during the fall would cause temperature control problems in the following year under conditions of low carryover storage in Shasta Reservoir or low inter inflow conditions. The fall flow needs to consider the need for carryover storage to provide temperature control in the following year.

If a flow event of equal or greater magnitude has not occurred between Keswick Dam and Red Bluff by March, then supplementing base flows or augmenting small natural releases or reservoir spills with additional reservoir releases is the only means to provide flow events. Such releases would be used only if there is an equivalent or greater inflow to Lake Shasta. March is the logical month to provide such flows, because it is the month when "natural" flow events occurred historically in dry and below normal years, and because opportunities for such flow to occur "naturally" as a function of normal project operation would have been exhausted by then. Water forecasts of the water-year type (critically dry, dry, below normal, above normal, or wet) are available by February and March. The flow event in March would be expected to proceed unimpaired downstream to the Delta, because few or no diversions from the Sacramento River occur during March. (Note that additional flow events are prescribed for the Feather River in March, which will further enhance Sacramento River flows below its confluence with the Feather River.) A March flow event could also help satisfy Delta outflow requirements.

Maintaining natural base flows will help promote natural channel forming, riparian vegetation, and foodweb functions. Base flows also serve to attract steelhead and fall-run and late-fall-run chinook salmon. Unimpaired base flows in fall are approximately 4,000 cfs to 6,000 cfs in dry years, and up to 8,000 cfs in wetter years. Natural base flows are prescribed only for fall, because, under present project operation, flows in excess of 10,000 cfs are maintained in summer for irrigation and to lower water temperatures for winter-run salmon.

COARSE SEDIMENT SUPPLY

TARGET 1: Increase gravel recruitment in the upper Sacramento River between Keswick Dam and the RBDD by 10,000 to 20,000 cubic yards annually to provide adequate spawning habitat for targeted levels of salmon and steelhead and to sustain stream meander processes below Red Bluff. (This is the estimated amount of spawning-sized gravel captured annually by Shasta Dam.) (◆◆)

PROGRAMMATIC ACTION 1A: Develop a cooperative program to stockpile gravel at strategic locations along the Sacramento River below Keswick Dam where riverflow will move gravel into the river channel to mimic natural gravel recruitment into the upper river. Determine the adequacy of this action and adjust amount and locations as necessary.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to reactivate gravel recruitment to the river by exposing existing sources of river gravel on islands, bars, and banks that have become armored to riverflows. This action should be implemented on a conservative basis, because the availability of such inchannel gravel, costs of activating the gravel, indirect impacts, and potential effectiveness have not been determined.

RATIONALE: *Replenishing gravel supplies to a level sufficient to support target populations of* *salmon and steelhead will help to improve populations to desirable levels and to maintain such levels once achieved. Replenishing gravels to maintain channel-forming processes and stream meanders in the upper Sacramento River will help to maintain fish and wildlife habitats, aquatic algae and invertebrate production, and streamside vegetation (California Department of Water Resources 1980). A predevelopment level of gravel recruitment should be adequate to restore the natural ecological processes supported by gravel recruitment, but may require experimenting, monitoring, and experience to determine the exact amount of gravel supplies necessary to meet the objective. Implementation of gravel supplementation projects above RBDD will be subject to adaptive management, with elements that include focused research on sediment transport processes, and monitoring of gravel quality and quantity. Sediment supplementation programs need to be integrated with downstream channel forming processes, which will be subject to adaptive management, as well as to a different set of indicators, monitoring, and focused research.*

On the river side of natural levees in alluvial valleys, fluvial processes typically create dynamic river meander patterns, including oxbow lakes from bend cutoffs, secondary channels that carry flow only during high stage, and nonvegetated point bars where new deposits of sand and gravel collect in low-energy zones of inside bends and bendway crossovers (riffles). In cross section, natural alluvial streams are typically terraced and asymmetrical, with steep banks on eroding outside bends, low-angle banks on inside bends, and several nearly horizontal surfaces corresponding to river floodplain elevations of various magnitude and frequency. If a river has incised (i.e., eroded down below the original channelbed surface) as a result of natural or human-induced factors, the abandoned upper floodplain may become a "terrace" (former floodplain) where riparian forest may then convert to valley oak woodlands or grassland-oak savannah.

The characteristic three-dimensional shape of a river described above (its "fluvial geomorphology" or landforms created by flowing water) is indicative of a river that is in dynamic balance with the interaction of its flood regime, sediment supply, vegetation patterns, climate, and valley slope. Rivers with a natural shape and hydrologic condition generally support the most diverse mixture of habitats and fish and wildlife species and are the most resilient to natural or human disturbance.

STREAM MEANDER

TARGET 1: Preserve and improve the existing stream meander belt in the Sacramento River between Red Bluff and Chico Landing by purchase in fee or through easements of 8,000 to 12,000 acres of riparian lands in the meander zone (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the feasibility of removing riprap from banks to the extent possible, consistent with flood management requirements, and reduce effects of other structures, such as bridges, to provide a sustainable meander corridor.

PROGRAMMATIC ACTION 1B: Purchase easements to offset losses to property owners for land lost to meander process.

TARGET 2: Preserve and improve the existing stream meander belt in the Sacramento River between Chico Landing and Colusa by purchase in fee or through easements of 8,000 to 12,000 acres of riparian lands in the meander zone (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to evaluate the feasibility of removing riprap from banks to the extent possible, consistent with flood control management, and reduce effects of other structures, such as bridges, to provide a sustainable meander corridor.

PROGRAMMATIC ACTION 2B: Purchase easements to offset losses to property owners for land lost to meander process.

RATIONALE: *Preserving and improving the stream meander belt below Red Bluff will ensure that this important natural process is maintained in the Sacramento River. This reach is important for spawning and rearing salmon and steelhead. A natural meander process will provide near-optimal habitat for spawning (through gravel recruitment), rearing (channel configuration, cover, and foodweb), and migration. There is limited potential natural channel above Red Bluff. Below Chico Landing, flood control levees limit the potential of restoring the natural meander of that reach. Overall, the program must be consistent with flood control requirements and in the longer-term, should reduce need for future flood control efforts by using natural system resilience and flood control characteristics.*

During the selection process and during implementation, additional benefits will accrue by looking for land within or adjacent to the meander belt which support special status species and to include these areas whenever available in the acquisition. Some the species to be considered include the valley elderberry longhorn beetle, bank swallow, western yellow-billed cuckoo, and giant garter snake.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Increase and maintain floodplains in conjunction with stream meander corridor restoration (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program, consistent with flood control requirements, to evaluate the feasibility of altering river channel configurations in leveed reaches of the Sacramento River to increase the areal extent of floodplains inundated during high flow periods.

RATIONALE: *Floodplain inundation is the seasonal flooding of floodplain habitats, including riparian and riverine aquatic habitats. Flooding of these lands provides important seasonal habitat for fish and wildlife and provides sediment and nutrients to both the flooded lands and aquatic habitats that receive the returning or abating floodwater. The flooding also shapes the plant and animal communities in the riparian, wetland, and upland areas subject to flooding. Floodplain flooding is a secondary ecosystem process related to water and sediment flow through the Sacramento-San Joaquin basin and their landforms. Opportunities to restore or enhance this process are possible by changing landscape features, landforms, and seasonal distribution of flow volume through the system.*

Channelizing and shortening rivers; removing instream vegetation and gravel; and creating symmetrical, trapezoidal channels sandwiched between narrow, steep-sided levees diminish the natural tendency of alluvial rivers to form characteristic compound dimensions and patterns. A channelized river may be relatively stable if the potential for major flood events has been eliminated, sediment input is minimal, vegetation does not naturally grow along the banks, and the channelbed is incapable of incising. The absence of river floodplains and adequate meander width for bar and riffle formation within levee-confined channels prevents or depresses the formation of natural river morphology that is the structural framework for riverine and estuarine fish and wildlife habitats. Stabilizing artificial banks with rock riprap and clearing vegetation further degrades habitat and diminishes natural channel-forming processes.

An important exception here is the existence of the Sacramento River basin overflow system: the Butte basin and Sutter and Yolo Bypasses. Although considerably smaller than their original extent, these three floodplains move and detain floodwaters in volumes and patterns similar to those of presettlement flow, while reducing the risk of overtopping levees near populated areas.

At flood peak, there is approximately five times more flow in the Sacramento River bypass floodplain system than in the main river channel it drains. However, the floodplain bypass system does not exist in the largest historic flood basin of the Sacramento River, the Colusa basin, which is disconnected by levees from the river. Also, the lowest areas of the Sutter basin are outside of the levees and the Sutter Bypass traverses slightly higher ground on a portion of the historical basin floodplain.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain mean daily water temperatures at levels suitable for maintaining all life-history stages of chinook salmon and steelhead in the Sacramento River between Keswick Dam and RBDD in above normal and wet years, and between Keswick Dam and RBDD in other year types (◆◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively develop and implement a balanced river regulation program that provides sufficient carryover storage at Shasta Dam to ensure that suitably low water temperatures are reached to protect chinook salmon and steelhead spawning, incubating eggs, and young fish, particularly in consecutive dry and critically dry years.

RATIONALE: *The temperature objective for the upper Sacramento River is less than or equal to 56°F from Keswick Dam to RBDD for operation of CVP in the State Water Resources Control Board's (SWRCB's) Order 90-5. However, these criteria cannot be met consistently, and other structural facilities and operation measures are needed. These facilities and operational measures must be developed and implemented to enable the long-term attainment of the SWRCB-required temperature criteria.*

A temperature control or "shutter device" has been installed to permit the selective withdrawal of water from Shasta Reservoir over a wide range of depths and temperatures. With this device, warm water could be withdrawn from the upper lake levels when needed, while conserving the deeper, cold water for release when it would most benefit chinook salmon. Operation criteria for temperature criteria needs to include temperature requirements of steelhead trout which spawn in the late-winter/early spring. Controlling temperatures solely for chinook salmon would have serious impacts to naturally spawning steelhead. Operating the temperature control device allows Reclamation greater effectiveness and flexibility in temperature control operations while maintaining hydroelectric power generation. The temperature control device also provides a secondary benefit to anadromous fish by controlling turbidity. Because the temperature control device is installed and operational, operations and carryover storage requirements must be reassessed and new criteria established to optimize attainment of water temperature objectives.

In the long term, Sacramento River water temperatures can be moderated by restoring a healthy riparian forest. Implicit in restoring an extensive riparian forest is a need to reconnect the river with its floodplain to promote natural riparian succession.

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Provide conditions for riparian vegetation growth along channelized portions of the Sacramento River (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to plant vegetation on unvegetated, riprapped banks consistent with flood control requirements. Implementation will occur in phases, results will be monitored and restoration approach will be adjusted as necessary under adaptive management.

PROGRAMMATIC ACTION 1B: Setback levees may be constructed on leveed reaches of the river to provide a wider floodplain and greater development of SRA habitat. Because of the potential indirect impacts on land use and uncertainty of cost and technical feasibility of setback levees, such development will be experimental and conservative, and will depend on adaptive management.

PROGRAMMATIC ACTION 1C: Cooperatively develop and implement a study to determine appropriate conditions for the germination and establishment of riparian woody plants along the river.

TARGET 2: Increase the ecological value of low- to moderate-quality SRA habitat by changing land use and land management practices (◆◆).

PROGRAMMATIC ACTION 2A: Purchase property or easements and allow habitat to improve naturally. Properties to be considered should be developed through a prioritizing process that considers habitat quality and importance, technical feasibility and cost of purchase and improvement, and consent of landowners.

PROGRAMMATIC ACTION 2B: Provide incentives and technical support for private landowners to protect and improve existing SRA habitat.

TARGET 3: Maintain existing streamside riparian vegetation (◆◆◆).

PROGRAMMATIC ACTION 3A: Through purchase, conservation easement, and voluntary participation of landowners, protect SRA habitat from development. Where high-priority properties are already in government ownership or available for purchase or easement, preservation efforts should be undertaken as experiments to develop technical details, cost-effectiveness, and overall approach and consensus for the program. Full implementation of this program would depend on results of experiments and would be subject to adaptive management.

RATIONALE: *Riprapped banks in the leveed section of the river below Chico Landing downstream to Sacramento are the greatest cause of SRA fragmentation. Restoring vegetation will benefit juvenile salmon rearing by providing cover and food, spawning substrate for other fish, such as Sacramento splittail, and refuge for juvenile fish during periods of high water. Improving low- to moderate-quality SRA habitat will benefit juvenile salmon and steelhead by providing improved shade, cover, and food. Wildlife will also benefit from improved habitat. Protecting and improving existing SRA habitat may involve changes in land use. Limited available funds may require that priorities be set, with high-priority, low-cost sites developed initially. For sites where consensus exists, immediate experimental action can be taken. Because of the importance and limited distribution and abundance of SRA habitat, all existing quality habitat should be protected.*

In developing this element of the restoration plan, it is important not to develop just a very long, narrow band of riparian vegetation. Although it needs further development, a "string-of-pearls" approach should be considered. In this concept the long, narrow band of riparian vegetation would be interspersed with larger patches of riparian vegetation. This concept would mesh well with nodes of setback levees to provide a minimal floodplain, seasonal floodplain inundation, and natural or supplemented riparian revegetation.

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the Sacramento River and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce entrainment of juvenile salmon, steelhead, sturgeon, and splittail into water diversions to levels that will not impair stock rebuilding or species restoration (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to screen all diversions greater than 250 cfs and one- to two-thirds of all smaller unscreened diversions. This programmatic level of action should be sufficient to provide the data necessary to modify this target through adaptive management.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to upgrade screening at diversions with ineffective screening. Where existing screening has proven less than effective and entrainment problems continue, immediate action should be taken to upgrade screens.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to reduce diversions when and where juvenile salmon are present in large or significant numbers. Even with screens, some diversions may pose a threat to young salmon and steelhead, and it may be necessary to modify operations of the diversion. Such determinations will be made after necessary monitoring and evaluation, and on a case-by-case basis. Decisions will be made with agency and stakeholder involvement and with consideration given to appropriate alternatives.

PROGRAMMATIC ACTION 1D: Promote and support relocating water diversions and developing alternate methods of supplying water from the Sacramento River that protect fish but also minimize conflict with maintaining dynamic fluvial processes.

RATIONALE: *Juvenile chinook salmon, steelhead, green and white sturgeon, Sacramento splittail, and American shad are lost at water diversion sites all along the Sacramento River during the spring-to-fall irrigation season. (Note that diversion losses include direct loss into unscreened diversions and other losses associated with the screened and unscreened intake facilities, such as from predators, including squawfish and striped bass.) Reducing entrainment losses to minimal levels is a reasonable target for the short term, given the existing poor health of many of the fish populations that use the Sacramento River and its tributaries for spawning and rearing of young. Emphasis should be on the upper river above Chico Landing, because this is the reach where winter-run chinook young rearing coincides with the spring-to-fall irrigation season.*

Determining which diversions need to be screened will be based on appropriate monitoring and evaluation, with decisions made with agency and stakeholder involvement, and with consideration given to appropriate alternatives. Actions will be taken on a case-by-case basis, with consideration given to results of pilot experiments to determine technical feasibility and cost-effectiveness of screening diversions of different size, type, and location. Priority will be given to screening diversions that pose the most threat and where *screening has been determined to be effective. Emphasis should be given to projects that include the consolidation of several diversion points to a single location.*

In application, priority for screening diversions will be based on several criteria including but not limited to the geographical location, the volume of water diverted, the location of the intake in the water column, and the cost effectiveness of the installation. Alternatives to screening will be considered. When a fish screen is installed, it should be tested to determine that it can perform to the criteria of the fish regulatory agencies. After testing has indicated that the screen meets the criteria, monitoring should be conducted to ensure that the screen can meet the criteria under the range of hydrologic conditions expected at the site. When operation monitoring indicates that everything is working satisfactorily, the diverter should routinely inspect the screen to ensure that the facility is undamaged.

DAMS AND OTHER STRUCTURES

TARGET 1: Minimize survival problems for adult and juvenile anadromous fish at RBDD by permanently raising the gates during the non-irrigation season and improving passage facilities during the irrigation season (◆◆◆).

PROGRAMMATIC ACTION 1A: Upgrade fish passage facilities at the RBDD.

TARGET 2: Reduce blockage to fish migrations at the ACID dam (◆◆).

PROGRAMMATIC ACTION 2A: Upgrade fish passage facilities at the ACID dam.

RATIONALE: *At present, the RBDD gates are in the raised position from September 15 through May 14, allowing free passage to about 85% of the spawning run (based on average run timing from 1982-1986). This may have reduced the number of redds (spawning nests created by salmon) being built below the dam. The remaining portion of the run migrating upstream after May 15 is likely to be delayed or blocked from passing the dam.*

Adults that are obstructed from passing the dam are forced to spawn downstream where temperature conditions are typically unsuitable during the spawning and incubation period. Temperatures of 56 °F usually cannot be maintained below RBDD without severely depleting Shasta carryover storage during the winter-run chinook incubation period; eggs and larvae usually have 100% mortality.

Adults that must make repeated attempts to pass the dam, but eventually are successful, undergo physiological stress that may contribute to their reduced fecundity. Because migration of these adults is delayed, the fish are likely to spawn farther downstream where suitable temperatures for spawning and incubation may not be attainable.

Adult chinook salmon must negotiate fish ladders at the ACID dam during the irrigation season (typically April through November) to reach upstream spawning habitat. However, an antiquated ladder on the east abutment of the dam is ineffective in providing safe passage, and a recently installed denil ladder on the west abutment has proved only marginally successful. The ladders at this facility do not provide suitable flows to attract adults, and the ladders are not easily adjustable to compensate for varying flow conditions. A feasibility study is being conducted by the ACID to identify, develop, and evaluate alternatives to resolve adult passage problems.

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Construct setback levees along leveed reaches of the river as part of the stream meander corridor (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program, consistent with flood control requirements, to evaluate potential sites for establishing setback levees along leveed reaches of the Sacramento River.

RATIONALE: *Levees, bridges, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains and allow stream channels to meander. Levees prevent flood flows from entering historic floodplains behind levees, stopping evolution of floodplain habitats dependent on overbank flows. Confinement of flood flows to channels by levees and bank protection structures also increases the fluvial energy of flows that scour or incise channel beds and reduces or halts the rate of channel migration and oxbow formation.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce the area of invasive non-native woody species, such as giant reed (i.e., Arundo or false bamboo) and salt cedar (Tamarisk), that compete with native riparian vegetation (◆◆).

PROGRAMMATIC ACTION 1A: Implement a program along the length of the Sacramento River to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation.

PROGRAMMATIC ACTION 2B: Implement a program eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat along the Sacramento River. In most cases, the removal of invasive plants will require the replanting of native vegetation to maintain adequate levels of herbaceous cover, canopy closure, habitat structure, and to limit exotic recolonization.*

PREDATION AND COMPETITION

TARGET 1: Reduce the adverse effects of predatory fish by identifying and eliminating human made in-stream structures or operational conditions that allow unnatural predation rates (◆◆).

PROGRAMMATIC ACTION 1A: Selectively evaluate areas and make physical changes to structures in the Sacramento River, such as bridge abutments, diversion dams, rip-rap banks, and water intakes, that currently may attract predators and provide them with additional advantages in preying on juvenile salmon and steelhead. Pilot studies and evaluations are needed to determine the types of changes required and the potential degree of implementation.

RATIONALE: *Upgrading fish passage facilities at the two diversion dams will reduce delays to upstream migrating winter-run chinook salmon and hindrance of downstream migrating juvenile winter-run chinook salmon. This will contribute to a reduction in predation rates on young fish.*

During operation of RBDD, juvenile chinook are adversely affected while approaching the dam, passing the dam, and moving downstream of the dam. As juveniles migrate toward the dam, they experience increased predation in Lake Red Bluff from predatory fish and birds. Juveniles passing under the lowered dam gates become disoriented because of high water velocities and turbulence, and are subject to heavy predation downstream by squawfish and striped bass. Juveniles bypassed around the dam through the Tehama-Colusa fish bypass system may have improved survival rates because of new facilities and positive-barrier fish screens, but complete evaluations are needed.

To help protect winter-run chinook from predation and other losses associated with passage at RBDD, the dam gates have been raised for varying durations since the end of 1986. Juvenile chinook suffer mortality in passing the dam from squawfish and striped bass predation and disorientation or injury when passing beneath the dam gates or through the fish bypass system. Under the present schedule of gate operations, about 26% of the juvenile outmigrants must pass the dam when the gates are lowered and are susceptible to mortality associated with that passage. In a 1988 study, juvenile hatchery salmon were released above and below the dam to estimate total mortality during dam passage. In all, 16% to 55% fewer fish were recaptured from the releases made above dam than those made below. USFWS determined predation, primarily by squawfish, as the major cause of mortality to juvenile salmon migrating past the dam, whereas the number of deaths from physical injury received while passing under the dam were minor.

CONTAMINANTS

TARGET 1: Reduce losses of fish and wildlife resulting from pesticide, hydrocarbon, heavy metal, and other pollutants in the Sacramento River (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to remedy heavy metal pollution from IMM to meet basin plan standards, and implement reliable and proven remedies that ensure continued treatment and control of heavy metal waste before water is discharged to the Sacramento River.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to eliminate scouring of toxic, metal-laden sediments in the Spring Creek and Keswick Reservoirs.

PROGRAMMATIC ACTION 1C: Control contaminant input to the Sacramento River system by constructing and operating stormwater treatment facilities and implementing industrial best management practices (BMPs) for stormwater and erosion control.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to assess and monitor contaminant input from agricultural drainages in the Sacramento River watershed.

RATIONALE: *Note: Actions proposed here to reduce the adverse effects of contaminants in the Bay-Delta system will be coordinated with recommendations and actions developed by the CALFED Water Quality Common Program.*

The drainage from inactive mines on the IMM Superfund site represents the largest source of pollutant discharge to the Sacramento River. This discharge is at least equal to all the combined industrial and municipal discharges of dissolved metals to the San Francisco Bay and estuary system. This mine water is among the most acidic in the world and contains extremely elevated concentrations of copper, zinc, cadmium, and other metals known to be toxic to fish and wildlife. On occasion, fish deaths (including salmon) may have occurred as toxicity levels have been exceeded and documented in the upper Sacramento River as a result of IMM waste. More frequently, there are documented instances of metal concentrations that exceed toxic levels considered safe for early life stages of salmon.

The wastes from IMM, located in the Spring Creek watershed, are collected in the Spring Creek Reservoir and metered out into the releases of clean water from Shasta and Whiskeytown Reservoirs to achieve the best water quality possible. However, because of the extremely large waste load (averaging more than 1 ton of copper and zinc per day), it has not always been possible to consistently attain the water quality objectives for copper, cadmium, and zinc in the basin plan, and interim criteria have been established until pollution control is completed. Highly toxic conditions are exacerbated when heavy winter rains induce uncontrolled spills from Spring Creek Reservoir, and flows from Shasta and

Whiskeytown Reservoirs are not made available for dilution because of other CVP constraints.

Within the lower portion of the IMM site, remediation must be developed for the metal sludge deposits in Spring Creek Reservoir and in Keswick Reservoir adjacent and downstream of the Spring Creek power plant tailrace. Preliminary monitoring in the Keswick Reservoir has documented that the sludge is highly toxic and that the deposits are extensive and up to 15 feet thick. Under certain conditions, flows from the Spring Creek power plant can mobilize large quantities of the sludge into the river, creating an acute toxicity risk to aquatic species. The sludge deposits can also contribute to chronic toxicity when combined with other sources.

Major sources of pollution include industries, municipalities, and agriculture, which discharge such contaminants as herbicides, pesticides, organic compounds, inorganic compounds, and warm water. Pollution is described as originating from point sources, such as discharge pipes or other localized sources, or from nonpoint sources, which are dispersed. Individual sources of nonpoint pollution may be insignificant, but the cumulative effects can be significant and can contribute high levels of pathogens, suspended solids, and toxins. Major contributors of nonpoint-source pollution to the Sacramento River, Sacramento-San Joaquin Delta, and San Francisco Bay include sediment discharge, stormwater and erosion, and agricultural drainage. Mandatory performance standards are needed for these sources, with flexibility granted to landowners to adopt whatever management practices are best suited for local conditions.

A primary point source of pollution is from municipal treatment plants, which release heavy metal contaminants, thermal pollution, pathogens, suspended solids, and other constituents. Implementing enhanced treatment, pretreatment programs, and tertiary treatment should help to reduce contaminant input.

Sediments constitute nearly half of the materials introduced into rivers from nonpoint sources, such as plowed fields, construction and logging sites, and mined land, and are mainly generated during storm events. Stormwater runoff in urban and developing areas is another major source of sediments and contaminants. Sedimentation from nonpoint sources should be reduced by implementing BMPs for urban and nonurban pollution, and implementing appropriate treatment and technological options that reduce pollutant loads.

An assessment of water quality and impacts from various other agricultural drainages to the Sacramento River is needed. Results from these evaluation programs should generate recommendations for corrective actions. Top priority should be given to the Sutter Bypass, which receives drainwater from rice growing areas and has outflows equivalent to those from the Colusa Basin drain. Assessments should also be conducted on Butte Slough, Reclamation District 108, and Jack Slough.

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal harvest of fish species to a minimum to maintain or increase populations by increasing enforcement efforts by 50 to 100% (♦♦♦).

PROGRAMMATIC ACTION 1A: Increase enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to educate the public on the threats to populations from illegal harvest. Various actions include ad campaigns, signs along streams, and various types of outreach programs to schools, watershed conservancies, and groups.

PROGRAMMATIC ACTION 1C: Provide additional funding for the poaching hotline and rewards for arrest and convictions of poachers.

TARGET 2: Manage the legal harvest of chinook salmon, steelhead, and sturgeon by shifting harvest from natural stocks to hatchery-reared stocks, where possible, or reducing harvest of wild stocks until the naturally produced populations recover (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to mark all hatchery salmon, allowing selective harvest of hatchery fish, while limiting harvest of wild fish. This action should be implemented on a short-term and experimental basis to ensure that it meets its objective and is cost-effective.

PROGRAMMATIC ACTION 2B: Encourage regulatory agencies to change fishing regulations (i.e., by restricting seasons, limits, and gear and reducing harvest of wild fish) to further reduce legal harvest and any ancillary effects of fishing gear or techniques. Restrictions should be severe in the short term. Long-term restrictions would depend on response of populations and effectiveness of restrictions and the degree of effectiveness of the action.

RATIONALE: *Some populations of salmon and steelhead in the Sacramento River are at such depressed levels that drastic reductions in any factors that contribute to mortality are necessary. Harvest management policies have been established by state and federal agencies to minimize mortality on natural chinook stocks, including severe harvest restrictions and size limits. Illegal harvest is known to occur along the Sacramento River. This target will be subject to adaptive management. Mass marking of hatchery steelhead began in 1997 and it should be continued.*

ARTIFICIAL FISH PROPAGATION

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead in the upper Sacramento River will stray into non-natal streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the costs and benefits of limiting stocking of hatchery-reared salmon and steelhead in the upper Sacramento River. Stocking may be reduced in years when natural production is high in selected populations.

TARGET 2: Limit hatchery stocking to populations that cannot be sustained through natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment winter-run, spring-run, and late-fall-run chinook salmon and steelhead with hatchery-produced smolts during the short-term rebuilding phase of restoration efforts and only when alternative measures are deemed insufficient to provide recovery of the populations. Stocking of hatchery-reared fish will be undertaken as experiments and adjusted or terminated as necessary, depending on results.

TARGET 3: Employ methods to limit straying and loss of genetic integrity of wild and hatchery supported stocks (◆◆◆).

PROGRAMMATIC ACTION 3A: Rear salmon and steelhead in hatcheries on natal streams to limit straying. If hatchery augmentation of Sacramento River populations of salmon and steelhead is necessary, then hatcheries should be built on the Sacramento River for that purpose.

PROGRAMMATIC ACTION 3B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

TARGET 4: Minimize further threats of hatchery fish contaminating wild stocks of salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 4A: Where hatchery production is underway and continues, methods should be adopted and improved for the selection of an appropriate cross section of the adult population for spawning at the hatchery.

PROGRAMMATIC ACTION 4B: Select spawning adults of appropriate genetic makeup to minimize genetic contamination of existing hatchery and naturally producing stocks of salmon and steelhead. Given the present difficulty of determining genetic makeup of spawning adults selected for hatcheries, this action will necessarily be experimental. Hatchery-reared adults may be preferentially selected or not selected if they are adequately marked or tagged, or have other identifiable feature. Other methods may be developed to genetically categorize naturally produced or hatchery fish.

RATIONALE: *In watersheds such as the Sacramento River, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited in extent and to levels that do not inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds may also threaten the genetics of wild stocks. Hatchery fish may also threaten the genetic makeup of stocks in natal rivers. Some general scientific information and theory from studies of other river systems indicate that hatchery supplementation may limit recovery and long-term maintenance of naturally producing populations of salmon and steelhead. Further research and experimentation are necessary to determine the degree to which this issue is addressed. Long-term hatchery augmentation of healthy wild stocks may genetically undermine that stock and threaten the genetic integrity of other stocks. Spawning and rearing habitats are limited, and adverse conditions may occur in drought or flood years that would undermine the population without additional hatchery production.*

Release of hatchery-reared fish into the upper Sacramento River and its tributaries could lead to a loss of the genetic integrity of wild salmon and steelhead populations. Adults straying into non-natal streams may interbreed with a wild population specifically adapted to that watershed, possibly leading to the loss of genetic integrity in the wild population. Although some irreversible contamination has occurred in salmon and steelhead populations, measures are necessary to minimize further deterioration of contaminated populations and to protect populations that are not contaminated.

Recent returns to CNFH of fall-run chinook salmon seem to indicate that the hatchery is heavily supporting the entire fall-run population, particularly in Battle Creek, all of which probably originated from CNFH. A recent estimate for the rest of the Sacramento River above RBDD, excluding Battle Creek, was only 40,000 fish, which may also have been heavily supported by CNFH production.

Some stocking of hatchery-reared fish may be necessary in the short term to rebuild naturally spawning populations; however, there is a lack of consensus among agencies and stakeholders as to the degree of stocking that is detrimental or necessary to sustain sport and commercial fisheries. This action will necessarily be short term and experimental, with subsequent efforts dependent on results and effectiveness.

Additionally, the relationship of the resident rainbow trout of the mainstem Sacramento River below Keswick (a.k.a. "river trout") with hatchery and naturally spawning steelhead populations should be investigated. There is a substantial number of large, steelhead-sized resident rainbow trout in the upper Sacramento River, and it is unknown if these fish comprise a discreet population, are a component of the steelhead/rainbow trout population, or an artifact *of artificial production. The large number of non-migratory rainbow trout may be a result of ecological conditions that exist in the tailwater reaches below dams, and this needs to be investigated.*

STRANDING

TARGET 1: Eliminate the straying, stranding, and loss of adult chinook salmon and other species along the Sacramento River.

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of preventing adult chinook salmon from straying into the Colusa Basin Drain.

RATIONALE: *The straying of adult chinook salmon into the Colusa Basin Drain has long been recognized as a problem. Recent water use practices in the basin have greatly reduced the volume of discharged water, which has reduced the high water temperature and contaminant problems. Still, fish have direct access to the drain under certain flow conditions. This action is consistent with actions described in the Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997) and the Department of Fish and Game anadromous fish restoration plan (California Department of Fish and Game 1993). The feasibility should evaluate water use practices, redirection of waste water, and alternative structures to eliminate entry into the drain.*

REFERENCES USED TO DEVELOP THE VISION FOR THE SACRAMENTO RIVER ECOLOGICAL MANAGEMENT ZONE

California Department of Fish and Game. 1993. Restoring Central Valley Streams: a plan for action. Department of Fish and Game. November 1993. 198 p.

California Department of Fish and Game. 1996. Steelhead restoration and management plan for California. Department of Fish and Game. February. 234 p.

California Department of Water Resources. 1980. Upper Sacramento River spawning gravel study. Department of Water Resources, Northern District. December. 157 p

Hallock. R.J. 1987. Sacramento River system salmon and steelhead problems and enhancement opportunities. A report to the California Advisory Committee on Salmon and Steelhead Trout. June 22, 1979. 92 p.

NMFS 1989. Endangered and threatened species; critical habitat; winter-run chinook salmon. National Marine Fisheries Service Federal Register 32085. Vol 54(149).

NMFS 1996. Recommendations for the recovery of the Sacramento River winter-run chinook salmon. Sacramento River winter-run chinook salmon recovery team. National Marine Fisheries Service March. 228 p

PFMC. 1999. Review of the 1998 Ocean Salmon Fisheries. Pacific Fishery Management Council. February 1999.

Resources Agency 1989. Upper Sacramento River fisheries and riparian habitat management plan. January. 158 p.

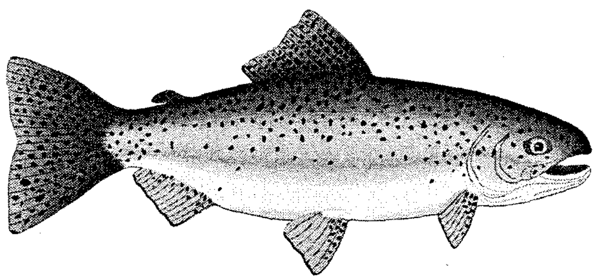
Sacramento River Advisory Council. 1998. Sacramento River Conservation Area Handbook (Draft). May 1998. Prepared for The Resources Agency State of California by the Sacramento River Advisory Council under the SB 1086 program.

USFWS 1996. Recovery plan for the Sacramento/San Joaquin Delta native fishes. U.S. Fish and Wildlife Service November. 195 p.

USFWS 1997. Revised draft anadromous fish restoration plan: a plan to increase natural production of anadromous fish in the Central Valley of California. U.S. Fish and Wildlife Service. May 30, 1997.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. Pp. 309-362 in Sierra Nevada Ecosystem Project, Final Report to Congress, vol. III, assessments, commissioned reports, and background information. Davis: University of California, Centers for Water and Wildland Resources.

◆ North Sacramento Valley Ecological Management Zone



Introduction

The health of the North Sacramento Valley Ecological Management Zone contributes to the health of the Sacramento-San Joaquin Delta in many ways. Ecological processes within this zone contribute sediment, nutrients, and streamflow to the Sacramento River. They also provide important migration, holding, spawning, and rearing areas for spring-, fall-, and late-fall-run chinook salmon steelhead, lamprey, and native resident fish species. Many streams in this zone also provide seasonal non-natal rearing for juvenile steelhead and chinook salmon. Riparian and shaded riverine aquatic habitats provide for many terrestrial species, including neotropical birds, amphibians, and invertebrates.

The North Sacramento Valley Ecological Management Zone encompasses the geographic area and tributary streams generally surrounding the City of Redding and includes the following ecological management units:

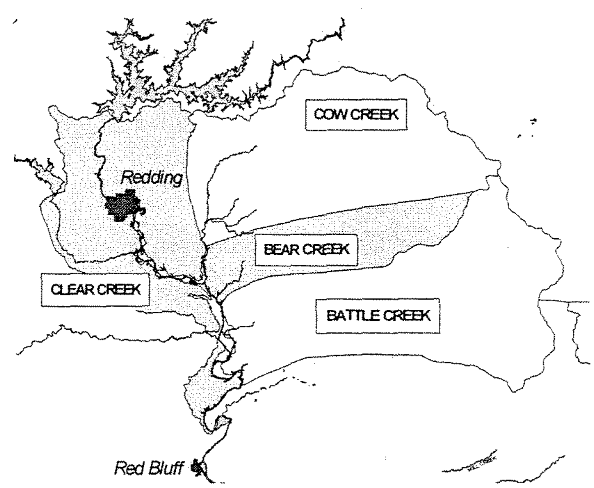
- Clear Creek Ecological Management Unit
- Cow Creek Ecological Management Unit
- Bear Creek Ecological Management Unit, and
- Battle Creek Ecological Management Unit.

Description of the Management Zone

This ecological management zone provides habitats for a significant variety of fish, wildlife, and plant communities, including spring-, fall-, and late-fall-run chinook salmon, steelhead trout, lamprey, native resident fish, neotropical migratory birds, and native anuran amphibians.

Important ecological processes and functions shared by the individual ecological units of the North Sacramento Valley Ecological Management Zone include their respective streamflow patterns and capacity for natural sediment transport; stream meander; gravel recruitment; and stressors, such as water conveyance structures, water diversion, and invasive plant species.

Opportunities to maintain or reactivate these processes and functions are constrained to varying degrees because of past and existing human activities, such as dam construction and gravel extraction from the active stream channel. Many of these constraints are described as stressors that impair ecological function and the creation and



Location Map of the North Sacramento Valley Ecological Management Zone and Units.

maintenance of habitats or that cause direct mortality to important species.

The construction and operation of Whiskeytown and McCormick-Saeltzer dams and past large-scale gravel extraction activities constrain ecological processes and functions in the Clear Creek Ecological Management Unit. Ecological processes and functions on Cow and Bear creeks are impaired by alterations to the runoff pattern resulting from water diversions and land use practices. Small hydropower projects, water diversion and water diversion structures constrain ecological processes and functions on Battle Creek. Past and current operation of Coleman National Fish Hatchery on the lower section of the creek further impairs opportunities to improve the distributions of wild salmon and steelhead stocks.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE NORTH SACRAMENTO VALLEY ECOLOGICAL MANAGEMENT ZONE

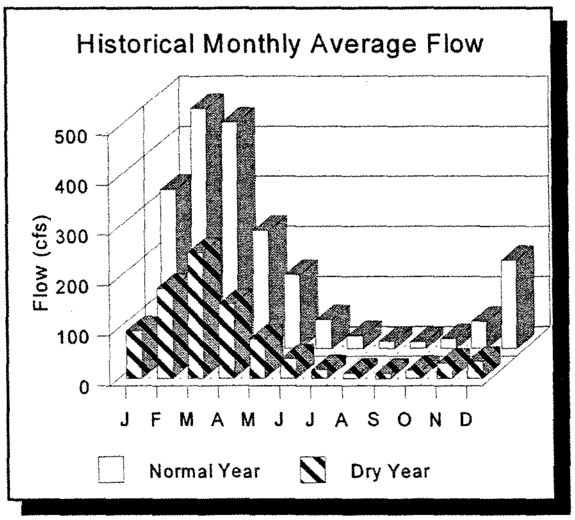
- spring-run chinook salmon
- fall-run chinook salmon
- late-fall-run chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

CLEAR CREEK ECOLOGICAL MANAGEMENT UNIT

Clear Creek is a major tributary to the Sacramento River and drains approximately 238 square miles. It originates in the mountains east of Trinity Lake and flows into the Sacramento River near Redding. Whiskeytown Reservoir stores natural creek flows and water diverted from the Trinity River at Lewiston Dam through the Clear Creek Tunnel. Whiskeytown Dam, constructed in 1963, is 10 miles upstream of McCormick Dam. The dam diverts more than 80% of Clear Creek's average natural flow to the Spring Creek Powerhouse at Keswick Reservoir on the Sacramento River.

The Clear Creek watershed has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills instead of the Cascade or Sierra crests. The stream is nearly dry during summer and fall months of low rainfall years. In wettest years, flows in winter months average 1,000 to 2,500 cubic feet per second (cfs). In winter months of dry years, average monthly flows reach only 100 to 250 cfs. In the driest years, winter monthly average flows reach only 20 to 35 cfs. Whiskeytown Dam, at the lower end of the watershed, receives water diverted from the Trinity River by way of the Clear Creek Tunnel. Most of the Clear Creek and Trinity River water is conveyed from Whiskeytown Lake to Keswick Reservoir on the Sacramento River through the Spring Creek Tunnel. Flows in Clear Creek below Whiskeytown Lake are maintained at 50 cfs from January through October and 100 cfs in November and December, regardless of flow in the upper



Clear Creek Streamflow, 1952-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

watershed. Approximately 10 cfs are diverted from the lower river at McCormick Dam, 8 miles upstream of the confluence with the Sacramento River.

Spawning gravel in the lower Clear Creek drainage has been significantly depleted by mining. Because recruitment of new gravel into this area is restricted by McCormick and Whiskeytown dams, Shasta County adopted an ordinance in 1977 prohibiting new gravel mines in Clear Creek below McCormick Dam. Although the future of this ordinance is uncertain, it constitutes the best protection for spawning gravel. The existing gravel mining operations have refrained from mining in the floodplain for more than 4 years, allowing some riparian reforestation to occur naturally.

Before the construction of Whiskeytown Lake, Clear Creek delivered large amounts of gravel to the lower alluvial reaches and the Sacramento River. Flow regulation since 1963 has greatly reduced the frequency of floodflows capable of moving bedload. The instream gravel is not renewable, because gravel from the upper reaches is trapped in the reservoir. Flow regulation has also allowed dense stands of vegetation to encroach on the main channel, particularly the lower 3 miles before the confluence. This vegetation further reduces velocities and the gravel transport capacity of the stream.

In 1980, the California Department of Water Resources (DWR) estimated that the average annual instream extraction rate of sand and gravel was approximately 75,000 tons per year, equivalent to 20 times the natural transport rate. Subsequent field observations in 1980 and 1994 suggest that gravel mining, flow regulation, and vegetative encroachment combined to reduce the available gravel in Clear Creek. The average annual contribution of gravel to the Sacramento River was estimated to be approximately 5,000 tons per year. In recent year years, gravel operators have halted the practice of instream mining. During this same period, gravels were distributed to the spawning area from tributary stream sources, stream meander, and artificially introduced gravel stockpiles. At this time there are two completed gravel injection projects and one in progress.

Spawning habitat restoration work in Clear Creek is necessary. The work will require placing spawning gravel at appropriate locations. Implementing this restoration will require monitoring spawning gravel to determine whether it successfully meets the needs of adult salmon and steelhead. It also will be necessary to continuously maintain and replenish the gravel. The intent is to provide the habitat and flow necessary to achieve its strategic objective.

The abundance of fall-run chinook salmon spawners in Clear Creek has increased during recent years when the fall flows have been increased by a factor of three. During this interim flow increase, the spawning population estimates have been between 7,000 and 9,000 representing 5% to 8% of the upper Sacramento River salmon population.

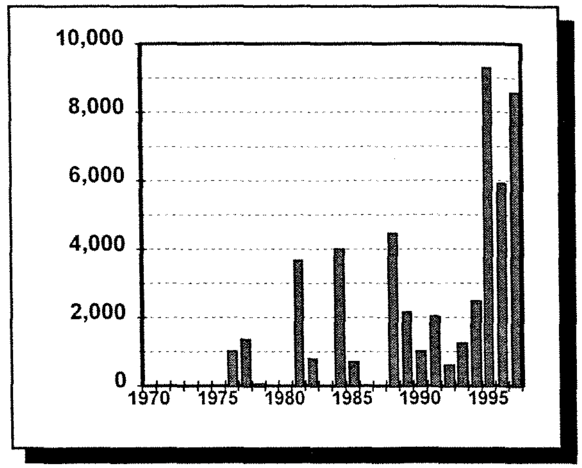
Spring-run chinook could have historically migrated to the uppermost reaches of Clear Creek above the town of French Gulch (Yoshiyama et al. 1996). In 1956, Azevedo and Parkhurst (1958) saw spring-run chinook in Clear Creek for the first time since 1949. Passage to the upper watershed was severely restricted by the construction of McCormick-Saeltzer Dam around the turn of the century, then completely eliminated by the construction of Whiskeytown Dam in 1964. It is likely the steelhead also ascended Clear Creek at least as far as French Gulch.

In spite of improved conditions, there are no spring-run chinook salmon in Clear Creek (California Department of Fish and Game 1998) and the status of the steelhead population is unknown. Habitat in Clear Creek has the potential to support spring-run chinook and steelhead if passage at McCormick-Saeltzer Dam is improved to allow adult fish access to the stream reach immediately below the Whiskeytown Dam. Operation of the dam can provide suitable cold-water habitat downstream to allow adult spring-run chinook to oversummer and then spawn in the fall. The cold water would also support juvenile salmon and steelhead rearing through the summer.

Restoring habitat and increasing flow releases from Whiskeytown Reservoir could significantly improve the present production of chinook salmon in Clear Creek. Steelhead populations would similarly benefit.

Restoring the Clear Creek chinook salmon and steelhead populations has been the focus of fishery management efforts in the upper Sacramento River drainage below Shasta Dam for most of the Twentieth Century. Interest and concern regarding the status of salmon and steelhead in this stream began shortly after the 1903 construction of the McCormick Dam, located 6 miles upstream of the Sacramento River. Early restoration efforts attempted to provide suitable adult fish passage at McCormick Dam, but as watershed and instream habitats continued to decline, the need for additional habitat restoration efforts increased. The cumulative effects of water export, gold mining, gravel extraction, timber harvest, road building, and the construction of Whiskeytown Dam have contributed to the decline of the Clear Creek anadromous fishery. Only in recent years has there been a recognition of the complexity of the problem and a multiagency cooperative effort to seek corrective actions designed to restore habitat and fish passage in Clear Creek. Local environmental groups and individuals have also been seeking solutions to the problems limiting Clear Creek's fishery potential.

The California Department of Fish and Game (DFG) manages Clear Creek for fall- and late-fall-run chinook salmon and steelhead trout. The stream is uniquely suited for intensive management because of its ability to provide cool temperatures in the upper reach and adequate flows in fall. The stream below McCormick Dam



Clear Creek Fall-run Chinook Salmon Returns, 1970-1997.

is most suitable for fall- and late-fall-run chinook salmon spawning, but unsuitable for oversummering spring-run chinook salmon or for year-round rearing of steelhead. Conditions above the dam are suitable for steelhead and spring-run chinook salmon.

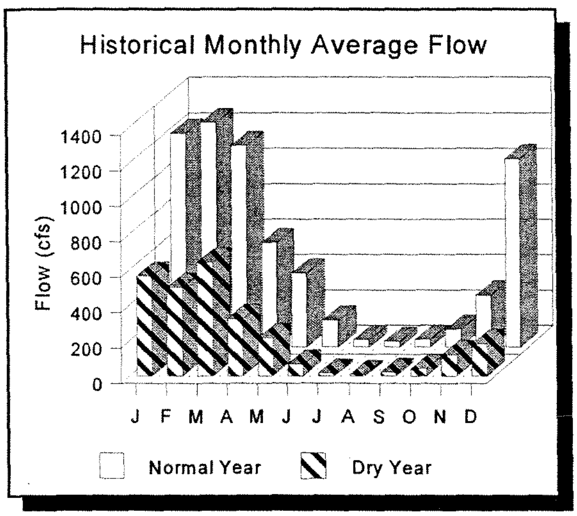
McCormick Dam impairs the up- and downstream passage of juvenile and adult anadromous fish. Removal of the dam would improve passage and survival of chinook salmon and steelhead and improve the transport of natural sediments from the stream reach above the dam to the lower reach.

Cow Creek Ecological Management Unit

Cow Creek flows through the southwestern foothills of the Cascade Range and enters the Sacramento River 4 miles east of the town of Anderson in Shasta County. Cow Creek encompasses five major tributaries: Little (North) Cow, Oak Run, Clover, Old Cow, and South Cow creeks. The drainage area is approximately 425 square miles, and the average discharge is 501,400 acre-feet per year.

Cow Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills rather than from the Cascade or Sierra crests. Near its mouth (where the gaging station is located), the stream is nearly dry during the summer and fall months of dry years. USGS surface water records show the mean August flow of 35 cfs, September at 45 cfs, and October at 131 cfs with a maximum August flow of 115 cfs and a minimum of 1 cfs.

In wetter years, flows in winter months average 2,600 to 6,000 cfs. In winter months of dry years, average monthly flows peak at 500 to 650 cfs. In the driest years, winter monthly average flows reach only 80 to 120 cfs. Small agricultural diversions contribute to lower flows in summer and fall. A Pacific Gas and Electric Company (PG&E) hydropower project diversion reduces flow on a 10-mile section of the South Fork.

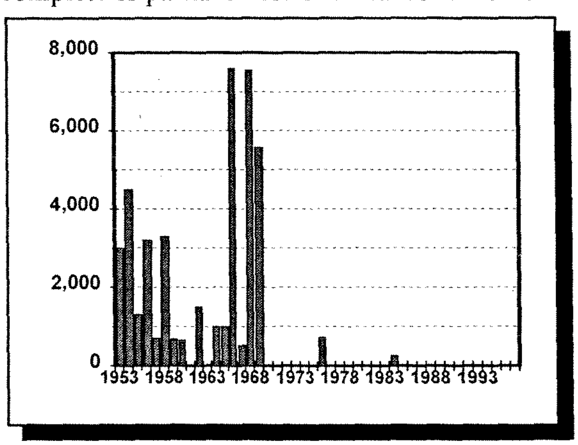


Cow Creek Streamflow, 1953-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

In the past, Cow Creek has supported eight small gravel mining operations. The lower 10 miles of channel is approximately 50% exposed bedrock. Where bedload is deposited, it is generally only a thin veneer. Instream mining was eliminated with the passage of a Shasta County gravel mining ordinance. There has been no instream gravel mining in Cow Creek for at least 12 years. Because of the limited availability of gravel, the bedload transport rate was estimated to be 19,000 tons per year.

Fall-run and late-fall-run chinook salmon spawn in the creek on the valley floor and in all five tributaries. Adult steelhead trout have been observed in South Cow, Old Cow, and North Cow Creeks. Previous management plans have estimated the potential of fall-run salmon in Cow Creek at 5,000 spawners; however, fall-run chinook salmon populations have been as high as 7,600. The average run size from 1953 to 1969 was 2,800 salmon. In recent drought years, there have been too few salmon in Cow Creek to make population estimates. No major diversions exist in the fall-run spawning reach, and the average monthly flow from October through December has actually increased since 1969. The decline in the Cow Creek fall-run salmon population coincides with salmon population declines throughout the Sacramento River basin. There are no estimates for late-fall-run chinook in Cow Creek.

In 1992, DFG conducted stream surveys of four of the five Cow Creek tributaries. Emphasis was placed on evaluating habitat for spring-run chinook salmon and steelhead trout holding, spawning, and rearing. The survey results concluded that Cow Creek is not suitable for spring-run chinook salmon because of warm summer water temperatures and lack of large holding pools. Steelhead, however, could survive if provided access to the tributaries above the valley floor. North Cow, Clover, and Old Cow Creeks have natural bedrock falls that are either complete or partial barriers to anadromous fish.



Cow Creek Fall-run Chinook Salmon Returns, 1954-1997.

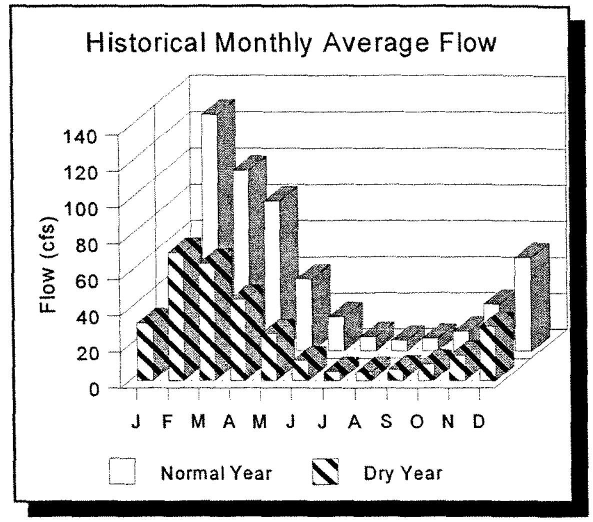
Land use activities in the Cow Creek drainage include agriculture, timber harvest, livestock grazing, and hydropower production. Loss of habitat and water diversions are largely the result of activities associated with livestock production. The only laddered dams and screened diversions are part of hydropower facilities. Agricultural diversions are unscreened, ditches are unlined and poorly maintained, and grazing is destroying some of the riparian corridor and causing excessive erosion.

Population growth in the towns of Palo Cedro, Bella Vista, Oak Run, and Millville is resulting in increased demand for domestic water and is affecting riparian habitat in the Cow Creek watershed. Measures are required to protect the existing habitat from further damage associated with gravel extractions, water diversions, creek-side development, and livestock grazing. Cow Creek presents a unique opportunity to maintain and preserve fall- and late-fall-run salmon and steelhead habitat while nearby development increases.

BEAR CREEK ECOLOGICAL MANAGEMENT UNIT

Bear Creek is a small, eastside tributary entering the Sacramento River 5 miles below Anderson. The stream has low streamflow in spring through fall months of most years and flows year round at the Highway 44 bridge in dry years. All steelhead habitat is above this bridge. During spring and summer, the limited natural streamflow is further reduced by irrigation diversions in the lower reaches, where the stream enters the valley floor. Adequate streamflows in fall and spring are prerequisites for anadromous fish migration and reproduction.

The limited runoff in this small stream makes it difficult to simultaneously meet the limited agricultural water demands and instream flow needs of anadromous fish, especially in below-normal water years. During above normal water years, there is a reduced risk to juvenile salmon and steelhead during the spring diversion season, because irrigation water demands are reduced and the diversion rates are relatively small compared to the total streamflow.



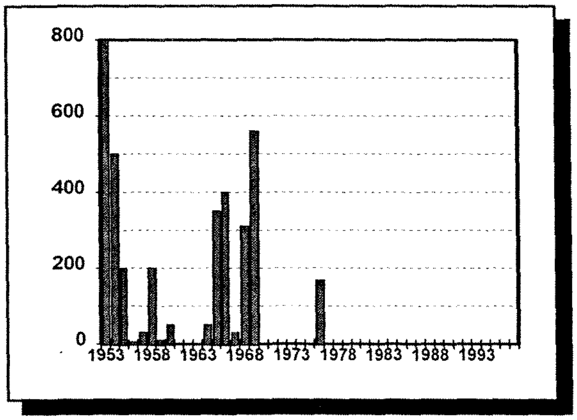
Bear Creek Streamflow, 1960-1967 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Bear Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills rather than the Cascade or Sierra crests. Near its mouth (where the gaging station is located) the stream is nearly dry during summer and fall months of low rainfall years. In wettest years, flows in winter months average 1,100 to 2,000 cfs. In winter months of dry years, average monthly flows reach only 30 to 70 cfs. In the driest years, winter monthly average flows reach only 20 to 35 cfs. Small agricultural diversions contribute to lower flows in summer and fall.

Bear Creek is able to support populations of fall-run chinook salmon only when early fall rains create suitable conditions for passage over shallow riffles and allow access to the limited spawning habitat. Because of low and warm streamflow conditions in spring, juvenile salmon and steelhead must emigrate early in the season to survive.

Salmon spawning surveys conducted during years with sufficient flows to attract adult salmon indicate that Bear Creek can support 150-300 spawning salmon. Steelhead have been observed in the creek, but no population estimates have been made.

Unscreened irrigation diversions operating during the juvenile emigration period for chinook salmon and steelhead can significantly reduce survival rates.



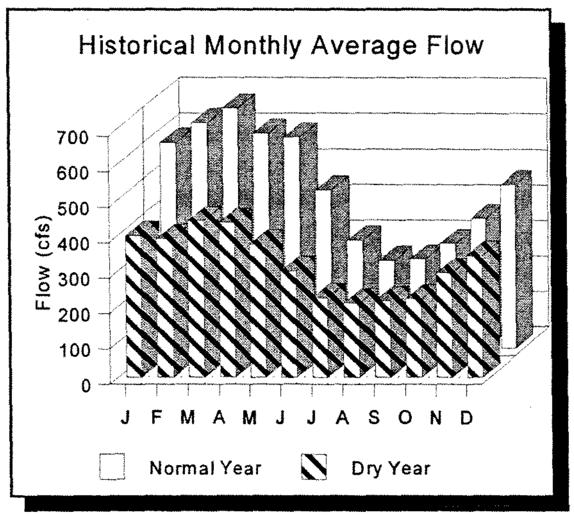
Bear Creek Fall-run Chinook Salmon Returns, 1943-1997.

Battle Creek Ecological Management Unit

Battle Creek enters the Sacramento River approximately 5 miles southeast of the Shasta County town of Cottonwood. It flows into the Sacramento Valley from the east, draining a watershed of approximately 360 square miles.

Battle Creek has a natural flow pattern of high winter and moderate summer-fall flows, typical of Mount Shasta-Cascade spring-fed streams. Near its mouth (where the gaging station is located), the stream has average flows of 240 to 260 cfs in summer and fall. Even in the drier years, flows are more than 150 cfs. In wettest years, flows in winter months average 1,200 to 2,400 cfs. Battle Creek has the best connection between the river and mountainous areas of any Sacramento River ecological management unit. PG&E operated a series of small run-of-the-river hydroelectric diversions that divert up to 98% of the stream's baseflow and a much smaller portion of the wet season flow. Under and interim agreement, the required minimum fishery releases to the creek are increased by a factor of 10 at three diversions in a 17-mile section of the creek system.

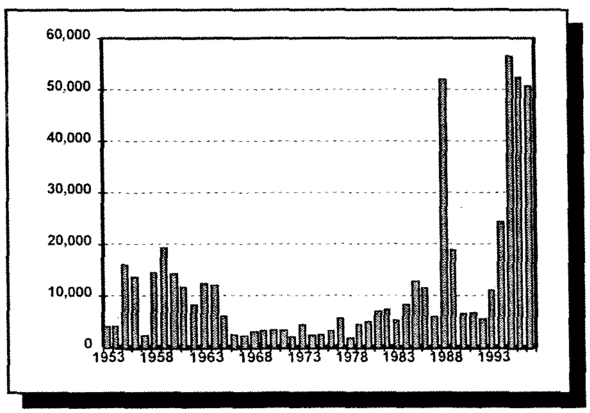
PG&E owns and operates the Battle Creek project, which consists of two small storage reservoirs, four unscreened hydropower diversions on the North Fork Battle Creek, three unscreened hydropower diversions on South Fork Battle Creek, a complex system of canals and forebays, and five powerhouses.



Battle Creek Streamflow, 1963-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

ERPP proposes to restore important ecological functions and processes and habitats in a step-by-step approach over several years. Restoration of these ecosystem elements will permit the restoration of anadromous fish in the basin. In addition, restoration will require disease management measures for the fish hatchery water supply. As the range of anadromous fish in the watershed is increased, additional efforts will be directed at fish screens, fish ladders, hatchery water supply management, and increased releases of water from hydroelectric diversions. The approach will first restore the stream reach capable of supporting all types of anadromous fish. This approach will restore approximately one-half of the available anadromous fish habitat without subjecting the hatchery to increased disease risk or degrading the quality of the hatchery water supply.

Before development, Battle Creek was one of the most important chinook salmon spawning streams in the Sacramento Valley. Runs of fall-, winter-, and spring-run chinook salmon and steelhead were found there. Natural spawning of salmon and steelhead in Battle Creek between the Coleman National Fish Hatchery weir and the mouth is still significant but suffers from spawning populations too large for available habitat. The blockage of the fall-run chinook salmon migration at the hatchery and the effect of low flows caused by PG&E's hydropower operations have combined to reduce salmon and steelhead populations above the hatchery to remnant status.



Battle Creek Fall-run Chinook Returns, 1953-1997.

There is one large, unscreened agricultural diversion (Battle Creek Diversion). DFG constructed a screen for this diversion, but because of landowner concerns, installation of the screen was delayed. The screen has recently been installed.

Restoring the remnant populations of naturally spawning chinook salmon and steelhead located above the fish hatchery barrier dam to a healthy status can be done in a manner that integrates the beneficial uses of hydropower production and aquaculture in the watershed. Physical and operational changes of PG&E's projects include screening or removing the diversions on the North Fork and South Fork of Battle Creek, increasing releases from project diversions, and stopping removal of stream gravel that accumulates at project diversions.

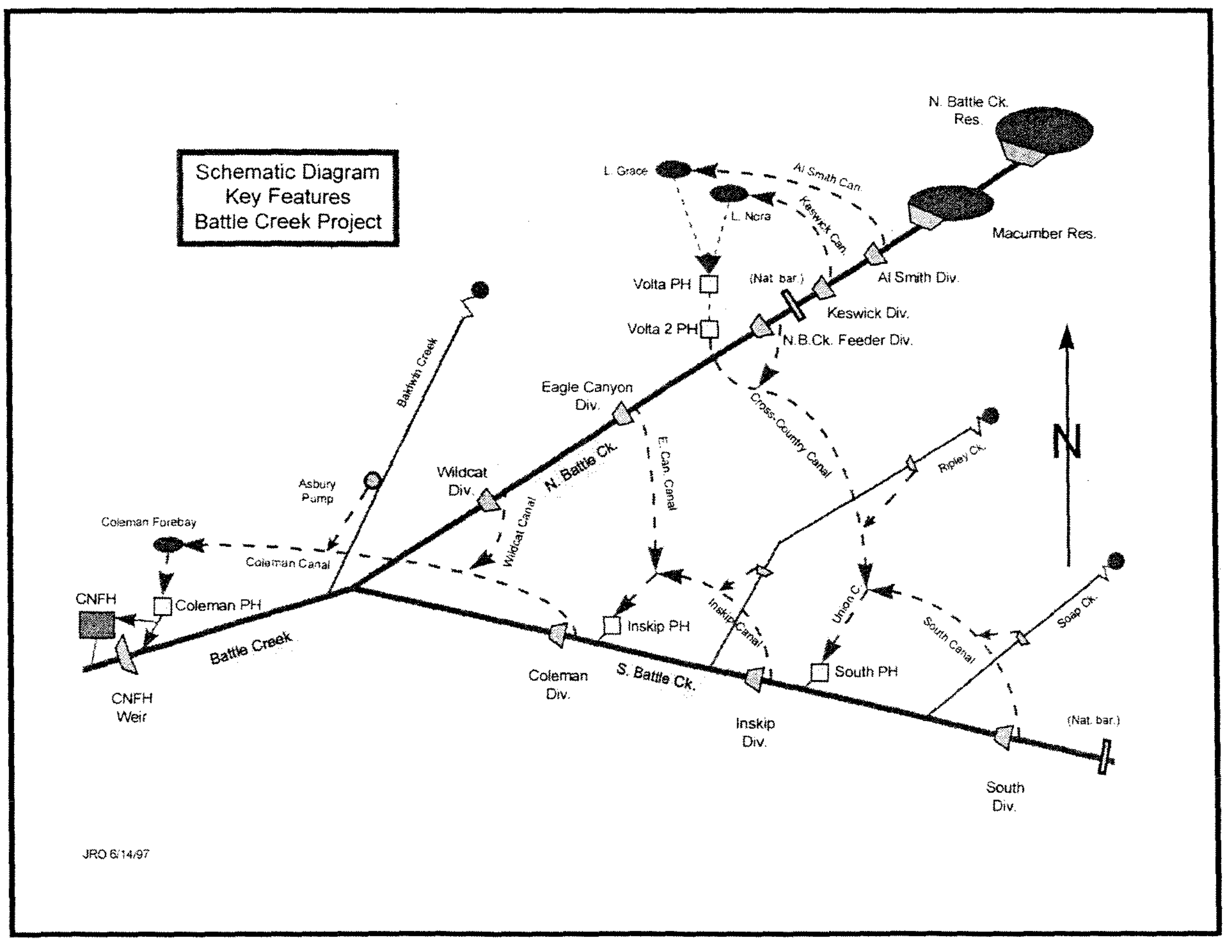
Anadromous fish have historically migrated above the hatchery during minor and major storm events each year which flood out the hatchery barrier dam and when the fish ladder at the barrier dam has been opened for four to five months during past years. The Coleman Hatchery Development Plan proposes a phased installation of an ozone sterilization system. The present level of ozonation at Coleman Hatchery (10,000 g.p.m.) is sufficient to sterilize all the water needed to produce the early life stages of chinook salmon and steelhead and one-third of the water necessary to produce juvenile fish. The environmental documents and preliminary funding arrangements have been completed to begin the construction of the remaining two-thirds of the water supply needed for juvenile fish production.

The restoration of naturally produced runs of anadromous fish in Battle Creek can be conducted in a manner compatible with the phasing in of the ozone treatment plant. If those races of salmon that represent a significant disease risk are restricted through seasonal fish ladder closures to the first 17-mile reach of Battle Creek above the hatchery for the initial phase of restoration, a hatchery water supply can be maintained and the capacity to supply the balance of the hatchery water supply that will not be treated with ozone can be reached. It will be necessary to improve the reliability of the Coleman Canal water supply.

The fish hatchery, located approximately 6 miles upstream of the mouth of Battle Creek, is operated by the U.S. Fish and Wildlife Service (USFWS). It was constructed by Reclamation as partial mitigation for the construction of Shasta Dam and produces fall-run chinook salmon, late-fall-run chinook salmon, and steelhead trout. Winter-run chinook salmon, a federally and State-listed endangered species, was also successfully propagated in small numbers at the hatchery to supplement the wild population. The winter-run chinook artificial propagation program at Coleman was stopped and is in the process of being moved to a new facility at the base of Shasta Dam. This is scheduled to be operational in early 1998.

Restoration of Battle Creek's anadromous fish habitat above the valley floor will focus on restoring spring-run chinook salmon and steelhead trout. These actions will be sufficient to provide for the requirements of winter-run chinook salmon that may return to Battle Creek.

Surveys conducted before the construction of Shasta Dam indicate that, with sufficient water, the stream reaches above the fish hatchery could provide spawning habitat for more than 1,800 pairs of salmon. The stream reaches up to MacCumber Dam are not reachable by anadromous fish because of barriers. The anadromous reach in the North Fork Battle Creek extends up to approximately two miles above the North Fork Battle Feeder Dam. The recent (1991) evaluation of spawning habitat in the portions of Battle Creek watershed accessible to anadromous fish above Coleman Hatchery Fish Barrier estimate 166,000 square feet of spawning gravel. Potentially, this much spawning habitat could accommodate 3,500 spawning pair. The North Fork of Battle Creek, Eagle Canyon in particular, contains deep, cold, and isolated pools ideal for holding spring-run chinook salmon throughout summer. Because of the critically low numbers of spring-run chinook salmon and steelhead in the Sacramento River drainage, any expansion of available habitat for these fish has a high priority.



From 1985 through 1989, adult fall-run chinook salmon, surplus to the fish hatchery egg-taking needs, were released into Battle Creek above the hatchery weir to spawn naturally. Because of potential disease problems at the hatchery related to decomposing carcasses, the fish ladders on PG&E's two lowermost diversions (Wildcat Diversion on the North Fork and Coleman on the South Fork) were closed. This action prevented fish from ascending into the area above the hatchery water supply intake and eliminated the possibility of salmon migrating into the middle or upper reaches of those streams.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the North Sacramento Ecological Management Zone is to restore important fishery, wildlife, and plant communities to a healthy condition. To attain this vision, the Ecosystem Restoration Program Plan recommends developing and implementing comprehensive watershed management plans for the streams in this zone, which will restore important ecological processes that create and maintain habitats for fish, wildlife, and plant communities.

The vision focuses on restoring spring-run chinook salmon and steelhead to population levels of the late 1960s and early 1970s. To achieve this vision, ERPP recommends increased protection for naturally produced chinook salmon and steelhead as they rear and migrate downstream from the natal areas to the mainstem Sacramento River. This would involve improving passage at water diversion structures; installing positive-barrier fish screens to protect juveniles; and providing sufficient flows for migration, holding, spawning, and rearing.

Gravel extraction is a significant problem in many areas of this ecological management zone, and a cooperative effort is needed to relocate this activity to sites away from the active stream channels. ERPP also recommends reestablishing floodplains in the lower stream reaches to allow stream channel meander, sediment transport and deposition, and a healthy riparian corridor. Actions to maintain and restore healthy riparian zones include providing shaded riverine aquatic habitat and woody debris and maintaining biologically productive gravel beds for fish spawning and invertebrate production.

ERPP envisions that the fish, wildlife, and riparian needs of the North Sacramento Valley Ecological Management Zone will be met and an acceptable level of ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

CLEAR CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Clear Creek Ecological Management Unit is to restore flows from Whiskeytown Dam to allow successful upstream passage of chinook salmon and steelhead to historical habitat, restore sediment transport and gravel recruitment in the stream channel, and establish a clearly defined stream meander zone, and riparian and riverine aquatic plant communities.

The potential of providing sustainable and resilient ecological processes and habitats will be enhanced by developing a locally sponsored watershed management planning process for this unit.

CLEAR CREEK WATERSHED DEMONSTRATION PROGRAM: Clear Creek has tentatively been selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1, CALFED will support and bolster ongoing efforts to implement a successful management and rehabilitation effort within this watershed so that lessons learned in this watershed can be applied to similar watersheds.

Clear Creek has some interesting attributes that have contributed to its selection.

- The upper watershed is in mixed private and federal ownership and is included in the President's Northwest Forest Planning effort.
- The watershed is addressed by the Northwest Sacramento Province Advisory Committee comprised of representatives of federal agencies such as the U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management and others.
- Streamflows in Clear Creek below Whiskeytown Dam are controlled largely by the U.S. Bureau of Reclamation.
- Restoration of Clear Creek is specified in the Central Valley Project Improvement Act.
- Clear Creek supports chinook salmon and with restoration could support spring-run chinook salmon and steelhead.
- Strong local interest in the watershed.
- Many ongoing restoration activities and efforts such as land acquisition, water acquisition, and passage improvement.

Cumulatively, an investment in Clear Creek during Stage 1 will provide direct benefits to the creek and provide the types of restoration information needed to successfully move the Ecosystem Restoration Program into subsequent implementation phases. A few of the lessons to be learned in the Clear Creek watershed include how to improve overall watershed health; how to integrate local, state, federal, and private efforts in a large-scale restoration program; how to design and implement actions to benefit spring-run chinook salmon and steelhead; and how to best manage ecological processes such as sediment transport and stream meander in a highly modified stream system.

Cow Creek Ecological Management Unit

The vision for the Cow Creek Ecological Unit includes reducing adverse effects of timber harvest, erosion, and cattle grazing on the stream and riparian system and maintaining or restoring streamflows during important periods of the year to allow fish migration, spawning, and rearing of fall-run chinook salmon and steelhead trout. A comprehensive watershed management plan developed and implemented at the local level would assist in restoring this creek. In addition, sediment in the creek is limited, and ERPP recommends a cooperative program to relocate gravel extraction operations to areas outside the active stream channel.

Actions on Cow Creek include obtaining flow agreements, screening diversions to protect all life stages of anadromous fish, improving fish passage at agricultural diversion structures, and fencing selected riparian corridors in the watershed to exclude livestock and promote riparian regeneration.

Bear Creek Ecological Management Unit

The vision for the Bear Creek Ecological Management Unit will emphasize restoring and maintaining important ecological processes, such as streamflow and sediment supply. Steelhead trout is an important species that will benefit from improvements related to fish passage and immigration and holding, spawning, and rearing habitats. The individual value of Bear Creek is small, but, cumulatively, the values of streams such as this can be integral and valuable in restoring ecological health to the Bay-Delta system, particularly for the steelhead trout and fall-run chinook salmon resources. Recent, but limited field studies, have shown that in some years lower Bear Creek can provide valuable non-natal rearing habitat for juvenile salmonids.

ERPP recommends a cooperative program with water users for a mutually acceptable flow schedule that would not only provide protection for downstream migrating salmon and steelhead but recognize the needs of agriculture. This could be accomplished through conjunctive use of groundwater.

BATTLE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Battle Creek Ecological Management Unit includes support for a local watershed conservancy and developing and implementing a comprehensive watershed management plan, increasing flows, improving the water supply to Coleman National Fish Hatchery, removing diversion dams or installing new ladders, and installing positive-barrier fish screens to protect juvenile chinook salmon and steelhead.

Improving water management operations and installing positive-barrier fish screens will provide large benefits to many aspects of the ecological processes and fish and wildlife in the watershed. ERPP also envisions that Battle Creek will provide much-needed habitat for steelhead trout and spring-run chinook salmon, in addition to maintaining its existing importance to fall- and late-fall-run chinook.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Healthy instream flows are sustained to restore ecological processes and functions that maintain habitats and support aquatic species. Streamflows shape channels, support riparian vegetation, provide habitat for fish, and transport young fish downstream. Healthy streamflow patterns in the streams tributary to the upper reach of the Sacramento River below Keswick Dam would emulate natural flow patterns, with late-winter/early-spring flow events and sustained flow well into the summer. The vision is that streamflow will be provided at levels that activate ecological processes that shape the stream channels and sustain riparian and riverine aquatic habitat, transport sediments, and sustain juvenile anadromous fish during the summer.

COARSE SEDIMENT SUPPLY: The supply of sediments to the streams in the North Sacramento Valley Ecological Management Zone support stream channel maintenance and sustain riparian and riverine aquatic habitats. This sediment includes gravel for fish spawning and invertebrate production The vision is that processes to provide a continual supply of coarse sediments will be restored, reactivated, or supplemented.

STREAM MEANDER: Streams in the North Sacramento Valley Ecological Management Zone exhibit a natural tendency to meander. This provides for the continual supply of coarse sediments, regeneration of the riparian corridor, and the rejuvenation of gravels used for fish spawning and invertebrate production. The vision is that stream meander corridors will be established or maintained to provide much of the needed sediments and habitats for fish, wildlife, and plant communities.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: River-floodplain interactions are important ecological events that occur at varying intervals, ranging from annual inundation of some of the floodplain to flow or flood events that inundate most of the floodplain. The larger events occur within 5-, 10-, 50-year or longer intervals. This recurrent flood cycle maintains the stream channel, allows the stream to contact higher gravel terraces, supports riparian regeneration, and allows the stream channel to migrate. The vision is that the floodplains of streams in the North Sacramento Valley Ecological Management Zone will be maintained at levels that permit recurrent floodplain inundation.

CENTRAL VALLEY STREAM TEMPERATURES: Chinook salmon and steelhead are dependent on specific stream temperatures. Optimum spawning and egg incubation typically occurs at 52°F while optimum rearing temperatures are slightly higher. Temperature requirements also vary among chinook runs, species, and life stage. The vision for stream temperatures is to provide sufficient flows to sustain cool water during important life stages to support all life stages of chinook salmon, steelhead, and other aquatic organisms.

VISION FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC: Riparian and riverine aquatic habitats support a wide diversity of aquatic and terrestrial species. Healthy riparian corridors provide a migratory pathway between lower and higher elevation habitats for terrestrial species, such as mammals and birds. Shaded riverine aquatic habitat provides important habitat complexity in the stream, which includes shade and escape cover for juvenile fish. The vision for riparian and riverine aquatic habitat is that riparian corridors will be maintain and restored by improvements in sediment transport, stream meander, reconnecting streams with their floodplains, improved grazing and other land use practices, and by the creation of extensive riparian protection zones.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper sections of these creeks are typical of salmon-steelhead streams while the lower sections are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The vision is that the quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Clear, Cow, Bear, and Battle creeks have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision is for EFH is to maintain or restore substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSION: Water diversions reduce the quantity of flow below the diversion point and cause direct mortality by entraining young fish. The vision for water diversion and unscreened diversion in the North Sacramento Valley Ecological Management Zone is that sufficient flow will remain below diversion points to permit the successful up- and downstream migration of adult and juvenile fish, and that water will be diverted through state-of-the-art positive barrier fish screens to reduce loss of juvenile fish.

DAMS AND OTHER STRUCTURES: Instream structures frequently impair the upstream and downstream passage of anadromous fish. The vision for the North Sacramento Valley Ecological Management Zone is that the connections between upstream holding, spawning, rearing, and migration habitats and the Sacramento River will be reestablished, improved, maintained, and reestablished on some streams to permit unobstructed fish passage.

GRAVEL MINING: Gravel mining can greatly reduce the quality and quantity of coarse sediments in the streams of the North Sacramento Valley Ecological Management Zone. The vision is that gravel mining operations in the active stream channel will be reduced and relocated to alluvial deposits outside the active stream channel.

INVASIVE RIPARIAN AND MARSH PLANTS: Invasive riparian plants can outcompete and displace native vegetation. Often, these invasive plants have little or no value to native fish or wildlife species. The vision for reducing invasive riparian plants in the North Sacramento Valley Ecological Management Zone is to establish cooperative and coordinated eradication programs that allow the regeneration of native plant species and communities.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of chinook salmon and steelhead can reduce the number of spawning fish and impair other efforts to restore and rebuild spawning populations. The vision for illegal harvest in the North Sacramento Valley Ecological Management Zone is to implement a stronger enforcement and public education program. The vision for legal harvest is to develop harvest strategies that assist in the restoration of anadromous fish species.

ARTIFICIAL PROPAGATION OF FISH: The production of chinook salmon and steelhead at Coleman National Fish Hatchery on Battle Creek supports important sport and commercial fisheries and mitigates loss of salmon and steelhead habitat that resulted from the construction of Shasta Dam. Due to release practices, hatchery fish from Battle Creek and other Central Valley hatcheries supplement the numbers of naturally spawning salmon and steelhead in the Sacramento River and its tributaries. Hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for resources. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers. The vision for artificial production in the North Sacramento Valley Ecological Management Zone is to implement hatchery practices that contribute to the recovery of naturally spawning populations of salmon and steelhead.

VISIONS FOR SPECIES

SPRING-RUN CHINOOK SALMON: The vision for spring-run chinook is to recover this State-listed threatened species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. Spring-run chinook are dependent on late-winter/early-spring flows for upstream passage, deep pools and cool water for oversummer survival, and quality gravel for successful spawning in the fall. The vision for spring-run chinook salmon in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support adult and juvenile populations.

FALL-RUN CHINOOK SALMON: The vision for the fall-run chinook salmon is to recover all stocks proposed for listing under ESA. Fall-run chinook depend on late-summer and fall streamflow for access to spawning areas in the lower stream reaches. Habitat suitability is influenced by water temperatures. The vision for fall-run chinook salmon in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support spawning and juvenile rearing through late spring.

LATE-FALL-RUN CHINOOK SALMON: The vision for late-fall-run chinook salmon is to recover this run proposed for listing under the ESA. Late-fall-run chinook typically depend on winter stream flows and quality spawning gravel. The vision for late-fall-run chinook salmon in the North Sacramento Valley Ecological Management Zone is to improve ecological processes that create and maintain spawning habitat and reduce sources of mortality that diminish survival of juvenile and adult fish.

STEELHEAD: The vision for Central Valley steelhead is to recover this federally listed threatened species and achieve naturally spawning populations of sufficient size to support inland recreational fishing at that use fully existing and restored habitats. Juvenile steelhead are dependent on cool water for oversummer survival, late-winter/early-spring flows for downstream passage, and quality gravel for successful spawning in the late winter/early spring. The vision for steelhead in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support adult and juvenile populations.

LAMPREY: The vision for lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors in the North Sacramento Valley Ecological Management Zone which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to better manage these species and their habitat.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

LOCAL WATERSHED PLANNING GROUPS

Maintaining and restoring the ecological health of the ecological units in the North Sacramento Valley Ecological Management Zone will depend heavily on local watershed groups, including local landowners, concerned individuals, and local resource experts. The only formal watershed planning group in this Ecological Management Zone is the Clear Creek Coordinated Resources Management Program (ARMP) fostered by the Western Shasta Resource Conservation District. A Battle Creek watershed interest group is forming but has not developed a formal approach to watershed planning. Additional groups are needed to sponsor watershed planning and restoration on Cow and Bear Creeks.

Ecosystem restoration efforts in the North Sacramento Valley Ecological Management Zone will be linked to cooperation from resource agencies, such as DFG, DWR, USFWS, and the National Marine Fisheries Service (NMFS), as well as participation and support from Reclamation, the U.S. Natural Resources Conservation Service, and private organizations, water districts, and individual landowners. These groups are expected to work together to maintain and restore streamflows and fish and wildlife habitat, reduce the impacts of diversions, and minimize poaching and habitat and water quality degradation in basin streams. In support of this effort, cooperating agencies should seek funding for enhancing streamflows, reducing fish passage problems, screening diversions, restoring habitats, and increasing Fish and Game Code enforcement to protect recovering populations of salmon and steelhead.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and assist in obtaining funding for feasibility studies, environmental permitting, and project construction. The vision will help DFG as it progresses toward doubling the number of anadromous fish over the number present in 1988.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The U.S. Fish and Wildlife Service and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoring habitats and species and eliminating many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment, fish passage, water temperature control in the reach between Keswick Dam and the Red Bluff Diversion Dam (RBDD), water acquisition, and other measures that will contribute to health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

The vision for the North Sacramento Valley Ecological Management Zone will contribute to and benefit from the Anadromous Fish Restoration Program (AFRP), which strives to double the natural production of anadromous fish in the system over the average production from 1967 through 1991.

Reclamation is willing to assist in restoring Clear Creek fish habitat by providing additional water from Whiskeytown Reservoir. The amount of water committed to maintain salmon and steelhead in this creek is presently recommended not to exceed 200 cfs from October 1 through June 1 and 150 cfs from June 2 to September 30. Flows are being evaluated to determine the instream flow necessary to achieve the strategic objective. Because passage and McCormick-Saeltzer Dam has not yet been achieved, AFRP recommended flows have not been implemented for Clear Creek (USBR and DWR 1999).

CALFED BAY-DELTA PROGRAM

CALFED has funded eight ecosystem restoration projects in the North Sacramento Valley. Most projects improve fish passage. One project improves fish passage on Clear Creek by removing McCormick Seltzer Dam. The most significant project in the Zone will re-open 42 miles of fish habitat on Battle Creek by removing five diversion dams and laddering and screening another three dams.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

The North Sacramento Valley Ecological Management Zone is most closely linked to the Sacramento River Ecological Management Zone and exhibits a high degree of connectivity through the confluences of Clear, Cow, Bear, and Battle creeks with the Sacramento River Ecological Management Zone.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Programmatic target: More closely emulate the seasonal streamflow patterns in Clear, Cow, and Battle Creeks in most year types by providing or maintaining flows that mobilize and transport sediments, allow upstream and downstream fish passage, create point bars, and contribute to stream channel meander and riparian vegetation succession.

Target 1: Increase flow in Cow Creek by 25 to 50 cfs, corresponding to the natural seasonal runoff pattern, and maintain 25 to 75 cfs during October (◆◆).

Programmatic Action 1A: Increase flow in Cow Creek by purchasing water from willing sellers or implementing a conjunctive groundwater program.

Target 2: Increase flow in Clear Creek to 150 to 200 cfs from October 1 to May 31 and to 100 to 150 cfs from June 1 to September 30 (◆◆).

Programmatic Action 2A: Develop a cooperative program to improve flow in Clear Creek by increasing releases from Clair Hill Whiskeytown Dams.

Target 3: Augment flow in Battle Creek by 25 to 50 cfs (◆◆).

Programmatic Action 3A: Increase flow in Battle Creek by purchasing water from willing sellers or providing compensation for forgone power production. This includes negotiating and renewing an existing interim flow agreement between the Department of the Interior and PG&E, and includes a provision for the release of 10 cfs at the Asbury Pump on Baldwin Creek, a dewatered Battle Creek tributary that provides steelhead habitat. In the longer-term, this action also include increasing flows at the Inskip Diversion Dam and South Diversion Dam.

Target 4: Augment flow in Bear Creek by 10 to 20 cfs (◆).

Programmatic Action 4A: Increase Bear Creek flow by purchasing water from willing sellers or providing alternative sources of water to diverters during important fish passage periods in spring and fall.

Rationale: *The streams in the North Sacramento Valley Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. One of the key attributes of streamflow in this ecological zone is providing for successful upstream passage of adult fish. Water is diverted from the streams in this zone during periods that impair upstream passage conditions and prevent fish from reaching important oversummering or spawning habitats. Acquiring water from willing sellers and implementing programs to provide alternative sources of water during important periods are direct approaches to solving this problem. For example, natural flow in Bear Creek is often less than the combined water rights of diverters, resulting in total dewatering of the creek in the valley reach during critical periods for chinook salmon.*

The recommended AFRP flows for Clear Creek, as specified in Target 2, should be implemented immediately. Because steelhead and spring-run chinook salmon do not have access to the better quality habitat upstream of McCormick-Saeltzer Dam, it is all the more imperative that adequate flows be provided to restore some conditions in the reach immediately below McCormick-Saeltzer Dam.

Central Valley Stream Temperatures

Target 1: Maintain suitable water temperatures in Clear Creek for spring-run chinook and steelhead holding, spawning, and rearing (◆◆◆).

Programmatic Action 1A: Maintain 56° F to approximately 3 miles downstream of McCormick-Saeltzer Dam from June through September.

Rationale: *Whiskeytown Dam provides an excellent opportunity to provide cold water releases from the lower depths of the reservoir to maintain adequate temperatures in downstream reaches. Because salmon and steelhead cannot access the higher quality habitat in Clear Creek because of the blockage at McCormick-Saeltzer Dam, greater releases will need to be made from Whiskeytown Dam to provide adequate temperatures in the reach below McCormick-Saeltzer Dam. Preliminary results from an ongoing temperature modeling study indicate that the AFRP recommended flows have the potential to provide adequate temperatures for spring-run chinook and steelhead in most of the reach between Whiskeytown and McCormick-Saeltzer dams. However, higher releases are necessary to achieve adequate temperatures below McCormick-Saeltzer Dam, and should be provided until McCormick-Saeltzer Dam is removed or modified to allow passage.*

Coarse Sediment Supply

Target 1: Maintain existing levels of erosion and gravel recruitment in streams of the North Sacramento Valley Ecological Unit and, where necessary, supplement gravel recruitment through adaptive management and monitoring (◆◆).

Programmatic Action 1A: Cooperatively develop appropriate land use plans that allow the natural recruitment of sediments to streams in the North Sacramento Valley Ecological Management Zone.

Target 2: Increase existing levels of erosion and gravel recruitment in Clear Creek by 25 to 50 tons per year (◆◆◆).

Programmatic Action 2A: Develop a cooperative program to improve gravel quality and quantity in lower Clear Creek to maintain high-quality spawning conditions for fall-run and late-fall-run chinook salmon by evaluating the addition of 5,000 to 10,000 cubic yards annually as needed. Evaluate the need to acquire or relocate existing mining operations. Alter McCormick Dam so that it no longer serves as a sediment trap.

Target 3: Increase existing levels of erosion and gravel recruitment in Cow Creek by 5 to 10 tons per year (◆◆).

Programmatic Action 3A: Develop a cooperative program to protect existing gravel and bedload movement in Cow Creek to maintain and increase future spawning gravel and sediment input to the Sacramento River by 5 to 10 tons per year by evaluating the need or opportunity to acquire or relocate existing gravel mining operations.

Rationale: *Replenishing gravel supplies to a level sufficient to support target populations of salmon and steelhead will help to improve populations to desirable levels and to maintain such levels once achieved. Replenishing gravels to maintain channel-forming processes and stream meanders will help to maintain fish and wildlife habitats, aquatic algae and invertebrate production, and streamside vegetation (California Department of Water Resources 1980). A predevelopment level of gravel recruitment should be adequate to restore the natural ecological processes supported by gravel recruitment, but may require experimenting, monitoring, and experience to determine the exact amount of gravel supplies necessary to meet the objective. Sediment supplementation programs, particularly in Clear Creek, need to be integrated with downstream channel forming processes, which will be subject to adaptive management, as well as* *to a different set of indicators, monitoring, and focused research.*

Rivers with a natural shape and hydrologic condition generally support the most diverse mixture of habitats and fish and wildlife species and are the most resilient to natural or human disturbance.

STREAM MEANDER

PROGRAMMATIC TARGET: Preserve or restore the 50- to 100-year floodplain and existing channel meander characteristics of Clear Creek, particularly in low-gradient areas where most sediment deposition occurs and where stream channel meander is most pronounced.

TARGET 1: Create a more defined stream channel in the lower 8 miles of Clear Creek to facilitate fish passage (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to improve lower Clear Creek by maintaining flow connection with the Sacramento River and by regrading the channel and controlling vegetative encroachment.

***RATIONALE**: Gravel deposits in Clear and Cow Creeks are essential to maintaining spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Whiskeytown Dam and extensive gravel extraction in the lower section of Clear Creek continue to reduce the amount of gravel transport to near zero; Cow Creek has only a limited natural supply and has been adversely affected by gravel mining in its lower reach near the Sacramento River. Although small, Cow Creek provides an important source of sediments to the Sacramento River, particularly for the 8- to 10-mile reach between its confluence with the river and the mouth of Cottonwood Creek.*

The Clear Creek stream meander belt is the area in which natural bank erosion and floodplain and sediment bar accretions occur. Natural stream meander belts in alluvial systems function dynamically to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish, as well as surfaces that are colonized by natural vegetation that support wildlife. The flow regime in Clear Creek has recently been improved by adding supplemental water under provisions of the CVPIA. This improved flow will assist in reactivating or reestablishing the natural stream channel. Because of low flow releases from Whiskeytown Lake in the past, vegetation has encroached into the lower 3 miles of the active stream channel on Clear Creek, prevented meander, and fixed stream sediments so that they no longer contribute to sediment load or provide substrate for fish spawning.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Increase and maintain the Clear Creek floodplain in conjunction with stream meander corridor restoration (◆◆◆).

PROGRAMMATIC ACTIONS 1A: Develop a cooperative program, consistent with flood control requirements, to evaluate the feasibility of altering stream channel configuration in the lower reach of Clear Creek to increase the areal extent of floodplains inundated during high flow periods.

TARGET 2: Reestablish natural floodplain and stream channel meander in the lower 8 miles of Clear Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Acquire floodplains by direct purchase or easement from willing sellers.

***RATIONALE:** Floodplain inundation is a secondary ecosystem process related to water and sediment flow through the Sacramento-San Joaquin Basin in combination with geomorphology. Floodplain inundation is the seasonal flooding of floodplain habitats, including riparian and riverine aquatic habitats. Flooding* *of these lands provides important seasonal habitat for fish and wildlife and provides sediment and nutrients to both the flooded lands and aquatic habitats that receive the returning or abating floodwater. The flooding also shapes the plant and animal communities in the riparian, wetland, and upland areas subject to flooding. Opportunities to restore or enhance this process are possible by changing landscape features, geomorphology, and seasonal distribution of flow volume through the system.*

HABITATS

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to establish riparian habitat zones along streams in the North Sacramento Valley Ecological Management Zone through conservation easements, fee acquisition, or voluntary landowner measures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to establish, restore, and maintain riparian habitat on Clear Creek through conservation easements, fee acquisition, or voluntary landowner cooperation.

PROGRAMMATIC ACTION 1B: Encourage the development of long-term measures in the comprehensive watershed management plan to further improve water temperatures. Develop a cooperative approach with counties and local agencies to implement land use management that protects riparian vegetation along the streams and develop programs to restore lost riparian vegetation

PROGRAMMATIC ACTION 1C: Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along the lower reaches of Cow, Bear, and Battle Creeks.

RATIONALE: *Many species of fish and wildlife in the North Sacramento Valley Ecological Management Zone depend on or are closely associated with riparian habitats. Of all the habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of creeks in the Ecological Management Zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

ELIMINATING OR REDUCING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce or eliminate conflicts between the diversion of water and chinook salmon and steelhead populations at all diversion sites on Battle Creek (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative approach to improve conditions for anadromous fish in Battle Creek by installing fish screens at diversions on the North Fork, three diversions on the South Fork, and one diversion on the mainstem, or acquire water rights to eliminate the need for diversion and screening.

PROGRAMMATIC ACTION 1B: Improve the survival of adult salmon and steelhead in Battle Creek by installing a rack at the head of Gover Diversion Canal to prevent straying.

TARGET 2: Reduce or eliminate conflicts between the diversion of water and chinook salmon and steelhead populations at all diversions on Clear Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Acquire water rights on Clear Creek at the McCormick Dam to eliminate the need for diversion.

RATIONALE: *Diversion, storage, and release of water in the Clear and Battle Creek watersheds directly affect fish and other aquatic organisms and indirectly affect habitat, foodweb production, and species abundance and distribution. Diversions cause consumptive loss of water, nutrients, sediment, and organisms. Seasonal and daily patterns of water released from storage may affect habitat, water quality, and aquatic organism survival. In both Clear and Battle Creeks, water diversion and water diversion structures have caused direct mortality by removing juvenile fish from the population. Water diversion also reduces the quantity and quality of stream habitats and the resiliency of fish populations. Where possible, it is more desirable to acquire water rights and eliminate the diversion than to install positive-barrier fish screens.*

Coleman National Fish Hatchery receives its water supply directly from Battle Creek. Because of past incidences of disease at the hatchery, adult salmon and steelhead were blocked from ascending the creek to prevent disease contamination of the hatchery water supply. Restoring naturally spawning fish in the upper watershed will be limited until water can be supplied to the hatchery in a manner that will not contribute to disease outbreaks.

DAMS AND OTHER STRUCTURES

PROGRAMMATIC TARGET: Eliminate or reduce water uses that conflict with increasing the success of spawning adults and survival of juvenile chinook salmon and steelhead by managing or reconstructing facilities and structures that impair fish passage and fish survival.

TARGET 1: Work with landowners and diverters on Cow Creek to reduce the adverse effects of 13 seasonal diversion dams in South Cow Creek, 10 diversion dams in Old Cow Creek, two diversion dams in North Cow Creek, and one diversion dam in Clover Creek that are barriers to migrating chinook salmon and steelhead. This would allow access to 100% of the habitat below any natural bedrock falls (◆◆◆).

PROGRAMMATIC ACTION 1A: Improve passage conditions on Cow Creek by acquiring water rights from willing sellers, removing diversions, or providing alternative sources of water during important periods.

TARGET 2: Work with landowners and diverters on Bear Creek to reduce the adverse effects of dewatering the stream channel at seasonal diversion dams, which results in no passage for migrating chinook salmon (◆◆◆).

PROGRAMMATIC ACTION 2A: Improve passage and habitat conditions in Bear Creek by acquiring water rights from willing sellers, evaluating the removal of diversion dams, or providing alternative sources of water during important periods.

TARGET 3: Work with landowners, diverters, and other state or federal agencies managing Battle Creek to improve fish passage (◆◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to upgrade or replace existing fish ladders or evaluate the removal of diversion dams and other impediments to passage.

TARGET 4: Work with landowners and diverters on Clear Creek to improve fish passage between its mouth and Whiskeytown Dam (◆◆◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative program to improve fish passage on Clear Creek by upgrading or replacing the fish ladder at McCormick-Saeltzer Dam or removing or modifying the dam..

TARGET 5: Reduce or eliminate conflicts in Battle Creek that require excluding anadromous fish from the upper section to protect the Coleman National Fish Hatchery water supply (◆◆◆).

PROGRAMMATIC ACTION 5A: Develop an alternative or disease-free water supply for Coleman National Fish Hatchery to allow naturally spawning salmon and steelhead access to the full 41-mile reach of Battle Creek above the Coleman National Fish Hatchery weir.

TARGET 6: Investigate possibility of providing access for steelhead to streams above Whiskeytown Dam (◆).

PROGRAMMATIC ACTION 6A: Develop a cooperative program to investigate the feasibility/desirability of providing access to tributaries above Whiskeytown Dam.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Fish passage in the North Sacramento Valley Ecological Management Zone is impaired in Clear, Cow, Bear, and Battle Creeks by a variety of permanent and seasonal dams used to divert water for irrigation or power production. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern, such as spring-run chinook salmon and steelhead, as well as the other stocks of chinook salmon. Improved fish passage will allow anadromous fish to reach the habitat they require to oversummer or to spawn in good health, which will increase their chances of successfully spawning. Improved fish passage will allow anadromous fish to reach the habitat they require to oversummer or to spawn and rear in good health, which will increase their chances of successful spawning.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow wild, naturally produced fish spawning populations to attain levels that fully use existing and restored habitat, and focus harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by providing increased enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet the target.

PROGRAMMATIC ACTION 1C: Continue the mass-marking program and selective harvest regulations for hatchery steelhead.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining populations of chinook salmon and steelhead to levels that fully take advantage of habitat may require restricting harvest during and even after* *the recovery period. Involving the various stakeholder organizations should help to ensure a balanced and fair allocation of available harvest. Target population levels may be such that existing harvest levels of wild, naturally produced fish cannot be sustained. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the harvest of wild fish, while hatchery fish are harvested at a level to reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in the Coleman National Fish Hatchery will stray into non-natal streams, thereby protecting naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking may be reduced in years when natural production is high.

TARGET 2: Limit hatchery stocking if populations of salmon or steelhead can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment populations of fall chinook salmon and steelhead only when alternative measures are deemed insufficient to provide recovery of the populations.

TARGET 3: Minimize further threats of hatchery fish contaminating naturally produced stocks of chinook salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting adult spawners for the hatchery from an appropriate cross-section of the adult population available to the hatchery.

RATIONALE: *In watersheds such as the Sacramento River and Battle Creek, where dams and habitat degradation have limited natural spawning, hatchery supplementation may be necessary. This would sustain fishery harvest at former levels and maintain a wild or naturally spawning population during adverse conditions, such as droughts. Hatchery augmentation, however, should be limited so as not to inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetics of wild stocks has occurred, additional protective measures are necessary to minimize further degradation of genetic integrity. Because of the extent of development on the Sacramento River and Battle Creek, chinook salmon and steelhead stocking may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries.*

STEELHEAD TROUT

SUPPLEMENTAL TARGET 1: Investigate the feasibility of using native rainbow trout currently isolated above dams to rebuild or recreate a steelhead run.

PROGRAMMATIC ACTION 1A: Conduct a comprehensive, basin-wide genetic evaluation of Central Valley steelhead stocks that includes analysis of self-sustaining populations of rainbow trout isolated above dams for purposes of identifying a suitable broodstock.

PROGRAMMATIC ACTION 2A: Conduct hatchery/ release investigations to determine if progeny of native resident rainbow trout raised in a hatchery will emigrate to the ocean.

RATIONALE: *Resident rainbow trout and anadromous steelhead likely comprise a single, interbreeding population in specific stream systems (IEP Steelhead Project Work Team 1999)*

. Native, resident rainbow trout presently isolated above dams could possess the genetic traits that would allow their use as an experimental broodstock to restore steelhead.. Planned and ongoing genetic analyses, conducted through the Comprehensive Central Valley Steelhead Genetic Evaluation (see ERPP Vol. 1, Species Vision for Steelhead Trout) and the Fish and Wildlife Service Upper Sacramento River Rainbow Trout Genetic Analysis, should be able to elucidate genetic relationships of resident and anadromous rainbow trout. If it is determined that native populations exist, experiments could be undertaken to determine if anadromous steelhead could be derived from an experimental hatchery population. If this is successful, then restoration of some stocks of native Central Valley steelhead thought to be extinct may be achievable through this method.

REFERENCES USED TO DEVELOP THE VISION FOR THE NORTH SACRAMENTO VALLEY ECOLOGICAL UNIT

Azevedo, R.L., and Z.E. Parkhurst. 1958. The upper Sacramento River salmon and steelhead maintenance program. 1949-1956. U.S. Fish and Wildlife Service, Office Report. 96 pp.

California Department of Fish and Game. 1993. Restoring Central Valley Streams: a plan for action. November 1993.

California Department of Fish and Game. 1998. Report to the Fish and Game Commission: A status review of the spring-run chinook salmon (Oncorhynchus tshawytscha) in the Sacramento River Drainage. Candidate Species Status Report 98-01.

California Department of Water Resources. 1994. Use of alternative gravel sources for fishery restoration and riparian habitat enhancement in Shasta and Tehama counties, California. Northern District. August 1994

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. *in* Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. App. VII-11

The Nature Conservancy. 1995. Sacramento Valley and foothill bioregional biological scoping project. August 1995.

U.S. Bureau of Reclamation and California Dept. of Water Resources. 1999. Effects of the Central Valley Project and State Water Project operations from October 1998 through March 2000 on steelhead and spring-run chinook salmon. Biological Assessment for ESA Section 7 consultation.

U.S. Fish and Wildlife Service. 1997. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase the natural production of anadromous fish in the Central Valley of California. May 30, 1997.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley Drainages of California. Cited in: Sierra Nevada Ecosystem Project, Final Report to Congress, vol. III, Assessments, Commissioned Reports, and Background Information. University of California, Davis, Centers for Water and Wildland Resources.

◆ Cottonwood Creek Ecological Management Zone

Introduction

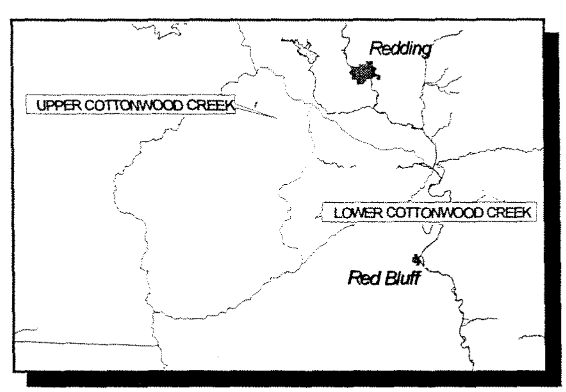
The health of the Sacramento-San Joaquin Delta is influenced by the interdependence and connectivity of the component ecosystem elements, particularly the 14 ecological management zones. The Cottonwood Creek Ecological Management Zone is located many miles from the Delta, but its status and health are ultimately reflected in the health of the Delta. The intermediate zone between the Delta and Cottonwood Creek is the Sacramento River. The Sacramento River Ecological Management Zone and its respective habitats and fish, wildlife, and plant assemblages depend on Cottonwood Creek, primarily for its ability to supply sediments and gravel to the river, but also for its seasonal contributions of flow.

Description of the Management Zone

Cottonwood Creek drains an area of 930 square miles on the west side of the Central Valley and enters the Sacramento River a short distance downstream of the Redding-Anderson area, approximately 16 miles north of Red Bluff. One of the outstanding attributes of Cottonwood Creek is its status as the largest undammed tributary on the westside of the Sacramento Valley.

The creek spans a broad elevational range and functions as an important regional wildlife corridor and neotropical bird habitat. Well-developed montane, foothill, and valley riparian forests are found throughout the Cottonwood Creek Ecological Management Zone, and these forests have good connectivity with the Sacramento River Ecological Management Zone. One of the most important ecological attributes of Cottonwood Creek is its role as the primary source of coarse sediments and spawning gravel for the Sacramento River. Cottonwood Creek supplies almost 85% of the gravel introduced into the Sacramento River between Redding and Red Bluff.

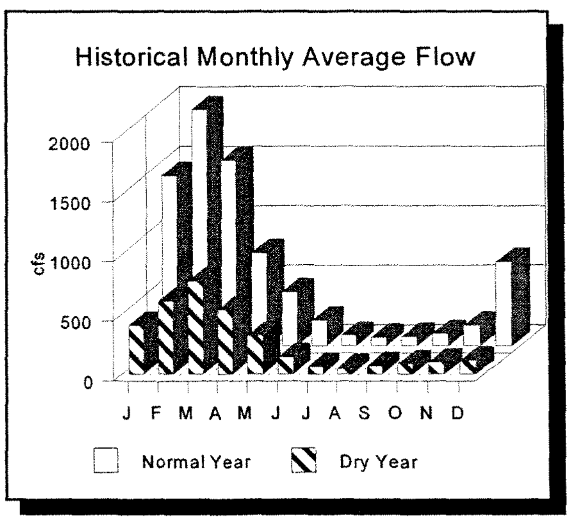
Attributes that affect the ecological health of the Cottonwood Creek Ecological Management Zone include streamflow, coarse sediment supply, gravel recruitment and transport, stream meander, and vegetation succession. Important fish and wildlife habitats include freshwater fish habitat, essential fish habitat, gravel substrate for invertebrate production and chinook salmon and steelhead spawning, riparian scrub and woodlands, and shaded riverine aquatic habitat.



Location Map of the Cottonwood Creek Ecological Management Zone and Units.

Cottonwood Creek has a natural flow pattern of high winter and low summer and fall flows, which is typical of many Sacramento Valley streams that originate in the foothills rather than at higher elevations in the Cascade or Sierra Nevada mountain ranges. In summer and fall months of low rainfall years, flows average 40 to 80 cubic feet per second [cfs]). In the wettest years, flows in winter average 5,000 to 11,000 cfs. In winter months of dry years, average monthly flows reach only 400 to 800 cfs. In the driest years, average winter monthly flows reach only 50 to 150 cfs.

In the past, streamflow in Crowley Gulch, a tributary to lower Cottonwood Creek, was intermittently augmented by the release of water from a waste gate on the Anderson-Cottonwood Irrigation District (ACID) canal. Waste gate releases during fall have attracted chinook salmon into an area where they became stranded and subsequently died without having spawned. This problem has been eliminated by operational changes by ACID personnel.



Historical Streamflow of Cottonwood Creek, 1952-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile year.)

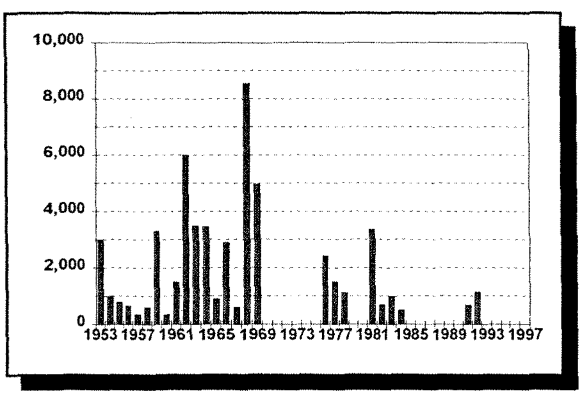
The estimated mean annual suspended sediment load transported from the Cottonwood Creek basin is second only to that of Cache Creek in the Sacramento River basin below Shasta Dam. The U.S. Army Corps of Engineers estimates that, of the total average annual gravel load transported by Cottonwood Creek, particles greater than 2.0 millimeters in diameter total approximately 19,000 tons per year. This amount is consistent with the average annual bedload of approximately 65,000 tons estimated by the U.S. Geological Survey. The California Department of Water Resources (1980) estimated that gravel mining reduced potential sand and gravel contributions to the Sacramento River by about 60%, resulting in a calculated bedload of 20,000 tons per year, with 3,000 tons of particles above one-half inch in diameter.

More is known about the hydrology and sediment transport process of Cottonwood Creek than about that of other streams in the northern Sacramento Valley because of studies conducted for the construction of several dams and environmental impact reports for gravel mining projects. Bankfull discharge (i.e., with the creek full to the tops of its banks) has been estimated at 20,000 cfs with a return interval of 1.8 years. The creek has a wide meander belt and a braided channel with perennial flow. The active channel width at low flow ranges from 50 to 150 feet but reaches more than 1,500 feet at bankfull discharge. The channel banks are mostly sand, gravel, and cobbles. The width of the floodplain varies, but it is generally wider and more poorly defined downstream. Sinuosity values (i.e., the ratio of creek length to the linear distance over which the creek travels) for Cottonwood Creek are low, ranging from 1.04 to 1.47. The low degree of sinuosity is attributable primarily to the high gravel and low silt and clay content of the bank material. The main channel tends to change course during large floods, resulting in a fairly wide belt of distributary channels and abandoned stream courses.

Some of the fish, wildlife, and plant resources dependent on the ecological health of Cottonwood Creek are fall-run, late-fall-run, and spring-run chinook salmon and steelhead trout. Although northern spotted owls, northwestern pond turtles, and foothill yellow-legged frogs in the South Fork will benefit from proposed restoration actions, these species are not a direct focus of actions in the Cottonwood Creek Ecological Management Zone.

The use of Cottonwood Creek by chinook salmon and steelhead trout is determined by the timing of rainfall. In years when storms arrive late in the season, the migration of salmon and steelhead is delayed. In some years, early rainfall allows salmon to enter the creek and spawn, but subsequent low winter and spring flows limit the production of young salmon.

The average annual return of fall-run salmon is approximately 1,000 to 1,500 adults but has ranged from a few hundred to more than 8,000 fish. The return of late-fall-run salmon is much smaller, consisting of fewer than 500 fish each year. The late-fall-run salmon enter Cottonwood Creek and spawn in the main stem and lower reaches of the North, Middle, and South Forks of the creek.



Fall-run Chinook Salmon Returns to Cottonwood Creek, 1953-1997.

Salmon spawning gravel habitat in the lower reaches of Cottonwood Creek has been degraded. Some areas are covered entirely with sand and silt, and others are compacted with sediments or have become armored. Silt in Cottonwood Creek is derived from many sources; some of these sources are natural, but most are a result of undesirable land use practices, including timber harvesting and road-building activities on private and public land in the upper watershed. Overgrazing, wildfires, extensive land clearing in the foothill and valley areas, and discharges of decomposed granite from Rainbow Dam are also sources of sediment.

Streamflow, coarse sediment supply, and stream meander are closely linked. Together, these processes support and promote the regeneration of healthy riparian and riverine plant communities. Important restoration components include protecting the floodplain and existing stream meander characteristics of Cottonwood Creek.

Important functions of the upper watershed of Cottonwood Creek are to moderate streamflows resulting from storm events and to provide high quality water to the Sacramento River and Delta. Erosion from timber harvest, road building, and the adverse affects of grazing practices diminish the watershed's ability to moderate flows and provide high quality water. The potential for catastrophic wildfire can be reduced by fuel management programs.

Cottonwood Creek has an extensive riparian and riverine aquatic plant community that can be enhanced by improved land management and maintenance of natural sediment supply. Denuded areas need an opportunity to regenerate, and existing riparian forest needs protection.

Water conveyance structures in the lower sections of Cottonwood Creek impair the upstream passage of adult chinook salmon and steelhead. Restoring natural sediment supply can alleviate these problems over time and permit unobstructed access to important aquatic habitats.

Extensive gravel mining in Cottonwood Creek has damaged spawning habitat and significantly reduced gravel recruitment to the Sacramento River. In addition, gravel mining creates passage and stranding problems for fish by allowing the creek to spread over the large extraction area.

During spring, low flows and high water temperatures may impede or prevent the upstream migration of adult spring-run chinook salmon to summer holding areas.

The Cottonwood Creek Ecological Management Zone includes two ecological management units: the Upper Cottonwood Creek Ecological Management Unit and the Lower Cottonwood Creek Fan Ecological Management Unit.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE COTTONWOOD CREEK ECOLOGICAL MANAGEMENT ZONE

- chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- plants and plant communities.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

UPPER COTTONWOOD CREEK

The Upper Cottonwood Creek Ecological Management Unit provides the streamflow and coarse sediments needed to maintain the overall ecological health of lower Cottonwood Creek and the Sacramento River. Important stream reaches in the Upper Cottonwood Creek Ecological Management Unit include the South and North Forks of Cottonwood Creek, Beegum Creek, and the mainstem reach of Cottonwood Creek above the confluence with the South Fork. The Upper Cottonwood Creek Ecological Management Unit can sustain important migration, holding, spawning, rearing, and emigration habitats for fish and wildlife species if streamflows are maintained and watersheds are rehabilitated.

The South Fork of Cottonwood Creek contains good to outstanding riparian vegetation in the foothills and lower stretches. Spring-run chinook salmon and steelhead trout can migrate to the headwaters of the South Fork, using Maple Gulch as their principal holding area. The length of the stream system below natural fish barriers is 130 linear miles, which includes the three main forks of the creek and Beegum Creek.

Spring-run chinook salmon enter Cottonwood Creek and migrate to the headwaters of the South and Middle Forks during April, May, and June. The two principal holding areas are the South Fork above Maple Gulch and Beegum Creek, a tributary to the Middle Fork. During spring of drier years, low flows and high water temperatures may impede or prevent the upstream migration of adult spring-run salmon to summer holding areas. There are no recent estimates of spring-run chinook populations; however, historic runs averaged approximately 500 salmon.

Steelhead trout enter Cottonwood Creek during late fall and early winter and spawn during winter and spring. The upper reaches of the Middle Fork, Beegum Creek, and the South Fork provide spawning and nursery areas. There are no recent estimates of steelhead populations for Cottonwood Creek. The creek also supports resident rainbow trout and brown trout in the upper tributaries.

LOWER COTTONWOOD CREEK

The Lower Cottonwood Creek Ecological Management Zone can provide important spawning areas for fall- and late-fall-run chinook salmon. Gravel transport through lower Cottonwood Creek is a significant ecological function and sufficient streamflows are needed to provide sediment transport and gravel cleansing. A long-term effort will be implemented to restore and maintain plant communities along the creek.

Salmon spawning areas in the lower reaches of Cottonwood Creek have been degraded. Some areas are entirely covered with sand and silt, and others are compacted with sediments or have become armored during floodflows. Sedimentation binds the gravel together, which prevents salmon from creating redds (salmon spawning nests); it also reduces intergravel oxygen transport, so eggs deposited in the gravel do not survive. Armoring results when gravel is washed away during floods, leaving rocks and boulders too large for salmon to move during spawning.

Gravel has been mined in the lower Cottonwood Creek fan for many years. Gravel extraction damages spawning areas in the creek and reduces the recruitment of spawning gravel to the Sacramento River. Two major instream gravel extraction projects operate in Cottonwood Creek below the Interstate 5 bridge.

VISIONS FOR THE ECOLOGICAL MANAGEMENT ZONE AND UNITS

The vision for the Cottonwood Creek Ecological Management Zone is to restore natural streamflow patterns, coarse sediment supply, natural floodplain and flood processes, and riparian forest and riverine aquatic habitats. In addition, the proposed restoration actions are designed to reduce or eliminate to the extent necessary stressors that impair ecological processes, including gravel mining operations, structures that inhibit chinook salmon and steelhead trout migrations, and land use activities (e.g., water diversions, logging, and grazing).

A restored Cottonwood Creek will provide incremental benefits to the overall objective of restoring and maintaining important aquatic species, such as chinook salmon and steelhead trout, in Cottonwood Creek and in the Sacramento River. With restoration, Cottonwood Creek Ecological Management Zone will support sustainable populations of fall-, late-fall-, and spring-run chinook salmon and steelhead trout after natural sediment supply and gravel recruitment, cleansing, and transport processes are reactivated; gravel spawning and riparian habitats are restored; and the adverse effects of upper watershed diversions, logging, and grazing are reduced.

VISION FOR UPPER COTTONWOOD CREEK

The vision for the Upper Cottonwood Creek Ecological Management Zone is to maintain coarse sediment recruitment, cleansing, and transport; improve habitat for chinook salmon, steelhead trout, and other native fishes; improve habitat corridors for wildlife populations; and restore riparian and riverine plant communities through improved land use and forest management practices.

The Cottonwood Creek watershed is a high-value area, both because it is a distinct Ecological Management Zone and because of its linkage with the Sacramento River Ecological Management Zone. Restoring and maintaining ecological processes and functions related to streamflow, sediment supply, gravel recruitment, cleansing, and transport, and the creation and maintenance of habitats can best be achieved by developing and implementing a local watershed management plan. The creation of a watershed management plan by a local watershed conservancy or planning agency is necessary. This planning effort would evaluate and develop recommendations for timber harvesting, land use, fire and fire suppression, and the management of oak woodland habitats to reduce erosion, maintain riparian zones, and provide for more sustained runoff patterns.

VISION FOR LOWER COTTONWOOD CREEK

The vision for the Lower Cottonwood Creek Ecological Management Zone is to restore, reactivate, and maintain coarse sediment supply, floodplain and flood processes, gravel recruitment, and stream meander. The vision also includes reducing stressors on these processes, including gravel mining activities in the Cottonwood Creek stream corridor.

Instream gravel extraction should be managed to protect salmon spawning and rearing habitat within Cottonwood Creek and to maintain and enhance sediment supply to the Sacramento River. Implementing such management would result in immediate benefits to salmon in Cottonwood Creek and the Sacramento River. Spawning gravel is a finite resource in the Sacramento River system, and Cottonwood Creek contains one of the most important reserves.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Streamflows shape the stream channels, support riparian vegetation, and transport nutrients and sediments. The vision for streamflows in Cottonwood Creek is to emulate the natural runoff pattern with a late-summer or early fall flow event.

COARSE SEDIMENT SUPPLY: Coarse sediments are abundant in Cottonwood Creek; however, gravel recruitment has diminished because of extensive mining activities. The vision is that restoring natural gravel recruitment and sediment transport processes will contribute to maintaining important habitat substrates and ecological processes in Cottonwood Creek and the Sacramento River.

STREAM MEANDER: In unimpaired systems, streams meander within their historic floodplains. This meander contributes sediments for transport and deposition, rejuvenates riparian succession, and creates new habitats for fish and other aquatic species. The vision is that a natural stream meander process will provide much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Coarse sediment supply, stream meander, and floodplain and flood processes are closely interrelated. The vision is that all three of these processes will moderate channel incision and scour by providing areas for bank overflow, contribute to species diversity by creating landforms that support different community structure, provide low-velocity refuge for fish and other aquatic organisms during floods.

VISIONS FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: Health riparian habitat provides a migratory corridor for terrestrial species that connects low and higher elevation habitats. Shaded riverine aquatic habitat provides shade, contributes to moderating stream temperatures, and provides woody debris, which juvenile fish use as escape and resting cover. The vision is that Cottonwood Creek will support healthy riparian, shaded riverine aquatic and woody debris habitats, which in turn will support improved survival of aquatic and terrestrial species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. Upper Cottonwood Creek is typical of a salmon-steelhead stream and lower Cottonwood Creek is typical of a fall chinook salmon spawning stream (Moyle and Ellison 1991). The vision is to maintain the quality of freshwater fish habitat in Cottonwood Creek through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Cottonwood Creek has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision is to maintain or restore EFH in Cottonwood Creek including substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space;

access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

GRAVEL MINING: Coarse sediment supply in Cottonwood Creek is adversely affected by gravel mining. This lack of instream sediments affects stream channel morphology, stream meander, and riparian systems. The vision for Cottonwood Creek is that gravel mining activities will be relocated to areas outside the active stream channel.

VISIONS FOR SPECIES

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. The fall-, spring-, and late-fall-runs of chinook salmon depend on Cottonwood Creek's streamflow, natural sediment supply, and riverine aquatic habitats. The vision is that Cottonwood Creek will provide for sustainable chinook salmon populations.

STEELHEAD: The visions of steelhead is to recover this species listed as threatened under ESA. Steelhead use Cottonwood Creek and will benefit from many of the actions that will improve conditions for chinook salmon. The vision is that Cottonwood Creek will support a sustainable steelhead population.

LAMPREY: The vision for lamprey is to maintain and restore population distribution and abundance to higher levels that at present. The vision is also to better understand life history and factors in Cottonwood Creek which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to better manage these species and their habitat.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Maintaining and restoring the ecological health of the Cottonwood Creek Ecological Management Zone and its respective Ecological Management Zones will depend primarily on cooperative endeavors to locate alternative sources of water in the upper watershed and to eliminate gravel extraction operations in the lower creek.

Watershed Management Planning

Restoration of this Ecological Management Zone requires developing and implementing a comprehensive watershed management program for the upper and lower areas. Eliminating gravel extraction operations will increase the delivery of sediments to the Sacramento River, improve upstream fish passage, improve spawning habitat for chinook salmon using the lower reach, and allow for restoring a riparian corridor and a clearly defined stream channel. Improved watershed management in the upper watershed will protect streamflow, gravel sources, spawning and rearing habitat of salmon and steelhead, and wildlife habitats.

Aggregate Resource Management Plan

In attaining the vision for the Cottonwood Creek Ecological Management Zone, ERPP encourages gravel operators and the local counties to cooperatively develop and implement an aggregate resource management plan (ARMP). Potential measures in a county wide ARMP would include recommendations or requirements for:

- limiting instream extraction to less than the sustained yield of the system while providing sediment input to the Sacramento River,
- implementing measures to prevent channel incision, such as installing stream grade control structures, and
- revegetating all permanently exposed land that has been denuded by mining operations.

Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA) added "mitigation, protection and restoration of fish and wildlife" as a purpose of the Central Valley Project. It required the implementation of a program that makes all reasonable efforts to increase the natural production of anadromous fish in Central Valley rivers and streams to not less that twice the average levels present from 1967 to 1991.

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the CVPIA, which provides for restoring habitats and species and eliminating many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1995) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment on the Sacramento River below Keswick Dam, water acquisition, and other measures that will contribute to health of the Cottonwood Creek, Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

Salmon, Steelhead Trout and Anadromous Fisheries Program Act

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game (DFG) to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and to assist in obtaining funding for feasibility studies, environmental permitting, and project construction.

CALFED Bay-Delta Program

CALFED has funded two ecosystem restoration projects in Cottonwood Creek. One project funded the formation of a watershed group and another funded restoration of the creek channel.

Linkage to Other Ecological Management Zones

Cottonwood Creek can support larger populations of fall-, late-fall-, and spring-run chinook salmon and steelhead trout, but there are many stressors outside the Cottonwood Creek Ecological Management Zone that impair or reduce the survival of adult and juvenile chinook and steelhead. Restoration efforts in the Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh/San Francisco Bay Ecological Management Zones will all contribute to improved returns of adult fish.

In addition, the gravel recruitment, cleansing, and transport functions of Cottonwood Creek are critical to maintaining the long-term ecological health of the Sacramento River Ecological Management Zone and the fish, wildlife, and plant resources that it supports.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: During summer and fall, more closely emulate the seasonal streamflow pattern, so that flows are sufficient for chinook salmon holding and spawning in most year types by providing up to 20 to 50 cfs. These flows can mobilize and transport sediments, allow upstream and downstream fish passage, create point bars, and contribute to stream channel meander and riparian vegetation succession (◆).

Programmatic Action 1a: Augment summer and fall flow in Cottonwood Creek by purchasing water from willing sellers and developing alternative supplies.

Rationale: *The streams in the Cottonwood Creek Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout and for fall-run chinook salmon in some years. One of the key attributes of streamflow in this Ecological Management Zone is to provide for successful upstream passage of adult fish and fish spawning. In some years, flows are insufficient to provide fish passage or recede too quickly after fish spawn and expose or dewater redds containing incubating eggs or sac fry. In addition, flow in Cottonwood Creek is the power that drives many ecological functions and processes linked to stream channel morphology, sediment transport and gravel recruitment, riparian communities, and fish habitat.*

Instream flow needs on Cottonwood Creek should be subject to focused research to determine if the proposed flow increase of 20 to 50 cfs is appropriate.

Coarse Sediment Supply

Target 1: Maintain existing levels of erosion and gravel recruitment in streams in the Cottonwood Creek Ecological Management Zone, and provide for increasing the transport of these sediments to the Sacramento River by an average of 30,000 to 40,000 tons per year (◆◆◆).

Programmatic Action 1a: Cooperatively develop and implement a gravel management program for Cottonwood Creek. The program would protect and maintain important ecological processes and functions related to sediment supply, gravel recruitment, and gravel cleansing and transport. This would involve working with state and local agencies and gravel operators to protect spawning gravel and enhance recruitment of spawning gravel to the Sacramento River in the valley sections of Cottonwood Creek.

PROGRAMMATIC ACTION 1B: Cooperate with the aggregate resource industry to relocate existing gravel operations on Cottonwood Creek to areas outside of the active stream channel.

TARGET 2: Repair and rehabilitate spawning gravels in 10 to 20 miles of the lower South Fork and mainstem of Cottonwood Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: In the short term, develop a cooperative program to rip and clean or reconstruct important salmon spawning riffles on the South Fork Cottonwood Creek and on lower Cottonwood Creek below the South Fork.

RATIONALE: *Gravel deposits in the lower South Fork and in the mainstem below the South Fork are essential to maintaining spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Historically, Cottonwood Creek was one of the most important sources of gravel to the Sacramento River. Since Shasta Dam was completed in the 1940s, Cottonwood Creek has become the single largest contributor of coarse sediments. Improving and maintaining sediment sources and transport capabilities of this stream are essential components necessary to restore and maintain the ecological health of the Sacramento River.*

Gravel transport is the process whereby flows carry away finer sediments that fill gravel interstices (i.e., spaces between cobbles). Gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing by flushing most of the fines and the movement of bedload (the load of material carried downstream in the streambed by flow) are important to maintaining the amount and distribution of spawning habitat in the Cottonwood Creek basin. Although these processes have been greatly reduced or altered as a result of human activities, they can be restored and maintained by changing water flow and sediment supplies, removing stressors, or directly manipulating channel features and stream vegetation. Gravel deposits in the lower South Fork and in the mainstem below the South Fork have been adversely affected by sedimentation from upstream sources in the watershed. Mechanical means will be used infrequently to free excessive quantities of fine sediments from the gravel substrates until upstream sources of sediment have been reduced or eliminated through watershed management and restoration.

STREAM MEANDER

TARGET 1: Preserve or restore the 50- to 100-year floodplain and existing channel meander characteristics of streams in the Cottonwood Creek Ecological Management Zone, particularly in low-gradient areas throughout the lower 20 miles where most deposition occurs and where stream channel meander is most pronounced (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate reestablishing the floodplain along the lower reach of Cottonwood Creek, and evaluate constructing setback levees to reactivate channel meander in areas presently confined by levees.

PROGRAMMATIC ACTION 1B: In the short term, develop a cooperative program to mechanically create a more defined stream channel in lower Cottonwood Creek. This would facilitate fish passage by minimizing water infiltration through the streambed and maintaining flow connectivity with the Sacramento River until natural meander returns.

RATIONALE: *Stream meander belts are the area in which natural bank erosion and floodplain and sediment bar accretions occur along stream courses. Natural stream meander in Cottonwood Creek functions dynamically to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish. Meander also creates surfaces that are colonized by natural vegetation that support wildlife. Cottonwood Creek is a nondammed tributary and* *a significant source of sediment to the Sacramento River. To maintain the creek's natural stream channel and fluvial dynamic processes and to provide long-term resilience for its watershed and stream channel processes in the Sacramento River, Cottonwood Creek should be fully restored and protected.*

NATURAL FLOODPLAINS AND FLOOD PROCESSES

TARGET 1: Develop a cooperative program to identify opportunities to allow Cottonwood Creek to seasonally inundate its floodplain.

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to determine means by which to increase floodplain interactions on lower Cottonwood Creek.

PROGRAMMATIC ACTION 1B: Minimize adverse effects of permanent structures such as bridges on floodplain processes.

RATIONALE: *Natural functioning floodplain processes on Cottonwood Creek are equally important with stream meander and natural sediment supply. A conceptual model of these interactions needs to be developed to further understand the dynamic structure of Cottonwood Creek and to allow the design and implementation of future actions to protect and restore these important ecological functions.*

TARGET 1: Restore upper watershed health (◆◆◆).

PROGRAMMATIC ACTION 1A: Reduce excessive fire fuel loads in upper watersheds.

PROGRAMMATIC ACTION 1B: Improve forestry management practices, including timber harvest, road building and maintenance, and livestock grazing practices.

PROGRAMMATIC ACTION 1C: Cooperatively evaluate the development of a watershed management program that could contribute to improved runoff patterns in the Upper Cottonwood Creek Ecological Management Unit.

TARGET 2: Protect, restore, and maintain the Cottonwood Creek watershed by eliminating conflict between land use practices and watershed health (◆◆◆).

PROGRAMMATIC ACTION 2A: Cooperatively work with landowners and federal land management agencies to facilitate watershed protection and restoration and reduce siltation to improve holding, spawning, and rearing habitats for salmonids.

PROGRAMMATIC ACTION 2B: Develop a cooperative program to implement improved fencing, grazing, and other land management practices on private and national forest lands, and encourage local counties to adopt stronger grading and road building ordinances to control erosion.

RATIONALE: *Resolving conflicts regarding land use in the Cottonwood Creek Ecological Management Zone must stress ecosystem processes and functions, habitats, and aquatic and terrestrial organisms. Land use activities that may be harmful include urban and industrial development, land reclamation, water conveyance facilities, livestock grazing, and agricultural practices.*

Improved watershed processes will maintain and restore seasonal water runoff patterns, water yield, and water quality and reduce sediment load to downstream storage reservoirs (reducing storage capacity and improving water quality). Healthier watersheds will also provide ancillary benefits to upper watershed habitats and species.

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to establish a continuous 130-mile riparian habitat zone along upper and lower Cottonwood Creek and its tributaries through conservation easements, fee acquisition, or voluntary landowner measures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to establish, restore, and maintain riparian habitat on Cottonwood Creek through conservation easements, fee acquisition, or voluntary landowner cooperation.

PROGRAMMATIC ACTION 1B: Encourage the development of long-term measures in the comprehensive watershed management plan to further improve water temperatures. Develop a cooperative approach with counties and local agencies to implement land use management to protect riparian vegetation along the streams. Develop programs to restore lost riparian vegetation.

PROGRAMMATIC ACTION 1C: Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along the lower reaches of Cottonwood Creek.

RATIONALE: *Many species of wildlife in the Cottonwood Creek watershed depend on or are closely associated with riparian habitats. Of all the habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Cottonwood Creek ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of Cottonwood Creek and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

DAMS AND OTHER STRUCTURES

TARGET 1: Facilitate passage of steelhead and spring-run chinook salmon to the holding, spawning, and rearing habitat in the higher elevation reaches and tributaries.

PROGRAMMATIC ACTION 1A: Begin an evaluation of structures (such as culverts, bridge abutments, grade control structures, etc.) that may be impeding or hindering migration to the high quality upstream habitat and implement measures to facilitate upstream passage.

RATIONALE: *Because Cottonwood Creek and its tributaries have no major dams, this system represents one of the best opportunities to restore* *steelhead and spring-run chinook salmon to the mid- to high-elevation habitats on which they depend. However, even in the absence of large impassable dams, migration of adults can be impaired by smaller structures, such as culverts and road grade control structures, that may not be complete barriers to migration but can hinder migration at low flows. Also, the cumulative effect of numerous structures can cause significant delays in migration, which can reduce survival. Restoring viable populations of steelhead and spring-run chinook to this system would contribute significantly to the over-all recovery of these fish in the Central Valley.*

REFERENCES USED TO DEVELOP VISION FOR THE COTTONWOOD CREEK ECOLOGICAL MANAGEMENT ZONE

California Department of Fish and Game. 1993. Restoring Central Valley streams: a plan for action. November 1993.

California Department of Water Resources. 1994. Use of alternative gravel sources for fishery restoration and riparian enhancement in Shasta and Tehama Counties, California. August 1994.

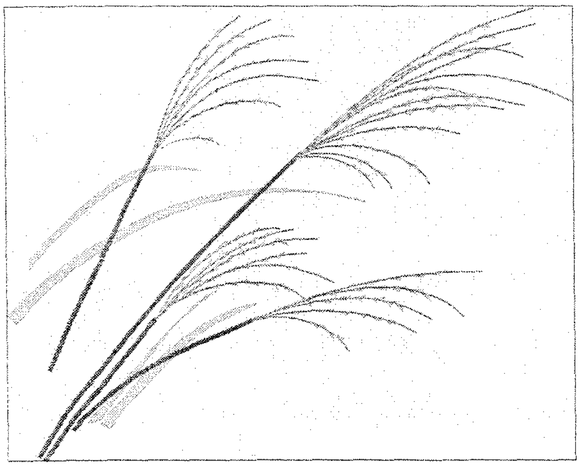
Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

The Nature Conservancy. 1995. Sacramento Valley and foothill bioregion biological scoping project. August 1, 1996.

U.S. Fish and Wildlife Service. 1997. Revised draft anadromous fish restoration plan: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

◆ Colusa Basin Ecological Management Zone



Introduction

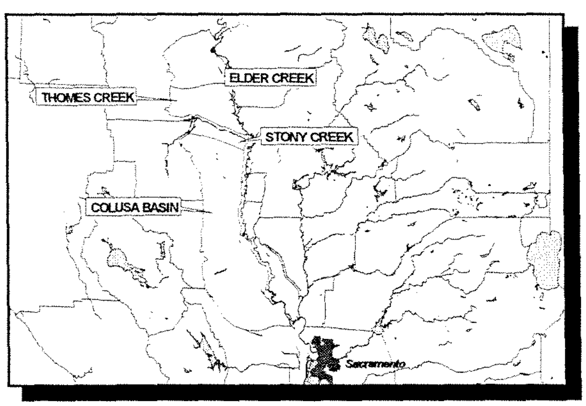
The long-term ecological health of the Delta depends on the health of its component parts. The Colusa Basin Ecological Management Zone contribution to the health of the Sacramento-San Joaquin Delta and Sacramento River Ecological Management Zones will increase after its ecological processes, habitats, and ability to support sustainable fish, wildlife, and plant communities are improved. The Colusa Basin Ecological Management Zone supports the Bay-Delta by contributing flow and sediment, and by providing riparian and riverine aquatic and wetland habitat that supports a wide variety of wildlife.

The streams in this Ecological Management Zone provide seasonally important rearing habitat for many fish species found in the Sacramento River.

The Colusa Basin Ecological Management Zone is one of the primary waterfowl and wetland migratory birds migration and wintering areas of the Pacific Flyway. The Zone contains three National Wildlife Refuges and some critical privately owned wetlands in the Sacramento Valley. The Colusa Basin Drainage area contains vital waterfowl and wetland habitats, contributes to the filtering of agricultural return flow, and has potential for riparian restoration. The wetlands along the drain provide important habitat for endangered and threatened species. The Colusa National Wildlife Refuge has some of the highest concentrations of giant garter snake in the Central Valley.

Description of the Management Zone

The Colusa Basin Ecological Management Zone is an extensive hydrologic and geographic area west of the Sacramento River between Cottonwood Creek to the north and Cache Creek to the south. This zone is divided into the Stony Creek, Elder Creek, Thomes Creek, and Colusa Basin Ecological Management Units.



Location Map of the Colusa Basin Ecological Management Zone and Units.

Protecting and improving important ecological processes and functions will help to maintain important attributes of the Colusa Basin Ecological Management Zone, and preserve its ability to serve as a source of sediment and nutrients to the Sacramento River Ecological Management Zone.

Important ecological processes needed to provide a healthy ecosystem in the Colusa Basin Ecological Management Zone and contribute to the health of the Sacramento River are the streamflow patterns of the basin and natural sediment supply.

The three largest tributary streams in this zone (Stony, Elder, and Thomes creeks) all discharge into the Sacramento River. The Colusa Basin maintains some of its historic capacity to retain and detain floodwater. It captures the seasonal inflow from small westside tributaries that flow into it.

The soils underlying the Stony, Elder, and Thomes Creek watershed are important sediment sources to the Sacramento River.

The Colusa Basin is a particularly important area for waterfowl and shorebirds and can provide a substantial amount of seasonally flooded wintering habitat.

List of Species to Benefit from Restoration Actions in the Colusa Basin Ecological Management Zone

- lamprey
- giant garter snake
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- waterfowl
- plants and plant communities.

Descriptions of Ecological Management Units

Stony Creek Ecological Management Unit

Stony Creek is a westside stream originating in the Coast Ranges and draining into the Sacramento River south of Hamilton City. Three storage reservoirs are located in the watershed. The primary focus area on Stony Creek is the stream reach below Black Butte Dam. This includes Stony Creek from Black Butte Dam to Interstate Highway 5 (I-5), I-5 to Highway 45, and Highway 45 to the confluence with the Sacramento River.

Stony Creek has a seasonal run off pattern of high winter and very low summer and fall flows, typical of western Sacramento Valley foothill streams. Unimpaired summer and early fall flows are 0 cubic feet per second (cfs) for 8-9 months, except in high rainfall years.

Summer and fall flows are higher than unimpaired flows as water is delivered below Black Butte Dam for agricultural use. These flows generally exceed 100 cfs in summer except in the driest years, when flows of only 10 to 30 cfs are released. Fall flows are generally less than 100 cfs except in the wettest years. Essentially no surface flows reach the Sacramento River during the summer and fall.

Water is diverted from several locations along the Stony Creek system below Black Butte Dam. About 150 cfs is diverted for irrigation from Black Butte Reservoir into the North Diversion Canal. Additional water is diverted at the South Diversion Canal, into the Tehama-Colusa Canal (TCC) east of Orland, and into the Glenn-Colusa Canal before the creek enters the Sacramento River.

Historically, riparian vegetation along Stony Creek below the site of Black Butte Dam was virtually non-existent.

A recent soil and mineral classification study by Glenn County indicates that Black Butte Reservoir has captured about 41 million cubic yards of sediment (Glenn County 1996).

ELDER CREEK ECOLOGICAL MANAGEMENT UNIT

Elder Creek is a westside tributary that enters the Sacramento River 12 miles south of Red Bluff. It flows into the Sacramento Valley from the west, draining a watershed of approximately 142 square miles. The watershed contains mostly shale, mudstone, and fine sedimentary deposits that produce minimal amounts of gravel, most of which is deposited where the stream enters the valley. No large gravel deposits are present in the lower stream reaches. An flood-control levee system in the lower section has directed and concentrated flows, increasing sediment transport and degradation throughout the reach.

Several small water diversions, but no large dams, have been constructed on Elder Creek. The flow is generally intermittent, with a widely fluctuating flow regime. Flow records indicate peak flows of more than 11,000 cfs, but the stream is normally dry from July to November.

Elder Creek has a natural flow pattern of moderate winter and spring flows and very low summer and fall flows, typical of streams in the western Sacramento Valley foothills. Summer and early fall flows are near 0 cfs, except in the highest rainfall years. In the wettest years, winter flows average 600 to 1,600 cfs. In the driest years, average monthly winter flows are only 5 to 20 cfs.

The stream reach from Rancho Tehama to the mouth is a low-gradient, braided channel. Approximately 20 miles upstream of the valley floor, the stream gradient increases rapidly in a rugged canyon area that supports resident fish, but probably has limited value for steelhead.

THOMES CREEK ECOLOGICAL MANAGEMENT UNIT

Thomes Creek is the largest gravel source in Tehama County. The stream has a watershed area of about 300 square miles. Thomes Creek enters the Sacramento River 4 miles north of Corning. No large dams have been constructed on the stream. The stream is usually dry or flowing intermittently below the U.S. Geological Survey (USGS) stream gage near Paskenta until the first heavy fall rains.

Thomes Creek has an unimpaired natural pattern of flashy winter and spring flows and very low summer and fall flows, typical of streams in the western Sacramento Valley foothills. The short-duration, high volume flows may impair riparian revegetation. Summer and early fall flows are near 0 cfs, except in the wettest years. Precipitation is seasonal, with more than 80 percent in December, January, and February. Precipitation in the drainage varies with elevation. The average annual rainfall is 15 to 45 inches

The lower reach of Thomes Creek has been significantly altered by the construction of flood-control levees and bank protection projects.

The lower Thomes Creek reaches contain large amounts of sediment and gravel. Thomes Creek has at least three year-round gravel mining operations and several seasonal ones. These gravel mining operations are conducted in compliance with the county gravel resource plan and permitted under terms of the Department of Fish and Game.

Thomes Creek is one of the most intact tributaries on the west side of the Sacramento Valley. Thomes Creek provides important spawning habitat for native Central Valley fish, such as Sacramento sucker, and Sacramento pikeminnow (squawfish). These native species may be a reason why the area is used by wintering bald eagles.

Some experts believe that Thomes Creek ranks second in importance, behind Cottonwood Creek, in terms of conservation priorities on the west side of the valley. Thomes Creek is in remarkably good condition in the upper watershed and has a well-developed riparian forest along much of its upper reach.

Colusa Basin Ecological Management Unit

The Colusa Basin drainage area extends from the Coast Ranges on the west to the Sacramento River on the east. It received flow and sediment from small streams located between Stony Creek on the north and Cache Creek on the south. The drainage encompasses approximately 1,500 square miles in Glenn, Colusa, and Yolo counties; 570 square miles of this area consists of the respective watersheds of the westside tributaries, with the rest located in the relatively flat valley bottom. Numerous small streams, including forks and branches, constitute the watershed, about 11 of which flow directly into the Colusa Basin Drain. Access to the upper portions of most smaller westside tributary streams is blocked where the GCID canal intersects the streams.

The main conveyance system in the Colusa Basin is known as the Colusa Trough, the Reclamation District 2047 Drain, the Colusa Basin Drainage Canal, or, more commonly, the Colusa Basin Drain. Flows in the basin generally discharge into the Sacramento River heading southeast through various sloughs. Reclamation efforts that began in the 1850s have converted wetlands and sloughs into agricultural areas.

Agricultural drainwater from the basin also enters the Sacramento River near Knights Landing through the Knights Landing Ridge Cut. In past years, this return water contributed to elevated water temperatures in the lower Sacramento River below the town. Water temperatures during May and June often exceeded 70°F, which is detrimental to juvenile chinook salmon. Recent improvements in agricultural and water management practices, reduced flow volume and reduced temperature and chemical loading, have diminished the problems formerly related to drainwater.

The Colusa Basin Ecological Management Unit provides important seasonal and permanent habitats for many species of migratory waterfowl and shorebirds, and the federally listed giant garter snake.

Vision For The Ecological Management Zone

The vision for the Colusa Basin Ecological Management Zone is to maintain or rehabilitate important fishery, wildlife, and plant communities and ecological processes and functions that contribute to the health of the Delta. Attaining this vision will involve restoring or reactivating important ecological processes and functions that create and maintain habitats for fish, wildlife, and plant communities throughout the Ecological Management Zone and its component Ecological Management Units.

This vision focuses on restoring ecological processes and functions related to sediment transport and restoring seasonally flooded aquatic habitats that provide important wintering areas for waterfowl and shorebird guilds, and in providing wetland habitats that will contribute to the recovery of the giant garter snake. The vision also included a large cooperative program with landowners to improve the wildlife benefits related to agricultural practices in the area. In addition, it emphasizes maintenance or improvements to the ecological processes and improvements to fish habitats. Visions for these ecosystem elements follow.

Visions For Ecological Management Units

Stony Creek Ecological Management Unit

Many native fish species use the lowermost reach of Stony Creek, below Highway 45, at its confluence with the Sacramento River for rearing from fall through early summer when water is suitably cool. The vision is to maintain and improve valuable aquatic and terrestrial habitat types by restoring upstream areas to improve system integrity and increase habitat complexity at the confluence.

Elder Creek Ecological Management Unit

The vision for the Elder Creek Ecological Management Unit is to restore degraded habitat, the sediment balance (to reduce the quantity of fine sediments in the gravel substrate),and a more natural stream channel and riparian habitat in the lower section.

Because of levees and other structures, Elder Creek transports sediment through the lower sections instead of allowing deposition.

Elder Creek's lower reach and its confluence with the Sacramento River may occasionally provide an important seasonal, and sometimes extended, rearing habitat for juvenile anadromous and resident fish. Maintaining and improving the ecological processes related to streamflow; sediment supply; a and transport will also provide a clearly defined stream channel and riparian zone.

Thomes Creek Ecological Management Unit

The vision for the Thomes Creek Ecological Management Unit is to establish a clearly defined stream channel, consistent with flood control needs, to effectively enhance sediment transport in the lower stream reach to improve sediment delivery to the Sacramento River.

Colusa Basin Ecological Management Unit

The vision for the Colusa Basin Drain Ecological Management Unit is to remedy ecological problems related to the Colusa Basin Drain and the mainstem Sacramento River and to maintain and improve the area's value in providing seasonally flooded wetland habitat.

The Colusa Basin Drain is sometimes a significant source of warmwater inflow to the Sacramento River, but is probably not a significant problem during May and June. In general, rice floodup and maintenance precludes significant drainwater during this period. There may be thermal impacts resulting from rice field dewatering prior to harvest in late August and September. The drain may also draw chinook salmon from their natural migratory corridor, resulting in their loss to the spawning population.

Visions For Ecological Processes

Central Valley Streamflow: The vision is that streamflows would be maintained to support many ecological processes and functions essential to the health of individual streams in the Colusa Basin Ecological Management Zone and contribute to the health of the mainstem Sacramento River.

Coarse Sediment Supply: The vision for sediment supply in streams of the Colusa Basin Ecological Management Zone is that natural stream sediments will contribute to stream channel formation and provide for native resident fish spawning and invertebrate production.

Natural Floodplain and Flood Processes: The Colusa Basin is one of the Sacramento Valley's natural overflow basins. The vision is to maintain the system's flood capacity, introduce nutrients to the system, and support natural regeneration and succession of riparian and riverine plant communities.

VISION FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding of leveed lands, use of the Colusa Basin's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITAT: The vision is to maintain existing riparian and shaded riverine aquatic habitats and to restore these habitats where feasible that support terrestrial and aquatic species. Throughout much of this zone, riparian protection and restoration will be in conjunction with flood control and levee maintenance practices.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The lower sections of these creeks are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The streams in the Colusa Basin Ecological Management Zone has been tentatively identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creeks include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Colusa Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

CONTAMINANTS: Pesticides and herbicides are applied extensively in this Ecological Management Zone and may adversely affect aquatic organisms. The vision is that contaminant input levels to the system will not impair restoration or maintenance of healthy fish, wildlife, and plant communities.

VISIONS FOR SPECIES

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Colusa Basin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Colusa Basin Ecological Management Zone and possibly increases in some populations would be expected.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The vision for the Colusa Basin Ecological Management Zone can be achieved by primarily relying on local resource conservation districts, landowner associations, watershed associations, watershed conservancies, water districts, and local landowners. In addition, the expertise of state, federal and local agencies can be used where appropriate to improve or assist in local planning efforts. Local groups presently include the Stony Creek Business and Landowners Coalition, the Thomes Creek Watershed Association, Tehama Colusa Canal Authority, and the Orland Unit Water Users Association. Key agencies in this effort are DFG, USFWS, the U.S. Natural Resources Conservation Service (NRCS), Reclamation, and local government agencies. The Colusa Basin Drainage District will play an important part in designing restoration efforts in the Colusa Basin Ecological Management Unit. The District recently completed major elements of a Basin Integrated Resource Management Plan and Watershed Priority Ranking Assessment Study. This planning process brought together representatives from agricultural, environmental, urban, and rural groups to identify, discuss, and resolve issues in a way that benefits all parties. In addition, local landowners, stakeholders, and private organizations will be important to restoration program success.

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 Colusa Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

In addition to many provisions for the restoration of anadromous fish in the Central Valley, the Central Valley Project Improvement Act contains provisions related to "other" programs to protect, restore, and mitigate for past fish and wildlife impacts of the Central Valley Project including threatened and endangered plants and animals.

CALFED BAY-DELTA PROGRAM

CALFED has funded one ecosystem restoration projects in Colusa Basin. This project reduces sediment inflow to Sand and Salt creeks.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

The Colusa Basin Ecological Management Zone is closely linked to the Sacramento River Ecological Management Zone and has a high degree of connectivity through the confluences of Stony, Elder, and Thomes Creeks. The Colusa Basin is directly linked to the Sacramento River through the Colusa Basin Drain. This Ecological Management Zone provides important habitats for a variety of migratory species including anadromous fish, waterfowl, and other species dependent on wetland and riparian habitats.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: Maintain the existing seasonal runoff patterns that mobilize and transport sediments, allow upstream and downstream resident fish passage, and contribute to riparian vegetation succession. (◆).

Programmatic Action 1a: Develop locally initiated programs to restore upper watershed health and functions.

Programmatic Action 1b: Reduce excessive fire fuel loads in the upper watersheds.

Programmatic Action 1c: Improve forestry management practices related to timber harvesting, road building and maintenance, and livestock grazing.

Programmatic Action 1d: Develop a watershed management plan for Thomes Creek.

Programmatic Action 1e: Develop a watershed management plan for Elder Creek.

Programmatic Action 1f: Develop a watershed management plan for Stony Creek.

Rationale: *Colusa Basin Ecological Management Zone streams provide several features that are important within the Ecological Management Zone and for adjacent zones. Major ecological processes and functions that are driven by flow include gravel recruitment, transport, deposition, and cleansing. Stony, Thomes, and Elder creeks can provide sediment for transport to the Sacramento River and habitat in the Sacramento River for chinook salmon and other aquatic species. Maintaining and improving the ecological health of streams in the Colusa Basin Ecological Management Zone will require maintaining existing runoff patterns and eliminating other stressors such as invasive exotic plants (Arundo and tamarisk) that constrain ecological processes. In addition, improvements in watershed health will contribute to maintaining seasonal runoff patterns, water yield, and water quality and reduce sediment loading to downstream storage reservoirs.*

Coarse Sediment Supply

Target 1: Maintain the sediment available for transport during storms and seasonal flow events in Thomes Creek (◆◆).

Programmatic Action 1a: Maintain sediment transport in Thomes Creek by continuing to monitor aggregate extraction activities to ensure sediment is available for delivery to the Sacramento River.

Target 2: Maintain the quantity of sediment transported from Elder Creek to the Sacramento River (◆◆).

Programmatic Action 2a: Maintain sediment transport in Elder Creek by continuing to monitor aggregate extraction activities to ensure sediment is available for delivery to the Sacramento River

Rationale: *Sand and gravel extraction activities on the streams in the Colusa Basin Ecological Management Zone are conducted in compliance with local and state regulations. The tributaries are important sediment sources for the Sacramento River. Sediments contribute to several important ecological functions and are required for specific habitats, particularly chinook salmon and steelhead habitats. Black Butte Dam on Stony Creek has eliminated natural gravel recruitment* *to the lower stream reach. The feasibility of protecting Stony Creek, its stream and riparian corridor, and its contribution of sediment to the Sacramento River should be evaluated.*

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Establish a desirable sediment deposition level in the Colusa Basin (◆).

PROGRAMMATIC ACTION 1A: Improve the Colusa Basin sediment deposition capacity by working with local landowners to develop an integrated plan consistent with flood-control requirements.

RATIONALE: *Floodplain processes include the natural floodwater and sediment detention and retention process whereby flows and sediment are retained within the floodplains. Retaining and detaining water and sediment in basin floodplains are controlled primarily by flow patterns and channel geomorphology, and secondarily by soils and plant communities.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Protect and manage 2,000 acres of existing seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 2,000 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 26,435 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Colusa Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Colusa Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Protect and maintain riparian vegetation along Stony Creek, Elder Creek, Thomes Creek, and the Colusa Basin Ecological Management Unit channels and sloughs where possible. This will provide cover and other essential habitat requirements for native resident fish species and wildlife (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to protect or rehabilitate riparian vegetation, where possible.

RATIONALE: *Healthy riparian corridors along creeks, sloughs, and channels, including those in the Colusa Basin Ecological Management Unit, provide essential cover, shade, and food for spawning, rearing, and migrating native resident fishes, and a wide variety of wildlife, neotropical birds, and other terrestrial species.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of Stony, Elder, and Thomes creeks and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively manage 111,285 acres of agricultural lands (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

PROGRAMMATIC ACTION 1B: Convert agricultural lands in the Colusa Basin Ecological Management Zone from crop types of low forage value for wintering waterfowl and other wildlife to crop types of greater forage value.

PROGRAMMATIC ACTION 1C: Defer fall tillage on rice fields in the Colusa Basin Ecological Management Zone to increase the forage for wintering waterfowl and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, *ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980).*

REDUCING OR ELIMINATING STRESSORS

CONTAMINANTS

TARGET 1: Reduce the adverse effects of herbicides, pesticides, fumigants, and other agents that are toxic to fish and wildlife in the Colusa Basin Ecological Management Zone (◆).

PROGRAMMATIC ACTION 1A: Work with local agricultural interests and water districts implement and evaluate a contaminant effects study.

RATIONALE: *Contaminants from point and nonpoint sources affect water quality and survival of fish, waterfowl, and the aquatic foodweb. Contaminants may cause severe toxicity and organism mortality or long-term, low-level toxicity that affects species' health and reproductive success.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Eradicate Arundo and tamarisk in watersheds where they have only small population, then concentrate on eradicating satellite populations extending beyond major infestations, and finally, reduce and eventually eliminate the most extensive populations.

PROGRAMMATIC ACTION 1A: Develop a cooperative pilot study to control Arundo (false bamboo) and tamarisk (salt cedar) in streams within the Colusa Basin Ecological Management Zone.

RATIONALE: *Invasive riparian and marsh plants have become sufficiently established in some locations to threaten the health of the Bay-Delta ecosystem. The riparian and salt marsh plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly affect rare native species, decrease foodweb productivity, and reduce populations of desired fish and wildlife species.*

Factors that relate to the degree of influence invasive riparian and salt marsh plants have on the Bay-Delta include additional introductions from gardens and other sources, and ground disturbances and hydrologic regimes that create favorable conditions for their establishment.

The effects of Arundo's ability to alter ecosystem processes may be profound. It is far more susceptible to fire than native riparian species. However, although it recovers from fires, most native vegetation does not, leading to increased postfire dominance by Arundo. By increasing sedimentation after establishing in stream channels, Arundo stabilizes islands, hinders braiding and shifting patterns in stream channel movement, and prevents native stream channel vegetation from establishing. An example of this can be seen at Stony Creek in northern California. Because Arundo has a vertical structure, it does not overhang water like native riparian vegetation. The result is less shade over water, providing less cover, increased water temperatures, and altered water chemistry, all conditions that can harm fish and other existing aquatic organisms and ultimately change the aquatic species composition.

Tamarisk is widespread in California rivers; however, an accurate assessment of the extent and rate of spread of the weed is unknown. Like Arundo, more survey mapping is needed to determine the extent of tamarisk, the levels of threat posed by the weed, the best time to safely control it, and a prioritized strategy for removing it.

REFERENCES USED TO DEVELOP THE VISION FOR THE COLUSA BASIN ECOLOGICAL MANAGEMENT ZONE

California Department of Fish and Game. 1993. Restoring Central Valley streams: a plan for action. November 1993.

California Department of Water Resources. 1994. Use of alternative gravel sources for fishery restoration and riparian habitat enhancement in Shasta and Tehama counties, California. Northern District. August 1994.

Madrone Associates. 1980. Sacramento-San Joaquin Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and U.S. Fish and Wildlife Service.

Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

The Nature Conservancy. 1995. Sacramento Valley and foothill bioregional biological scoping project.

U.S. Fish and Wildlife Service. 1997. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase the natural production of anadromous fish in the Central Valley of California. May 30, 1997.

◆ BUTTE BASIN ECOLOGICAL MANAGEMENT ZONE

INTRODUCTION

The ecological health of the Bay-Delta depends on ecological processes and functions, habitats, and fish and wildlife species present in Butte Basin Ecological Management Zone streams, wetlands, and floodplains. The status and abundance of spring-run chinook salmon and steelhead trout are important measures of the health, not only of the Sacramento-San Joaquin River Delta, but also of the Butte Basin. The Butte Basin Ecological Zone supports the Delta ecosystem through significant contributions of streamflow, sediments, and other attributes.

The Butte Basin Ecological Management Zone provides habitat for a wide variety of fish, wildlife, and plant communities and habitats. These include spring-run chinook salmon, steelhead trout, resident fish communities, waterfowl, riparian vegetation, and seasonally and permanently flooded wetlands. The Butte Sink contains important refuge areas including Gray Lodge Wildlife Area, Butte Basin Wildlife Area, Butte Sink National Wildlife Refuge, and the Butte Sink Wildlife Management Area.

Important ecological processes and functions in the Butte Basin Ecological Management Zone include the annual streamflow and storm runoff patterns, sediment supply and gravel recruitment, and stream meander in each stream's watershed. These important processes are in a reasonably healthy condition throughout the ecological management zone, but specific improvements are needed in certain watersheds. The greatest need is to maintain processes closely linked to the natural streamflow regime. Continued efforts toward improving low flows and reducing physical barriers to fish migration will improve the overall ecological health of the watersheds in the basin while contributing to species restoration.

Photo © California Department of Water Resources

Important fish and wildlife resources in the basin include spring-run chinook salmon, fall-run chinook salmon, steelhead trout, resident fish guilds, waterfowl guilds, shorebird and wading bird guilds, and riparian wildlife guilds. Generally, the wildlife populations are healthy. Spring-run chinook and steelhead, however, need to achieve higher sustainable annual population levels before they are considered healthy and no longer a problem in the Delta. Achieving healthy status for these fish populations is also dependent on implementing restoration actions downstream of this ecological management zone.

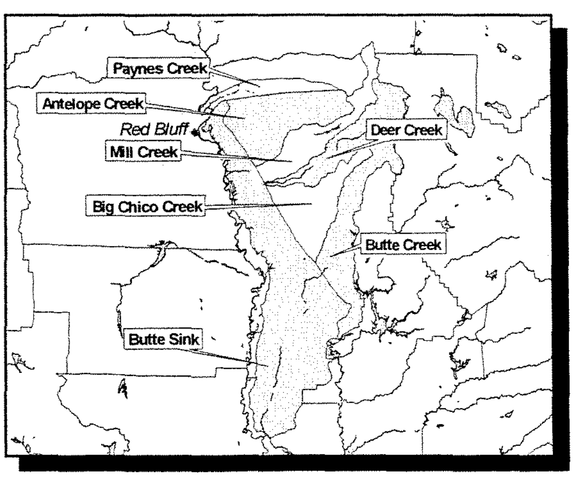
Important habitats in the Butte Basin Ecological Management Zone include anadromous fish migration, holding, spawning, and nursery habitats (freshwater and essential fish habitats), which are needed to maintain spring-run chinook and steelhead and other chinook populations. Seasonally flooded wetlands are prevalent through the lower portions of the basin and are extremely important habitat areas for waterfowl, shorebird, and wading bird guilds. Riparian and riverine aquatic habitat is important to aquatic and terrestrial species. Woody debris, such as tree branches and root wads, provide important cover for young fish. Healthy riparian vegetation provides a migration corridor that connects the mainstem Sacramento River with habitats in the upper watershed. This corridor is used by terrestrial species, such as birds and mammals.

Stressors to ecological processes, habitats, and species in the zone include diversion structures in the streams; unscreened diversions; insufficient flow in the lower portions of most of the streams, which may seasonally inhibit the upstream and downstream migration of anadromous fish; areas of inadequate riparian vegetation and woody debris; and the potential illegal harvest of spring-run chinook salmon that oversummer in isolated pools in many of the streams.

DESCRIPTION OF THE MANAGEMENT ZONE

The Butte Basin Ecological Management Zone encompasses a significant portion of the Sacramento Valley, east of the Sacramento River and north of the Colusa Basin Ecological Management Zone, and includes the following seven ecological units:

- Paynes Creek Ecological Unit,
- Antelope Creek Ecological Unit,
- Mill Creek Ecological Unit,
- Deer Creek Ecological Unit,
- Big Chico Creek Ecological Unit,
- Butte Creek Ecological Unit, and
- Butte Sink Ecological Unit.



Location Map of the Butte Basin Ecological Management Zone and Units

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE BUTTE BASIN ECOLOGICAL MANAGEMENT ZONE

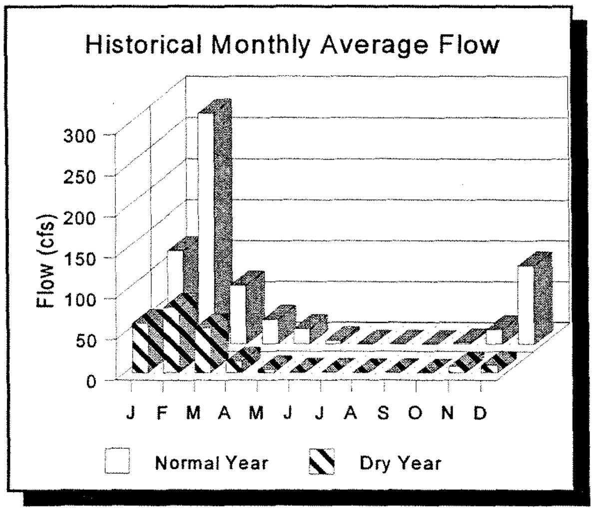
- fall-run chinook salmon
- spring-run chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- giant garter snake
- waterfowl
- plants and plant communities.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

PAYNES CREEK ECOLOGICAL MANAGEMENT UNIT

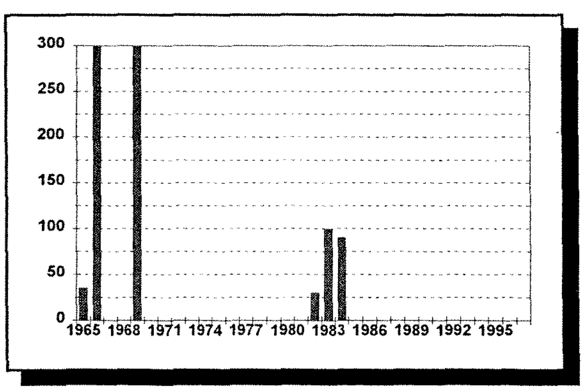
Paynes Creek enters the Sacramento River 5 miles north of Red Bluff. It flows into the Sacramento Valley from the east, draining a watershed of approximately 93 square miles. Paynes Creek originates in a series of small lava springs approximately 6 miles west of the town of Mineral. There are no significant dams on the stream; however, as many as 16 diversions seasonally divert water. Diverted water is used for irrigation, stock watering, and commercial aquaculture. Diversions are confined to the period between late spring and early fall. Significant losses of juveniles can occur in spring if the irrigation season begins when juvenile salmon are attempting to emigrate from the stream into the Sacramento River. Approximately 15 diversions in Paynes Creek need to be screened to protect juvenile fish.

Paynes Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate in foothills rather than the crests of the Sierra Nevada or Cascade ranges. Low summer and fall flows are further reduced by diversions. The stream is often dry during summer and fall. In wetter years, flows in winter average 200 to 600 cfs. In winter months of dry years, average monthly flows peak at only 50 to 80 cfs. In the driest years, winter monthly average flows reach only 10 to 20 cfs.



Paynes Creek Streamflow, 1956-1966 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall-run chinook salmon and steelhead trout use Paynes Creek when streamflow is sufficient to allow upstream passage. Surveys in the 1960s documented an average run size of 143 fall-run salmon; 300 fish was the maximum run observed in a single season. In most years, rainfall provides sufficient flow for the fall-run chinook salmon to move upstream by late fall.



Fall-run Chinook Salmon Returns to Paynes Creek, 1965-1997.

Riparian and riverine aquatic habitat needs to be improved by providing adequate streamflows and by protecting shorelines from livestock. Vegetation planting may be required in certain areas to hasten and sustain a riparian corridor along the stream.

The size of the salmon run in Paynes Creek is closely linked to rainfall. Therefore, actions to restore and improve conditions for chinook salmon and steelhead are more likely to succeed during periods of normal to above normal rainfall. Limiting water diversions during critical migration periods would help to maintain and improve flows. Reduced diversions could be achieved through voluntary restrictions; direct water purchase; or development of alternative sources, such as wells or storage facilities. Adequate flows are needed in Paynes Creek to provide for the fall adult migration, winter season fry rearing, and spring juvenile outmigration in drier years. Minimum flows in upstream summer rearing areas are needed to sustain steelhead.

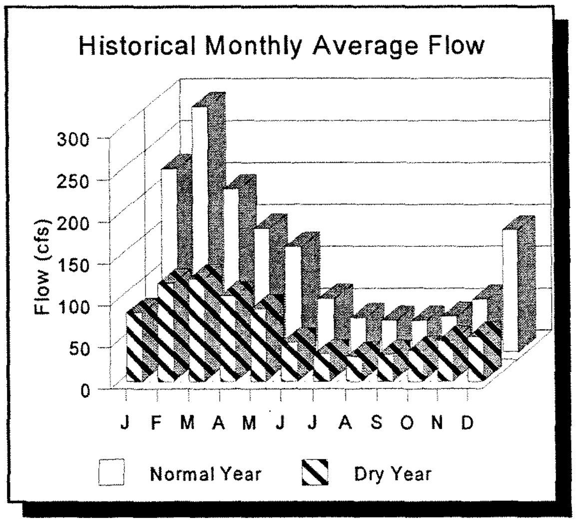
In addition to low flow, inadequate spawning gravel has been identified as a significant factor limiting salmon production. The California Department of Fish and Game (DFG) built five spawning riffles with 1,000 tons of spawning gravel in 1988. Improvement to the sediment supply, including gravel for fish spawning, needs further evaluation.

Restoration and maintenance of Paynes Creek could be improved by establishing a Paynes Creek watershed conservancy. Restoring and maintaining Paynes Creek could be facilitated by developing and implementing a comprehensive watershed management plan.

ANTELOPE CREEK ECOLOGICAL MANAGEMENT UNIT

Antelope Creek flows southwest from the Cascade Range foothills and enters the Sacramento River 9 miles southeast of Red Bluff. The drainage is approximately 123 square miles, and the average stream discharge is 107,200 acre-feet (af) per year. Antelope Creek is relatively unaltered above the valley floor, but the seasonal lack of flow to the Sacramento River reduces the creek's potential to produce anadromous fish.

Antelope Creek has a natural streamflow pattern like other nondammed streams in this ecological



Antelope Creek Streamflow, 1942-1982 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

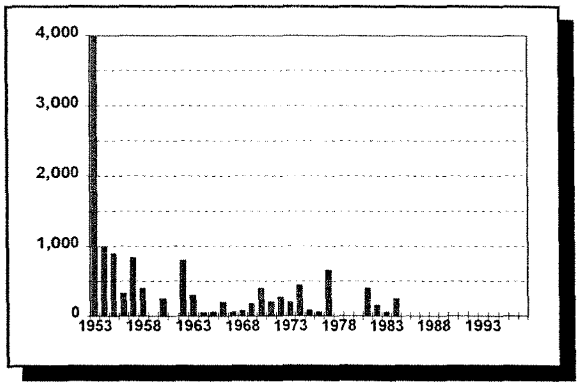
management zone. Peak flows occur in winter and spring. Lowest flows occur in summer and fall. In wettest years, average flows in winter months range from 200 to 1,200 cfs. In driest years, flows in winter months average below 50 cfs. In all but the wettest years, summer and early fall flows average from 20 to 50 cfs. The natural flow pattern is altered by diversions in the lower creek from spring through fall.

There are two water diversions at the canyon mouth on Antelope Creek. The Edwards Ranch uses water from both diversion points under riparian and pre-1914 water rights. The Los Molinos Mutual Water Company (LMMWC) shares one diversion with a water right of 70 cfs. Antelope Creek flow is typically diverted from April 1 through October 31. Average flow during this period, measured from 1940 through 1980, was 92 cfs. With water diversion rights exceeding streamflow, the lower reach of the stream is often dry. The seasonal flow needs improvement to permit unobstructed fish passage. To reestablish and increase salmon and steelhead in Antelope Creek, priority must be given to providing and maintaining adequate passage flows from October 1 through June 30 below the Edwards and LMMWC diversion dam. Diversions on Antelope Creek have been screened to protect juvenile salmon and steelhead during their downstream passage.

Migration flows and temperatures adequate to attract salmon must be provided at Antelope Creek's confluence with the Sacramento River. Diversions during the chinook and steelhead migration season should be limited to maintain a flow of at least 25 cfs at the mouth of Antelope Creek. Instream flows should be maintained throughout the irrigation diversion season to provide aquatic habitat and riparian vegetation benefits.

The riparian and riverine aquatic habit along the Antelope Creek corridor needs several improvements. Some areas have been denuded and will require significant revegetation. Woody debris, such as branches and root wads originating from the riparian forest, provides valuable cover for young fish. The riparian zone provides an important migratory corridor for terrestrial species by connecting the mainstem Sacramento River with upper watershed habitats.

Fall- and spring-run chinook salmon and steelhead trout have used Antelope Creek. Population estimates for fall-run salmon on Antelope Creek from 1965 through 1984 ranged from 50 to 4,000, with an average annual run of approximately 467 fish. Historically, an estimated 500 spring-run chinook salmon and approximately 300 steelhead trout annually used Antelope Creek. Since 1986, the California Department of Fish and Game has conducted intensive snorkle surveys on Antelope Creek. Over a period of 12 years, a total of only 19 spring-run chinook salmon have been observed. During 1997, no adult spring-run chinook salmon were observed. This series of observations suggest that Antelope Creek no longer supports a self-sustaining population of chinook salmon. The status of steelhead in Antelope Creek is unknown.



Fall-run Chinook Salmon Returns to Antelope Creek, 1953-1997.

The overall role of Antelope Creek in supporting viable populations of anadromous fish is strongly constrained by flow patterns, flow quantity, high water temperatures, geomorphology of the valley section of the stream, and the steep gradient in the upper reaches.

Insufficient fall flow patterns may delay the upstream migration and spawning of adult fall-run chinook and downstream migration of juvenile spring-run chinook. Likewise, inadequate late spring flows may limit part of the spring-run upstream migration and downstream juvenile fall-run chinook migration. In the lower stream section below the canyon mouth, Antelope Creek is subject to braiding and channel bifurcation, which also impair upstream fish passage.

The Antelope Creek Ecological Unit could be improved by establishing and supporting an Antelope Creek watershed conservancy. Restoring and maintaining Antelope Creek could be improved by developing and implementing a comprehensive watershed management plan. Forest management, including reducing fire fuel loads, would protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

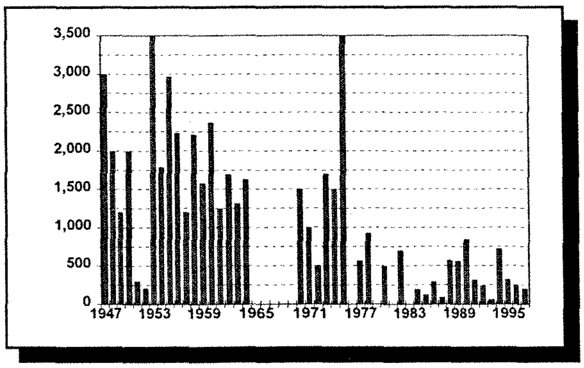
Mill Creek Ecological Management Unit

Mill Creek is a major tributary of the Sacramento River, flowing from the southern slopes of Mt. Lassen and entering the Sacramento River at river mile (RM) 230, 1 mile north of the town of Tehama. The stream originates at an elevation of approximately 8,500 feet and descends to 200 feet at its confluence with the Sacramento River. The watershed drains 134 square miles, and the stream is approximately 65 miles long. The creek is confined within a steep-sided, relatively inaccessible canyon in the upper watershed. Mill Creek spring-run chinook salmon are unique, because they spawn at altitudes above 5,000 feet—the highest altitudes known for salmon spawning in California. The stream flows through the Ishi Wilderness Area and the Gray Davis Dry Creek Reserve, which is managed by The Nature Conservancy. Two dams on the lower 8 miles of the stream divert most of the natural flow for irrigation purposes, usually from May and until September.

Mill Creek has a somewhat atypical seasonal flow pattern. Flows remain relatively high through spring, even in dry years, because of snowmelt and springs on Mt. Lassen. In wettest years, average monthly flows in winter and spring range from 800 to 1,800 cfs. In driest years, flows range only from 60 to 120 cfs. With no storage reservoirs and minimal diversions on the river, streamflows are near natural and unimpeded, except in the valley lowland reach.

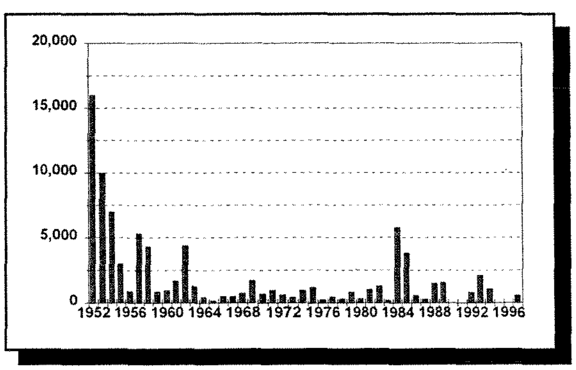
The ecological health of the Mill Creek ecological unit is rated above average due to unimpeded stream flow and the undisturbed quality throughout the holding and spawning habitat of spring-run chinook salmon and steelhead. Populations of spring-run chinook salmon and steelhead have declined sharply in recent years, in large part due to problems outside of the unit.

Spring-run chinook salmon populations in Mill Creek have ranged from a maximum of 3,500 fish to a low of no fish during the severe drought of 1977. During the past decade, annual spring-run chinook populations have averaged 390 fish. More than 2,000 steelhead have been counted at Clough Dam, and steelhead runs averaged 1,100 fish from 1953 to 1965. Anecdotal accounts place the present annual steelhead population at a few hundred fish.



Spring-run Chinook Salmon Returns to Mill Creek, 1947-1997

Fall-run chinook salmon population estimates have ranged from approximately 6,000 spawners in 1984 to 150 in 1965. The fall run has averaged 2,200 fish for the 38 years of record. Late-fall-run salmon have occasionally been observed spawning in the lower reaches of Mill Creek, but no estimates are available.



Fall-run Chinook Salmon Returns to Mill Creek, 1952-1997.

Mill Creek differs from other eastside streams because of its high silt load and turbidity during the spring snowmelt period. Recent water quality monitoring for Mill Creek indicates that lands within Lassen Volcanic National Park contribute the major source of silt from the steep barren slopes adjacent to the headwaters. There are insignificant land use activities that occur on the Lassen National Forest lands, however, most of the area is protected by its wilderness designation. The majority of the siltation sources in Mill Creek are the result of natural geologic processes that have existed for thousands of years and are not an impediment to the survival of the endemic anadromous fish populations.

Spawning areas in lower Mill Creek consist primarily of large cobbles and boulders, with very little spawning gravel. Spawning gravel naturally accumulates in the lower reaches of the stream but is flushed from the stream during higher flow events.

Three diversion structures were constructed on Mill Creek in the early 1900s, however, only two are operational. The upper and lower diversions are low structures and have been screened since the 1920s. The Department of Fish and Game has completed several improvements to these structures over the past 50 years including the addition of fish ladders and resloping and refacing the surface of the structures to improve fish passage. These diversion structures are owned and managed by the Los Molinos Mutual Water Company and are regularly inspected by the Department of Fish and Game to insure optimum fish passage conditions.

The middle diversion structure is known as the Clough Diversion which was constructed in the early 1920s and is privately owned. The structure was screened and has a functional fish ladder. The Clough Dam was breached during the January 1997 flood and presently is not a barrier to fish passage. Alternative designs for reconstructing the dam include options to provide water for irrigation without impairing fish passage.

All of the water diversions have screens, owned by the DFG, in place and in good operating condition.

Sufficient flows permit unobstructed fish passage and cleanse and distribute new spawning gravels. One of the key elements in restoring Mill Creek's salmon and steelhead populations is obtaining dependable flow in the lower stream reaches. A negotiated agreement with the water users is the preferable means of achieving this goal, because it would minimize conflicts between historical land uses and restoration of salmon and steelhead habitat. This has been partially achieved through a cooperative water exchange agreement which has been in place for seven years.

The riparian corridor needs improvement in several areas. Some locations have been denuded and will require significant revegetation.

Gravel spawning habitat in the valley floor section of the creek is not adequate for fall-run chinook salmon. Gravel recruitment is limited because of a relatively low natural supply attributable to the geologic features in the basin. Existing gravel sources may be enhanced to improve spawning areas for fall-run chinook salmon. An evaluation of the potential benefits of providing supplemental gravel into the channel should be completed.

Conservation, restoration, and preservation efforts on Mill Creek have been established by the Mill Creek Conservancy which supports the local approach to watershed management. The local residents, concerned citizens, and resource agencies worked together and prepared the Mill Creek Watershed Management Strategy which is a comprehensive document containing specific recommendation for resource protection.

Restoration activities are presently being implemented in accordance with the priorities stated in the Mill Creek Watershed Management Strategy. The Strategy Report addresses potential stressors including the potential adverse impacts from timber harvesting and additional recreational activities. However, the majority of the upper and middle watershed is protected from detrimental activity due to its Wilderness designation, PACFISH regulations, and private conservation easements.

The majority of the Mill Creek watershed remains undisturbed and is still capable of supporting historic runs of salmon and steelhead. Potential restoration work is concentrated in the lower watershed area on the valley floor that has been impacted by human activities. The major restoration efforts include replanting native riparian vegetation and securing additional instream flows.

Potential timber harvest in the upper watershed threatens loss of holding and spawning areas due to habitat degradation. Selective harvest and well-planned road construction would minimize this effect. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

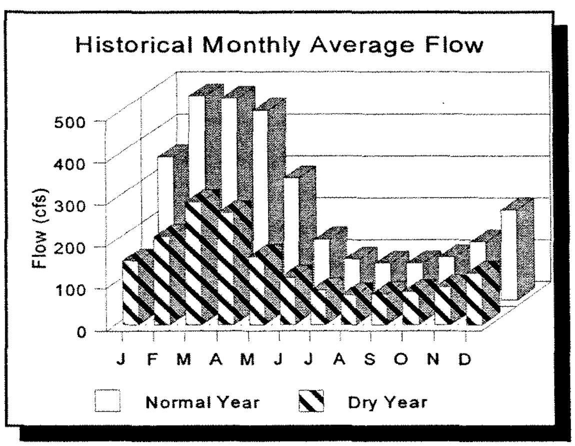
Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to illegal harvest. The remoteness of the spawning areas contributes to enforcement problems.

Deer Creek Ecological Management Unit

Deer Creek is a major tributary to the Sacramento River, originating upstream of Deer Creek Meadows on the slopes of Butt Mountain. The creek enters the Sacramento River approximately 1.5 miles north of Woodson Bridge State Park. The watershed drains 200 square miles and is 60 miles long. Part of the upper stream is paralleled by State Highway 32. The lower 10 miles of the creek flow through the valley, where most of the flow is diverted. This lower section encompasses a relatively large flood plain bounded on either side by levees.

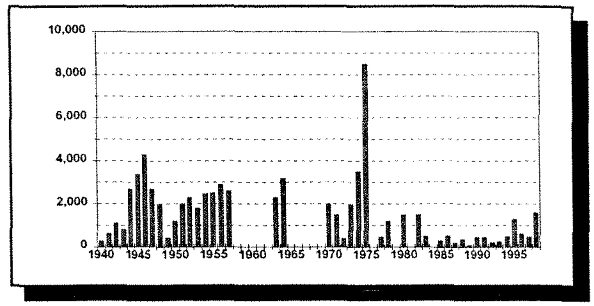
In many years prior to 1990, three diversion dams and four diversion ditches depleted all of the natural flow from mid-spring to fall. Since 1990, the local irrigation districts, with assistance from the Departments of Fish and Game and Water Resources, have voluntarily provided fish passage flows at critical times. All of the diversion structures have fish ladders and screens. Of all Sacramento Valley streams, Deer Creek has the greatest potential for restoring spring-run chinook salmon. Overall, the ecological health of the Deer Creek Ecological Management Unit is rated above average. Although spring-run chinook salmon and steelhead populations need to increase in size, the factors limiting these populations lie primarily outside of the unit.

Deer Creek has a seasonal flow pattern similar to that of Mill Creek. Flows are highest in winter and spring, and summer and fall flows. Peak monthly flows in wet winters reach up to 2,600 cfs. In driest years, winter flows reach only 90 to 110 cfs. Minimum summer and fall base flows are 60 to 80 cfs.

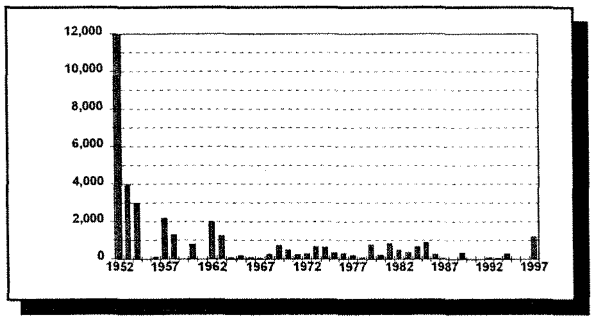


Deer Creek Streamflow, 1923-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall- and spring-run chinook salmon and steelhead trout use Deer Creek. During the past decade, an average of approximately 550 spring-run and 1,000 fall-run chinook have spawned annually in Deer Creek. Habitat in the upper watershed is relatively intact, with numerous holding areas and an abundance of spawning gravel. Some spawning areas in lower Deer Creek are lightly armored and could limit production of fall-run chinook salmon.



Spring-run Chinook Salmon Returns to Deer Creek, 1947-1998.



Fall-run Chinook Salmon Returns to Deer Creek, 1952-1997.

Except for the lack of streamflows on the valley floor below the agricultural diversions, fish habitat throughout the drainage is generally of good quality. Water right holders on Deer Creek have recently expressed interest in developing alternative water sources for fishery flows. Water users are concerned about the depleted status of the spring-run chinook salmon and have been working toward mutually acceptable solutions to restore the fishery.

Sufficient flows permit unobstructed fish passage and cleanse and distribute new spawning gravels. Inadequate flow for upstream passage is the most significant problem on Deer Creek. Flows necessary to provide unimpaired migration in the lower stream section for adult salmon and steelhead are undetermined but have been estimated to be 50 cfs at a minimum.

Adequate spawning gravel is found in lower Deer Creek for present population levels of fall-run salmon and existing gravel sources should be protected. Prior to any effort to supplement existing gravel supplies, a comprehensive analysis of stream channel dynamics is required. This study should include elements that address geomorphology, sediment transport flows, stream channel meander, sediment sources, and flood control needs or requirements.

Restoration efforts on Deer Creek will involves the ongoing participation and support of local landowners through the Deer Creek Conservancy, a local landowners organization. One role of the Deer Creek Conservancy has been the successful development of a cooperative watershed management plan including a watershed management strategy (Deer Creek Watershed Conservancy 1998). Plan formulation is in process and will help to preserve and restore spring-run chinook salmon and steelhead trout and other important attributes of the watershed. The ecological health of Deer Creek could be maintained by developing and implementing a comprehensive watershed management plan.

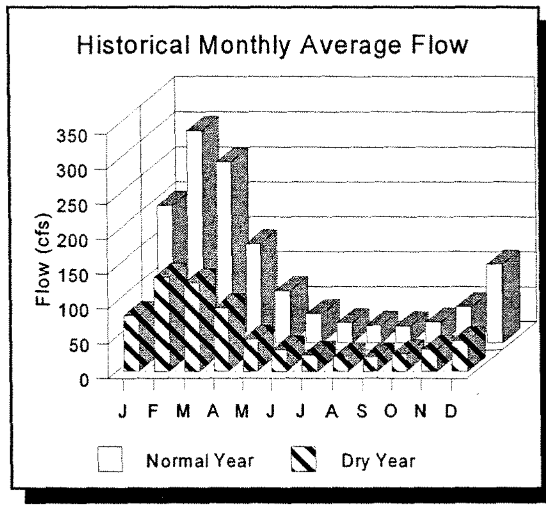
Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs protection and improvement in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities.

Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to poaching. The remoteness of the spawning area contributes to enforcement problems.

Big Chico Creek Ecological Management Unit

Big Chico Creek enters the Sacramento River 5 miles west of the City of Chico. It flows into the Sacramento Valley from the Sierra Nevada foothills, draining a watershed of approximately 72 square miles. There are no significant impoundments on the stream, and the only major water diversion has been relocated to the mainstem Sacramento River. The stream is the focal point of the local Chico community. The creek flows through Bidwell Park, downtown Chico, and the Chico State University campus. (Bidwell Park is the third largest city park in the nation.) Lindo Channel is an element of the local flood control system and originates at the Five Mile Recreation Area. The channel returns water to the creek near its mouth below the City of Chico.



Big Chico Creek Streamflow, 1936-1986 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

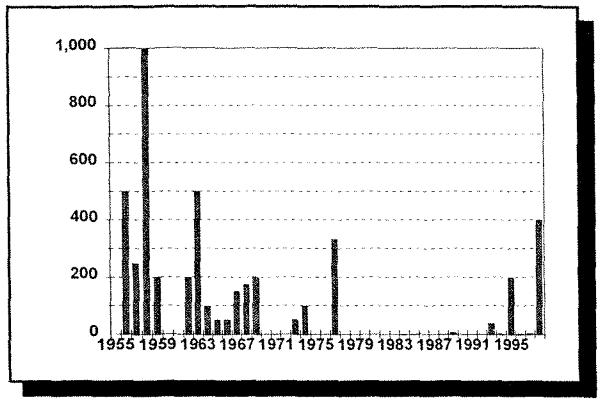
Big Chico Creek has a seasonal flow pattern similar to that of Antelope Creek with moderate winter flows and lower late spring to early fall flow than Mill and Deer Creeks. Peak winter month average flows reach 600-1,500 cfs. In driest years, winter flows reach only 20-40 cfs.

Minimum summer and fall base flows are 15-20 cfs in all but the wettest years.

Important resources in Big Chico Creek include spring- and fall-run chinook salmon and steelhead trout and resident native fishes. Although spring-run chinook salmon and steelhead populations are very low, factors limiting these population lie primarily outside of the unit. Some improvements in the steelhead trout and spring-run chinook salmon populations can be made if habitat and flows can be restored.

In 1958, the spring-run chinook salmon population was estimated at 1,000 adults, although the average annual run was probably less than one-half this amount during the 1950s and 1960s. An estimated 400 spring-run returned to Big Chico Creek in 1998 in response to a series of wet years and the relocation of the M&T Pumping Station to the mainstem Sacramento River. Steelhead populations are thought to have averaged approximately 150 returning adults during this same period. Recent estimates indicate only a remnant spring-run chinook population, a low steelhead population, and a highly variable spawning population of fall-run chinook salmon. In addition, adult spring-run chinook are deterred by intermittent flow in Lindo Channel and inadequate fish passage at the One and Five Mile Recreation Areas and at Iron Canyon in upper Bidwell Park. Marginal spawning and rearing habitat in Big Chico Creek and Lindo Channel below the Five Mile Recreation Area is used by fall-run chinook salmon. Big Chico Creek and Lindo Channel are used by many interests for a variety of purposes, including wildlife habitat, anadromous fisheries reproduction and rearing, urban storm drainage, flood control, and recreation.

Functioning in the flood control and recreational pool system, the ecological system supports three salmonid runs. Without careful coordination, successful management of one use may conflict with successful management of another. Even though excellent spawning gravel exists in Lindo



Spring-run Chinook Salmon Returns to Big Chico Creek, 1956- 1998.

Channel, in most years, intermittent flows preclude successful spawning. Big Chico Creek flows for nearly 11 miles through the City of Chico, much of it through Bidwell Park. Vegetation along Big Chico Creek in Bidwell Park is an excellent example of a mature riparian community. Lindo Channel functions as a flood relief channel for Big Chico Creek and supports riparian habitat. Both are surrounded by urban and agricultural uses that could degrade their environmental quality.

Inadequate flow for upstream passage is the most significant problem on Big Chico Creek. During all but the wetter years, flows in fall remain at summer lows. This inhibits and delays the upstream fall-run chinook salmon migration. Water management operations, such as the flow split at Five Mile Diversion Dam, that can improve flows for passage should be evaluated.

Gravel recruitment is limited by existing diversion dams, or gravel is in poor supply from past floods or flood control practices. Existing gravel sources should be protected and supplemental gravel placed into the creek channel as needed.

Restoration efforts on Big Chico Creek will involve the participation and support of local landowners through the Big Chico Creek Task Force, a local organization of stakeholders. The Big Chico Creek Task Force will be instrumental in developing a comprehensive watershed management plan and will assist or sponsor some of the needed restoration elements in the basin. One role of the Big Chico Creek Task Force will be to sponsor the development of a cooperative watershed management plan that will assist in the effort to preserve and restore spring-run chinook salmon and steelhead trout.

The ecological health of the creek could be improved by developing and implementing a comprehensive watershed management plan. Timber harvest in the upper watershed could threaten loss of holding and spawning areas because of habitat degradation. Selective harvest and well-planned road construction may minimize this effect. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs to be protected and improved in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities in cooperation with local landowners.

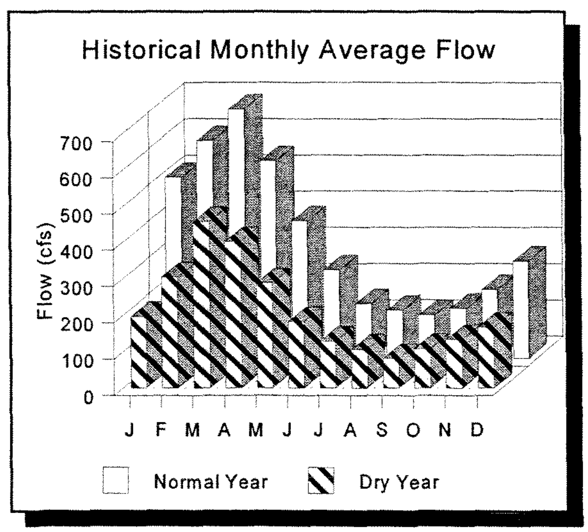
Salmon and steelhead passage problems at Iron Canyon, One-Mile Pool, and Five-Mile Diversion will be improved by repairing weirs and fishways.

Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to poaching. The remoteness of the spawning areas contributes to enforcement problems. Protect holding pools by obtaining willing seller titles or conservation easements on lands adjoining pools.

BUTTE CREEK ECOLOGICAL MANAGEMENT UNIT

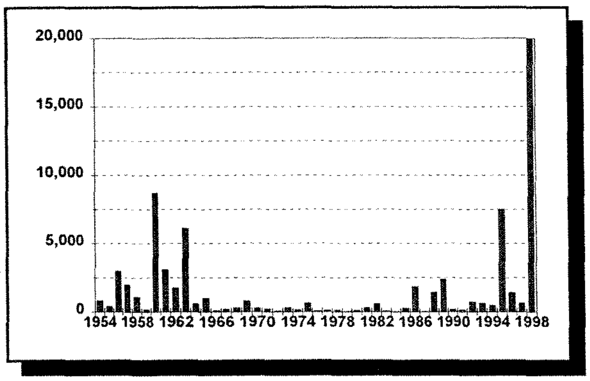
Butte Creek originates in the Jonesville Basin, Lassen National Forest, on the western slope of the Sierra Nevada. It drains the northeastern portion of Butte County. The creek enters the Sacramento Valley southeast of Chico and meanders in a southwesterly direction to the initial point of entry into the Sacramento River at Butte Slough. A second point of entry into the Sacramento River (at lower flows) is through the Sutter Bypass and Sacramento Slough. Butte Creek drains the foothills just south of the Big Chico Creek watershed and North Fork of the Feather River drainage. The upper Butte Creek watershed (northeast of Chico) has an area of approximately 150 square miles. Lower Butte Creek flows parallel to the Sacramento River for almost 50 miles to the Butte Slough outfall. It then continues through the Sutter Bypass and Sacramento Slough channels to join the Feather River near the confluence with the Sacramento River, almost 100 miles downstream of Chico. Butte Slough connects with the Sacramento River through flap gates in the Sacramento River levee. These gates may not be open during the salmon and steelhead migration periods.

Streamflow on Butte Creek is similar to that on Deer Creek, with water from snowmelt and springs to maintain summer and fall flow even in drier years. Peak flow in winter of wet years reaches 1,000 to 3,000 cfs. In driest years, winter flows average only 90 to 120 cfs. Summer and fall minimum flows generally average 120 to 160 cfs but may reach only 50 cfs in driest years.

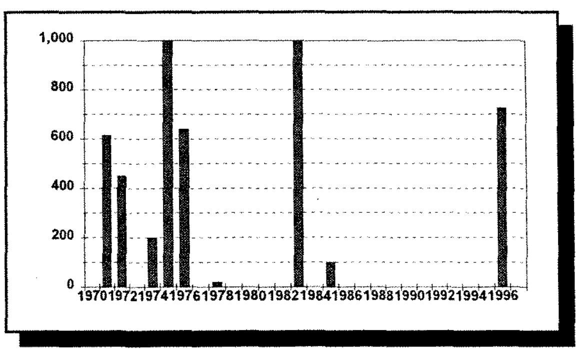


Butte Creek Streamflow, 1963-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall- and spring-run chinook salmon and steelhead trout exist in Butte Creek. As late as the 1960s, Butte Creek supported more than 4,000 adult spring-run chinook salmon, a lesser number of fall-run chinook salmon, and a small number of steelhead trout. More recently, the spring-run chinook populations have ranged from fewer than 200 adults to more than 1,000. Spring-run chinook salmon estimates reached a record of more than 8,000 in 1995, and Butte Creek demonstrated its ability to attract a large spring-run chinook salmon population with adequate streamflows. The fall-run chinook salmon population varies between a few fish to as many as 1,000. The number of steelhead is unknown.



Spring-run Chinook Salmon Returns to Butte Creek. 1954-1998.



Fall-run Chinook Salmon Returns to Butte Creek, 1970- 1997.

The decline of Butte Creek's chinook salmon and steelhead populations is attributed to:

- inadequate flows,
- unscreened diversions,
- inadequate passage over diversion dams,
- unblocked agricultural return drains that attract and strand adult fish,
- poor water quality, and
- poaching.

Nine diversion dams on Butte Creek above Butte Slough supply water for power generation, irrigation, gun clubs, and domestic use. All are known to impair and delay migrating fish. One, the Point Four Ranch Dam, was removed in July 1993. Passage at seven of the dams could be improved by either removing the dam or upgrading the ladders. All of the diversions from these dams are unscreened, except the diversion at the Parrott-Phelan Dam, which was recently screened. Presently, three of the seven dams are being removed as part of the Western Canal siphon project, and three others (Durham Mutual, Adams, and Gorrill) have defined projects to build or rebuild ladders and fish screens.

The Centerville Head Dam, immediately below the DeSabla powerhouse, is the upper limit of anadromous fish migration. Water diverted from three adjacent watersheds commingles with the natural flows of Butte Creek and often is the major portion of the flow. Feather River water enters Butte Creek at two locations: via the West Branch into DeSabla Reservoir and through the Thermalito Afterbay and the Western Canal. Flows from both Big and Little Chico Creeks enter Butte Creek from agricultural diversions that empty into Little Butte Creek. Flows from the Sacramento River reach Butte Creek from various diversion points, from as far north as the mouth of Big Chico Creek to the Reclamation District 1004 pumps located near Princeton.

Adult spring-run chinook salmon migrate into Butte Creek during February through June. They oversummer primarily in pools from the confluence of Little Butte Creek to the Centerville Head Dam and begin spawning in late September. Spring-run chinook fry emigrate as early as

December, whereas smolts emigrate the following spring. Generally, adequate migration flow exists from Centerville Head Dam downstream to the Western Canal Dam; however, during dry years, several areas above Western Canal may hinder upstream passage. In these dry years, adult spring-run chinook salmon encounter low, warm flows above Western Canal and may become stranded.

Adult fall-run chinook salmon enter lower Butte Creek during late September and early October. Their upstream passage is often blocked by dewatered stream reaches caused by diversions for flooding State and federal refuges and private duck clubs. Below the Western Canal, adult fall-run chinook often encounter impassable barriers, dewatered areas, silt deposition areas, lack of suitable gravel, and inadequate cover and shade. Several barriers exist above the Western Canal that impede the adult migration until high flows occur. Most fall-run chinook salmon spawn in the area from Durham to the Parrott-Phelan Dam, although some are known to spawn above these dams. Spawning generally occurs from October through December. Fall-run fry begin to emigrate during January and February, and smolts emigrate during April and May. However, many juveniles are entrained at the diversions or perish because of poor water quality.

Although little is known about steelhead in Butte Creek, adults probably ascend in the late fall and winter. They probably spawn during winter and spring in tributaries, such as Dry Creek, and the mainstem creek above Parrott-Phelan diversion.

The water allocation problems in the lower Butte Creek system need to be reduced. The diversion of water for agriculture, waterfowl refuges, and seasonally flooded wetlands should not impair efforts to rebuild salmon and steelhead stocks. Butte Creek water management is extremely complex. Maintaining adequate fishery flows will require close coordination among all water users in the basin. Extension of State Watermaster Service into the lower reach of Butte Creek should be considered to fulfill these management goals. This extension, however, requires the State Water Resources Control Board to adjudicate water below the Western Canal siphon. The area above is adjudicated. State Watermaster Service presently exists down to Western Canal. Extension of this service below Western Canal would require adjudication of the remaining water rights. Wildlife refuges and hunting clubs dependent on Butte Creek water provide some of the most valuable wildlife and waterfowl habitat in the Sacramento Valley. The timing of water needs conflicts among duck clubs, agriculture, and the anadromous fisheries .

Seasonal flooding of refuges and duck clubs conflicts with flows needed for spawning fall-run chinook salmon. Rice field irrigation overlaps with the need for transportation flows for both spring-run adults and juvenile salmon in April and May. Evaluating and determining water rights, water use, and instream flow needs will be a long-term effort requiring the involvement of irrigation districts, private landowners, and agency personnel. Rebuilding salmon runs in Butte Creek will require a negotiated balance among wildlife, agriculture, and fishery needs. Flow improvements can be gained by providing minimum flow requirements below diversions and acquiring existing water rights from willing sellers.

It is generally believed that gravel recruitment in the upper sections is not affected by existing diversion dam since they are either seasonal agricultural dams or relatively low-head hydropower dams which have not had major impacts on gravel recruitment of sediment supply. Existing gravel sources should be protected and supplemental gravel placed into the creek channel as needed.

The Butte Creek Watershed Conservancy is an important organization in developing, evaluating, and implementing measures to improve the ecological health of Butte Creek. This conservancy comprises local stakeholders who work closely with federal and State resource agencies to maintain and restore habitats along the creek. The

Butte Creek Watershed Conservancy will be instrumental in developing a comprehensive watershed management plan. It will assist or sponsor some of the needed restoration elements in the basin, including improving streamflows for gravel recruitment and fish passage. The management plan will help to preserve and restore spring-run chinook salmon and steelhead trout. The ecological health of the creek also could be improved by developing and implementing a comprehensive watershed management plan. Current timber harvest in the upper watershed is generally not a threat to chinook salmon or steelhead holding and spawning areas. Maintaining the existing harvest and well-planned road construction will minimize any future effects. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs to be protected and improved in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities in cooperation with local landowners.

Salmon and steelhead passage will be provided at diversion dams, including Western Canal, Durham Mutual, Adams, Gorrill, McGowan, and McPherrin. In some cases, dams will be removed. In others, fish ladders will be constructed or upgraded. Migration into lower Butte Creek via Butte Slough and the Sutter Bypass is the present means for salmon and steelhead passage to and from Butte Creek. Gates on the Sacramento River at the head of Butte Slough could be modified and operated to allow year-round passage of both juveniles and adult fish. There may also be improvements in the operation of weirs and diversions in the Sutter Bypass channels that will improve the survival of salmon and steelhead.

BUTTE SINK ECOLOGICAL MANAGEMENT UNIT

The Central Valley is one of the most important waterfowl wintering areas in the Pacific Flyway. In recognition of the value of waterfowl throughout North America, the Central Valley Habitat Joint Venture was formed to protect and restore wetlands in the Central Valley. The Butte Sink is one of the important elements of this venture. There are 11,363 acres of publicly owned and managed waterfowl habitat in the area, including the Butte Sink National Wildlife Refuge (733 acres), Gray Lodge Wildlife Area (8,375 acres), Upper Butte Sink unit of Gray Lodge (3,750 acres). The Gray Lodge WA is natural habitat in complex of wetlands and associated uplands whereas the Upper Butte Sink Unit and Butte Sink NWR are mostly agricultural land that will be restored to natural habitat. Hunting clubs maintain more than 30,000 acres of habitat in a normal year. Of this total, about 18,000 acres are natural wetlands and 12,000 acres are harvested rice fields flooded for hunting. Currently, 5,350 acres of private duck clubs are permanently protected by USFWS Conservation Easements in the Butte Basin. The National Audubon Society owns and manages another 500 acres of wetlands at the Paul L. Wattis Audubon Sanctuary west of Butte Creek (Central Valley Habitat Joint Venture 1990).

The area is also seasonally important for salmon and steelhead passage between the Sacramento River and holding, spawning, and rearing areas of the creeks. The sink is predominately wetlands interspersed with riparian vegetation all of which is subject to frequent natural seasonal flooding, which are major reasons for its importance to fish and wildlife, particularly waterfowl.

Vision for the Ecological Management Zone

The vision for the Butte Basin Ecological Management Zone includes restoring important fishery, wildlife, and plant communities to health. Generally, health will be attained when the status of specific biological resources is no longer a problem in the Delta. To attain this vision, this program will seek to improve streamflow and riparian corridors, screen diversions, remove barriers to fish migration, and restore watershed health through improved forest and rangeland management.

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. In addition, improvements in the riparian corridors will provide improved habitat for waterfowl and other wildlife. The program proposes targets and actions that will increase protection for naturally produced chinook salmon and steelhead as they rear and migrate to the mainstem Sacramento River. Important actions to improve survival include maintaining and restoring a healthy riparian zone, which includes ample shaded riverine aquatic (SRA) habitat, woody debris, and biologically productive gravel beds for fish spawning and invertebrate production. The vision also anticipates screening many small water diversions and providing sufficient flows during important periods of adult migration and juvenile emigration.

The Ecosystem Restoration Program Plan (ERPP) recommends the following approaches for restoring the Butte Basin Ecological Management Zone.

Visions for Ecological Management Units

Paynes Creek Ecological Management Unit

The vision for the Paynes Creek Ecological Unit is to improve steelhead trout and fall-run chinook salmon populations by improving streamflows and gravel spawning habitat. Paynes Creek can make minor but important contributions to the upper Sacramento River runs of these fish if adequate holding, spawning, rearing, and migration habitat are provided. Adequate streamflows are important for maintaining and restoring the connectivity of upstream spawning and nursery areas with the mainstem Sacramento River. Sufficient flows must be provided to cleanse and distribute new spawning gravels. The riparian corridor needs significant improvement in several areas; some have been denuded and will require significant revegetation.

Antelope Creek Ecological Management Unit

The vision for the Antelope Creek Ecological Unit is to increase its ability to make small contributions to chinook salmon and steelhead populations by improving fall and spring flows, increasing spawning gravels and restoring riparian corridors. The health of Antelope Creek will be maintained so that it can provide seasonal inflow, sediments, and nutrients to the Sacramento River. Antelope Creek will provide important migratory corridors for aquatic and terrestrial species. Antelope Creek could be important in some years for salmon and steelhead with adequate flows and improved spawning and rearing habitat.

Mill Creek Ecological Management Unit

Mill Creek is an important ecological unit in the Butte Basin Ecological Management Zone. It provides valuable habitat for anadromous and native resident fish. The vision for the Mill Creek Ecological Unit is to increase spring- and fall-run chinook salmon and steelhead by maintaining adequate streamflows, restoring riparian corridors, and maintaining upper watershed health. This could be accomplished by implementing a locally sponsored comprehensive watershed management and restoration program, and by implementing actions recommended for the Sacramento River, Delta, and Suisun Mash ecological management zones. It is important to note that Mill Creek's undisturbed condition offers holding and spawning habitat which is essentially unchanged from historic times. Restoration of the creek's anadromous fish populations may depend on the success of downstream restoration actions.

DEER CREEK ECOLOGICAL MANAGEMENT UNIT

The Deer Creek Ecological Unit is one of the more important ecological units in the Butte Basin Ecological Management Zone. It provides for highly valued populations of spring-run chinook salmon and steelhead, both of which are problems in the Delta, and populations of other chinook salmon and resident native fish. The vision for Deer Creek is to increase chinook salmon and steelhead runs by maintaining adequate streamflows, spawning gravels, fish passage, protecting and restoring riparian corridors, and maintaining upper watershed health. This is being accomplished by a locally sponsored comprehensive watershed management and restoration program which is supported by many state and federal agencies.

DEER CREEK WATERSHED DEMONSTRATION PROGRAM: Deer Creek has been tentatively selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1, CALFED will support ongoing management and restoration efforts in the watershed. Success in Stage 1 will set the stage for subsequent implementation phases as information derived in the Deer Creek watershed will have broad application in designing and implementing similar programs in other watersheds throughout the Sacramento Valley.

Cumulatively, an investment in Deer Creek during Stage 1 will provide direct benefits to the creek and provide the types of restoration information needed to successfully move the Ecosystem Restoration Program into subsequent implementation phases. A few of the lessons to be learned in the Deer Creek watershed include how to improve overall watershed health; how to integrate local, state, federal, and private efforts in a large-scale restoration program; how to design and implement actions to benefit spring-run chinook salmon and steelhead; and how to best manage ecological processes such as sediment transport and stream meander in a partially modified stream system.

One of the cornerstones to the probable success of this effort is the Deer Creek Watershed Conservancy. The Conservancy is an active organization comprised of landowners within the watershed who have joined together with state and federal resource management agencies to protect and restore the unique ecological attributes of the watershed. Though a stakeholder planning process, the Conservancy has completed a watershed management plan including and existing conditions report and an important watershed management strategy which outlines actions to protect the future of Deer Creek.

BIG CHICO CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Big Chico Creek Ecological Management Unit is to increase runs of chinook salmon and steelhead by providing adequate streamflows, providing unobstructed fish passage, protecting and restoring riparian corridors, and maintaining upper watershed health. This could be accomplished by implementing a locally sponsored comprehensive watershed management and restoration program.

BUTTE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Butte Creek Ecological Management Unit is restoring spring-run chinook salmon and steelhead populations by improving fish passage, increasing and improving streamflow, consolidating and screening diversions, and protecting and restoring the riparian corridor. These improvements will help to restore and maintain habitats needed to support a large population of spring-run chinook salmon and modest populations of fall-run chinook salmon and steelhead trout. Screening will allow continued water diversion for agricultural purposes and for the seasonal flooding of private wetlands and adjacent wildlife refuges. Restoring habitat in Butte Creek would allow the spring-run and fall-run chinook population to achieve increased annual spawning populations.

BUTTE SINK ECOLOGICAL MANAGEMENT UNIT

The vision for the Butte Sink Ecological Management Unit includes restoring stream channels, streamflow, and riparian SRA habitat, as well as adjacent wetland habitat. ERPP also envisions restoring or maintaining stream channels, streamflows, and SRA habitat to improve rearing and migrating conditions for salmon and steelhead and to improve habitats for resident native fishes, such as the Sacramento splittail.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Healthy streamflows are required to sustain sediment transport, stream meander, riparian plant communities and aquatic organisms. The vision is that streamflows will emulate (imitate) the natural seasonal runoff pattern. This would include a late-summer or early fall flow event to sustain ecological processes related to channel maintenance. Such flows would attract and improve the upstream migration of adult chinook salmon.

COARSE SEDIMENT SUPPLY: Natural sediment supplies and gravel recruitment below major dams have been eliminated. Supplementing gravel and other sediments at those sites and reactivating sediment transport in lower creek sections would assist in maintaining ecological processes and important habitat substrates used for invertebrate production and fish spawning. The vision is that existing natural sediment supplies will be protected to maintain stream channel gradients, provide gravel for spawning and invertebrate production, and contribute to maintaining riparian vegetation.

STREAM MEANDER: A natural stream meander process will provide much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species. The vision is that streams will be allowed to naturally migrate consistent with flood control requirements.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding of leveed lands, use of the Butte Sinks's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Habitats important to anadromous fish production in this ecological zone are impaired by land use activities, including developments along the stream corridors. Improvements are needed to restore riparian, shaded riverine (of rivers) aquatic (SRA), and woody debris habitats. These, in turn, will support improved aquatic species survival. The vision is that the riparian system will provide shading to moderate water temperatures, provide habitat for aquatic species, and provide a migration corridor for birds and other terrestrial species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper reaches of creeks in Butte Basin Ecological Management Zone are typical of salmon-steelhead streams and the lower section are typical of fall chinook salmon spawning stream (Moyle and Ellison 1991). The quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The streams in this ecological management zone have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creeks include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Butte Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Removing water through unscreened diversions is a direct source of young fish mortality. Reducing these losses would contribute to overall ecosystem health by promoting sustainable fisheries and higher population levels. The vision is that alternative water sources will reduce reliance on instream diversions and that water will be diverted in a manner that does not impair efforts to restore aquatic species and riparian habitat.

DAMS AND OTHER STRUCTURES: Improve the opportunity for the successful upstream and downstream migration of anadromous fish species. The vision is that instream structures will not impair the up- and downstream migration of aquatic species.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of chinook salmon and steelhead in the streams, Bay-Delta, and ocean constrain the recovery of wild populations. Harvest rate reductions will be necessary to allow recovery of populations. The vision is that harvest will not impair efforts to rebuild chinook salmon and steelhead populations.

ARTIFICIAL PROPAGATION OF FISH: The artificial production of chinook salmon and steelhead supports important sport and commercial fisheries and mitigates loss of salmon and steelhead habitat that resulted from dam construction. Due to release practices, fish from several Central Valley hatcheries supplement the naturally spawning salmon and steelhead in the Sacramento River and its tributaries. Hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for resources. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers.

Improvements in hatchery practices are necessary to ensure recovery of wild salmon and steelhead populations. The vision is that hatchery practices throughout the Sacramento Valley will not impair the genetic integrity or identity of chinook salmon and steelhead in the Butte Basin Ecological Management Zone.

VISIONS FOR SPECIES

FALL-RUN CHINOOK SALMON: The vision for fall-run chinook salmon is to recover all stocks presently proposed for listing under the ESA, achieve naturally spawning populations levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and the use fully existing and restored habitat. Fall-run chinook will directly benefit from restoration actions to improve ecological processes and habitat, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that fall-run chinook salmon will be sustained at levels that fully use existing and restored habitat.

SPRING-RUN CHINOOK SALMON: The vision for spring-run chinook salmon is to recover this State-listed threatened species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. Spring-run chinook will directly benefit from restoration actions to improve ecological processes and habitats, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that adult and juvenile spring-run chinook salmon will fully use existing and restored habitat.

STEELHEAD: The vision for steelhead it to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats. Steelhead will directly benefit from restoration actions to improve ecological processes and habitats, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that steelhead will fully use existing and restored habitat.

LAMPREY: The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to better manage these species and their habitat.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Butte Basin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Butte Basin Ecological Management Zone, particularly in the Butte Sink Ecological Management Unit, and possibly increases in some populations would be expected.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

WATERSHED ORGANIZATIONS

MILL CREEK CONSERVANCY

The Mill Creek Conservancy is spearheading a cooperative approach to watershed management with special emphasis on protecting and enhancing chinook salmon and steelhead habitat. In December 1994, the Conservancy developed a Memorandum of Understanding (MOU) to create a Mill Creek Watershed Management Strategy. There are 17 partners to the MOU, including the U.S. Forest Service, California Department of Fish and Game (DFG), Bureau of Land Management, California Department of Water Resources (DWR), The Nature Conservancy, Natural Resource Conservation Service, Los Molinos School District, and others. In 1995, the Conservancy secured funding and developed a work program for a cooperative, local resource management approach. In 1996, a wide range of stakeholders participated in eight Scoping Study sessions to discuss goals and project priorities. The result was the *Mill Creek Watershed Management Strategy Report,* which contained 13 recommendations from the Watershed Advisory Committee. The USFWS, through the CVPIA, has provided funding for riparian restoration projects along lower Mill Creek. Planting and monitoring will be done over a three-year period.

DEER CREEK WATERSHED CONSERVANCY

The Deer Creek Watershed Conservancy was created by the property owners within the drainage to protect Deer Creek's unique ecological values. The Conservancy provides a forum for all stakeholders to become involved in the watershed and to share ideas regarding land use decisions. The processes used by the Conservancy helps build a common information base, keeps communication channels open, and establishes trust and credibility among those wishing to protect and enhance the watershed. The first act of this conservancy was to author and initiate legislation to prevent the construction of any new dams within the watershed.

BUTTE CREEK WATERSHED CONSERVANCY

The Butte Creek Watershed Conservancy was formed to provide a forum for communication among stakeholders and property owners in the watershed and to develop a watershed planning and management program.

BIG CHICO CREEK WATERSHED ALLIANCE

The Big Chico Creek Watershed Alliance was sponsored by the City of Chico to address specific problems in the watershed. Still active, it has the potential to serve as the public forum to bring together stakeholders, landowners, and technical experts to develop a watershed management program for Big Chico Creek.

FOUR PUMPS AGREEMENT

(Agreement Between the Department of Water Resources and the Department of Fish and Game to Offset Direct Fish Losses in Relation to the Harvey O. Banks Delta Pumping Plant.) This agreement between the Departments of Water Resources and Fish and Game is a mutually beneficial program to protect and restore habitat for anadromous fish, particularly for chinook salmon. Project-by-project funding is available through this agreement. Projects that provide quantifiable benefits to spring- and fall-run chinook salmon, within specified cost-benefit parameters, are generally approved for funding.

Maintaining and restoring the ecological health of the Butte Basin Ecological Management Zone units will heavily depend on local watershed groups. The ERPP encourages similar watershed groups on Paynes and Antelope Creeks. Efforts in the Butte Basin will be linked to the California Waterfowl Association, Ducks Unlimited, The Nature Conservancy, and the California rice industry. Overall efforts will require cooperation from resource agencies, such as DFG, DWR, U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS), as well as participation and support from the U.S. Bureau of Reclamation (Reclamation), the Natural Resources Conservation Service, and other private organizations, water districts, and individual landowners. These groups are expected to work together to maintain and restore streamflows and fish and wildlife habitat, reduce impacts of diversions, and minimize poaching and habitat and water quality degradation in basin streams. ERPP may provide supporting funding for enhancing streamflows, reducing fish passage problems, screening diversions, restoring habitats, and increasing Fish and Game Code enforcement to protect recovering populations of salmon and steelhead.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoration of habitats and species and elimination of many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. The CVPIA calls for doubling the salmon and steelhead populations in the Butte Basin by 2002.

SALMON, STEELHEAD AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the DFG to implement measures to double the numbers of salmon and steelhead present in the Central Valley (CDFG 1993). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and assist in obtaining funding for feasibility studies, environmental permitting, and project construction.

Other efforts to improve habitat and reduce stressors will be coordinated with existing state and federal programs and with stakeholder organizations. Their objectives include restoring

Central Valley habitat and fish and wildlife populations.

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 Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

CALFED Bay-Delta Program

CALFED has funded approximately 20 ecosystem restoration projects in Butte Basin. Many of these projects address improving fish passage and restoring riparian habitat. One of the more significant projects constructed a siphon to pass an irrigation canal under Butte Creek, removed five diversion dams, and eliminated 12 unscreened diversion for the Western Canal Irrigation District.

Other Programs

- Lassen National Forest Land and Resource Management Plan.
- National Water Quality assessment Program-the Sacramento River Basin.
- Redding Resource Management Plan.
- Deer Creek Water Exchange Project.
- The Watershed Management Initiative.
- California Rivers Assessment (CARA).
- Rangeland Water Quality Management Plan.
- Sierra Nevada Ecosystem Project.
- Sacramento Coordinated Water Quality Monitoring Program.
- Sacramento River Toxic Pollutant Control Program.
- Sacramento River Watershed Program.
- Tehama County General Plan.
- Tehama County Groundwater Management Plan.

Linkage to Other Ecological Management Zones

Many of the resource elements in the Butte Basin Ecological Management Zone depend heavily on conditions or elements in other zones. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem Sacramento River, Delta, San Francisco Bay, and nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, contaminants, water quality, harvest, and a variety of other factors, restoring anadromous fish populations in the Butte Creek Ecological Management Zone will require efforts in other zones.

Reducing or eliminating stressors in the down-stream Ecological Management Zones and improving or restoring downstream habitat are important to restoring healthy fish, wildlife, and plant communities in the Butte Basin Ecological Management Zone.

Restoration Targets, and Programmatic Actions

Ecological Processes

Central Valley Streamflow

Target 1: Increase spring and fall flow in Paynes Creek (◆).

Programmatic Action 1A: Develop a cooperative approach to increase flow in Paynes Creek by acquiring water from willing sellers or by developing alternative supplies.

Target 2: Increase flow in Antelope Creek during October 1 through June 30 (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative approach to evaluate opportunities to increase flow in Antelope Creek. This involves acquiring water from willing sellers or providing alternative water supplies to diverters during the upstream and downstream migration of adult and juvenile spring- and fall-run chinook salmon and steelhead trout.

TARGET 3: Increase the flow in Mill Creek (◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative approach to increase flow in the lower 8 miles of Mill Creek. This involves acquiring water from willing sellers or by providing alterative water supplies to diverters during the upstream migration of adult salmon and steelhead.

TARGET 4: Increase flow in the lower 10 miles of Deer Creek (◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative approach to increase flow in the lower section of Deer Creek. This involves innovative means to provide alternative supplies during the upstream migration of adult spring-run and fall-run chinook salmon and steelhead trout.

TARGET 5: Increase flow in Butte Creek (◆◆).

PROGRAMMATIC ACTION 5A: Develop a cooperative approach to increase flow in Butte Creek by acquiring water from willing sellers.

TARGET 6: Maintain a minimum year-round flow of 40 cfs in Butte Creek between the Centerville Diversion Dam and the Centerville Powerhouse (◆◆◆).

PROGRAMMATIC ACTION 6A: Develop a cooperative program with PG&E to maintain a minimum flow in Butte Creek below the Centerville Diversion Dam.

TARGET 7: Develop and implement comprehensive watershed management programs to protect water quality, increase summer base flows, and protect and restore other resources such as riparian vegetation.

PROGRAMMATIC ACTION 7A: Support local groups in funding and developing watershed management plans including support for watershed coordinators.

RATIONALE: *The streams in the Butte Basin Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. One of the key attributes of streamflow in this Ecological Management Zone is providing for successful upstream passage of adult fish. In addition, flow is the power that drives many ecological functions and processes linked to stream channel morphology, riparian communities, and fish habitat. Many of the diversions on these streams are for agricultural purposes, and alternative water supplies during important periods could permit flow to remain in the creek while alternative sources are provided. The lower watersheds of many of these streams are being subdivided, and additional demands are being placed on the limited water supplies and instream flows. Two important periods are during the upstream migration of adult spring-run chinook salmon and the downstream migration of yearling spring-run chinook salmon and steelhead, which typically occurs in late winter and early spring. Water diversions often shorten the migration season, when streamflows naturally decline. This is the period when supplemental or alternative water supplies could be best used.*

COARSE SEDIMENT SUPPLY

TARGET 1: Develop a cooperative program to replenish spawning gravel in Big Chico Creek. Especially target stream reaches that have been modified for flood control so that there is no net loss of sediments transported through the Sycamore, Lindo Channel, and Big Chico Creek split (◆◆).

PROGRAMMATIC ACTION 1A: Assist in the redesign and reconstruct the flood control box culvert structures on Big Chico Creek near the Five-Mile Recreation Area to allow the natural downstream sediments transport.

TARGET 2: Develop a cooperative program to improve fall-run chinook salmon spawning habitat in the lower 8 miles of Mill Creek (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to improve chinook salmon spawning habitats in lower Mill Creek by reactivating and maintaining natural sediment transport processes.

TARGET 3: Improve spawning gravel and gravel availability in Butte Creek (◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to improve spawning habitat in Butte Creek by maintaining natural sediment transport processes.

RATIONALE: *Gravel transport and deposition processes in Butte Basin Ecological Management Zone streams are essential. These processes maintain spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Opportunities to maintain and restore gravel recruitment are possible by manipulating natural processes and controlling or managing environmental stressors that adversely affect gravel recruitment.*

STREAM MEANDER AND FLOODPLAIN

TARGET 1: Preserve or restore the 50- to 100-year floodplains along the lower reaches of streams in the Butte Basin Ecological Management Zone, and construct setback levees to reactivate channel meander in areas presently confined by levees (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate whether a more defined stream channel in the lower 10 miles of Antelope Creek would facilitate fish passage by minimizing water infiltration through the streambed and maintaining flow connection with the Sacramento River.

PROGRAMMATIC ACTION 1B: Cooperatively evaluate whether a more defined stream channel in the lower 10 miles of Deer Creek would facilitate stream meander, channel-floodplain interactions, gravel recruitment and transport, and riparian regeneration.

RATIONALE: *Stream meander belts are the areas in which natural bank erosion and floodplain and sediment bar accretions occur along streams. Natural stream meander belts in alluvial areas of the Butte Basin Ecological Management Zone function dynamically. They transport and deposit sediments and provide transient habitats important to aquatic invertebrates and fish. They also provide and maintain surfaces that are colonized by natural vegetation that supports wildlife. The lower valley stream reaches in this Ecological Management Zone serve as important migratory corridors to the upper watersheds for spring-run chinook salmon and steelhead and provide spawning substrate for fall-run chinook salmon.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Assist in protecting 10,000 acres of existing seasonal wetland habitat through fee acquisition or perpetual easements consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 10,000 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 26,150 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Butte Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Butte Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to restore and maintain riparian habitat along the lower 10 miles of Mill Creek (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore and maintain riparian habitat along Mill Creek by acquiring conservation easements or by voluntary land-owner participation.

TARGET 2: Develop a cooperative program to restore and maintain riparian habitat along the lower 10 miles of Deer Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore and maintain riparian habitat along Deer Creek by acquiring conservation easements or by voluntary land-owner participation.

TARGET 3: Develop a cooperative program to restore and maintain riparian habitat along Big Chico Creek (◆◆◆).

PROGRAMMATIC ACTION 3A: Cooperate with local landowners to encourage revegetation of denuded stream reaches and to establish, restore, and maintain riparian habitat on Big Chico Creek.

TARGET 4: Develop a cooperative program to restore and maintain riparian habitat along Butte Creek (◆◆◆).

PROGRAMMATIC ACTION 4A: Cooperate with local landowners to encourage revegetation of denuded stream reaches and to establish, restore, and maintain riparian habitat on Butte Creek.

RATIONALE: *Many wildlife species, including several listed as threatened or endangered under the State and federal Endangered Species Acts (ESAs), and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than all other habitat types in California. Riparian habitat degradation and loss have substantially reduced the habitat area available for associated wildlife species. This habitat loss has reduced water storage, nutrient cycling, and foodweb support functions.*

Freshwater Fish Habitat and Essential Fish Habitat

Target 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

Programmatic Actions: No additional programmatic actions are recommended.

Rationale: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat.. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of creeks in this ecological management zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

Agricultural Lands

Target 1: Cooperatively manage 108,832 acres of agricultural lands (◆◆).

Programmatic Action 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

Programmatic Action 1B: Convert agricultural lands in the Butte Basin Ecological Management Zone from crop types of low forage value for wintering waterfowl and other wildlife to crop types of greater forage value.

Programmatic Action 1C: Defer fall tillage on rice fields in the Butte Basin Ecological Management Zone to increase the forage for wintering waterfowl and associated wildlife.

Rationale: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980)

Reducing or Eliminating Stressors

Water Diversions

Target 1: Improve the survival of chinook salmon and steelhead in Butte Creek by helping to install positive-barrier fish screens (◆◆◆).

Programmatic Action 1A: Improve the survival of juvenile chinook salmon and steelhead in Butte Creek by helping to the install screened portable pumps as an alternative to the Little Dry Creek diversion.

Programmatic Action 1B: Increase the survival of juvenile chinook salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at the Durham-Mutual Diversion Dam.

Programmatic Action 1C: Increase the survival of juvenile chinook salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at Adams Dam.

Programmatic Action 1D: Increase the survival of juvenile salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at Gorrill Dam.

Programmatic Action 1E: Increase the survival of juvenile salmon and steelhead in Butte Creek by evaluating the need to install a positive-barrier fish screen at White Mallard Dam.

Programmatic Action 1F. Increase the survival of juvenile salmon and steelhead in the Sutter Bypass by evaluating the need to install positive barrier fish screens on diversions.

Rationale: *Diverting, storing, and releasing water in the watershed directly affects fish, aquatic organisms, and nutrient levels in the system and indirectly affects habitat, foodweb production, and species abundance and distribution. Diversions cause water, nutrient, sediment, and organism losses. Seasonal and daily water release patterns from storage may affect habitat, water quality, and aquatic organism survival. Flood control releases into bypasses also cause adult and juvenile fish stranding.*

Dams and Other Structures

Target 1: Improve chinook salmon and steelhead survival in Antelope Creek by developing a cooperative program to reduce the use of seasonal diversion dams by 50% during the late spring, early fall, and winter (◆◆).

Programmatic Action 1A: Develop a cooperative program to evaluate the reduced use of seasonal diversion dams that may be barriers to migrating chinook salmon and steelhead in Antelope Creek by acquiring water rights or providing alternative sources of water.

Target 2: Develop a cooperative program to improve the upstream passage of adult chinook salmon and steelhead in Big Chico Creek by providing access to 100% of habitat located below natural barriers (◆◆).

Programmatic Action 2A: Repair or reconstruct the fish ladders in Big Chico Creek to improve the upstream passage of adult spring-run chinook salmon and steelhead trout.

Programmatic Action 2B: Repair the Lindo Channel weir and fishway at the Lindo Channel box culvert at the Five Mile Diversion to improve upstream fish passage.

Target 3: Develop a cooperative approach to ensure unimpeded upstream passage of adult spring-run chinook salmon and steelhead in Mill Creek (◆◆◆).

Programmatic Action 3A: Cooperatively develop and implement an interim fish passage corrective program at Clough Dam on Mill Creek until a permanent solution is developed cooperatively with the landowners.

TARGET 4: Develop a cooperative program to improve the upstream passage of adult spring-run chinook salmon and steelhead in Butte Creek to allow access to 100% of the habitat below the Centerville Head Dam (◆◆◆).

PROGRAMMATIC ACTION 4A: Increase the opportunity for the successful upstream passage of adult spring-run chinook salmon and steelhead on Butte Creek by developing a cooperative program to evaluate the feasibility of removing diversion dams, providing alternative sources of water, or constructing new high-water-volume fish ladders.

PROGRAMMATIC ACTION 4B: Improve chinook salmon and steelhead survival and passage in Butte Creek by cooperatively developing and evaluating operational criteria and potential modifications to the Butte Slough outfall.

PROGRAMMATIC ACTION 4C: Increase chinook salmon survival in Butte Creek by cooperatively helping local interests to eliminate stranding at the drainage outfalls in the lower reach.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow the wild, naturally produced fish spawning population to attain a level that fully uses existing and restored habitat. Focus the harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by providing increased enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet the target.

PROGRAMMATIC ACTION 1C: Reduce the harvest of wild, naturally produced steelhead populations where necessary by marking hatchery-reared fish and instituting a selective fishery.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations to levels that fully take advantage of habitat may require restrictions on harvest during, and even after, the recovery period. Stakeholder organizations should help to ensure a balanced and fair allocation of available harvest. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the wild fish harvest, while hatchery fish harvest levels reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in the Coleman National Fish Hatchery will stray into non-natal streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking may be reduced in years when natural production is high.

TARGET 2: Limit hatchery stocking if salmon or steelhead populations can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment fall chinook salmon and steelhead populations only when alternative measures are deemed insufficient for populations recovery.

TARGET 3: Minimize further threats of hatchery fish contaminating naturally produced chinook salmon and steelhead stocks (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting adult spawners for the hatchery from an appropriate cross-section of the available adult population.

RATIONALE: *Hatchery augmentation should be limited to protect recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetics of wild stocks has occurred, additional protective measures are necessary to minimize further degradation of genetic integrity. Because of the extent of development on the Sacramento River and Battle Creek, stocking chinook salmon and steelhead may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries.*

REFERENCES USED TO DEVELOP THE VISION FOR THE BUTTE BASIN ECOLOGICAL MANAGEMENT ZONE

California Department of Fish and Game. 1993. Restoring Central Valley streams: a plan for action. Department of Fish and Game. November. 198 p.

California Department of Fish and Game. 1996. Steelhead restoration and management plan for California. Department of Fish and Game. February. 234 p.

Central Valley Habitat Joint Venture. 1990. Central Valley Habitat Joint Venture Implementation Plan, a component of the North American Waterfowl Management Plan. February 1990.

Deer Creek Watershed Conservancy. 1998. Deer Creek Watershed Management Plan. Prepared for The Resources Agency, State of California, California State Water Resources Control Board and U.S. Fish and Wildlife Service. June 1998.

Deer Creek Watershed Conservancy. 1998. Deer Creek Watershed Management Plan: Summary of plant and programs relevant to the management of Deer Creek and the Deer Creek Watershed May 1998.

Madrone Associates. 1980. Sacramento-San Joaquin Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and U.S. Fish and Wildlife Service.

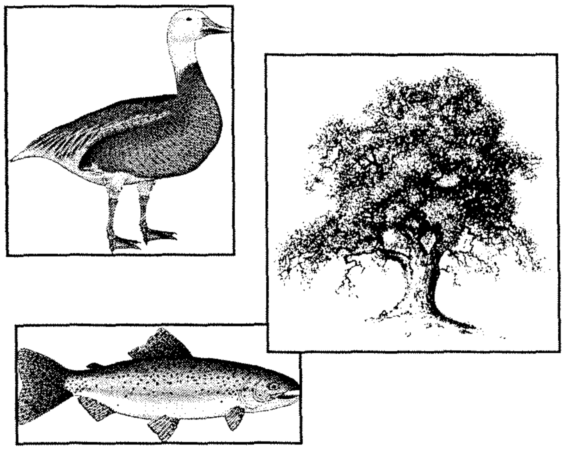
Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

Resources Agency 1989. Upper Sacramento River fisheries and riparian habitat management plan. January. 158 p.

US Fish and Wildlife Service. 1997. Revised draft anadromous fish restoration plan: a plan to increase natural production of anadromous fish in the Central Valley of California. U.S. Fish and Wildlife Service. May 30, 1997.

◆ Feather River/Sutter Basin Ecological Management Zone



Introduction

The Feather River/Sutter Basin Ecological Management Zone contributes to the health of the Sacramento-San Joaquin River Delta by sustaining ecological processes that support anadromous fish and other aquatic and terrestrial wildlife and plant habitats in this zone and in the Delta. Streamflow, sediment, and nutrients, including nitrogen, phosphorous, and organic detritus coming from this Ecological Management Zone, are all important to the Delta.

Chinook salmon, white sturgeon, green sturgeon, steelhead and lamprey are important anadromous fish species and striped bass and American shad are harvestable (sport) species that depend on healthy conditions in the Sacramento-San Joaquin Delta and Feather River/Sutter Basin Ecological Management Zones. The Feather River is important for spawning and rearing fall-run and spring-run chinook salmon, steelhead, white and green sturgeon, striped bass, and American shad. The Yuba River is important for fall-run chinook salmon, steelhead, and American shad, and potentially for spring-run chinook salmon. Bear River and Honcut Creek support small runs of fall-run chinook salmon. Sutter Bypass is an important migration route for spring-run and fall-run chinook salmon from Butte Creek. In most years, almost all populations of upper Sacramento River migratory fish are potentially affected by the Sutter Bypass. The bypass system (Tisdale, Colusa, and Moulton weirs) are configured such that at river flows exceeding approximately 22,000 cfs, flows begin to begin to be diverted into the bypass. During periods of high runoff, all flows above 30,000 cfs are diverted into the bypass. The Sutter Bypass also is an important spawning and rearing area for splittail, which migrate from the Bay-Delta each winter to spawn in flooded portions of the lower rivers, such as the Sutter Bypass. Under certain hydrologic conditions, bypass flooding may cause stranding and loss of juvenile fish and other aquatic resources.

Important ecological processes that would maintain or increase Feather River/Sutter Basin Ecological Management Zone health are:

- streamflow,
- coarse sediment supplies
- stream meander
- floodplain processes, and
- water temperature.

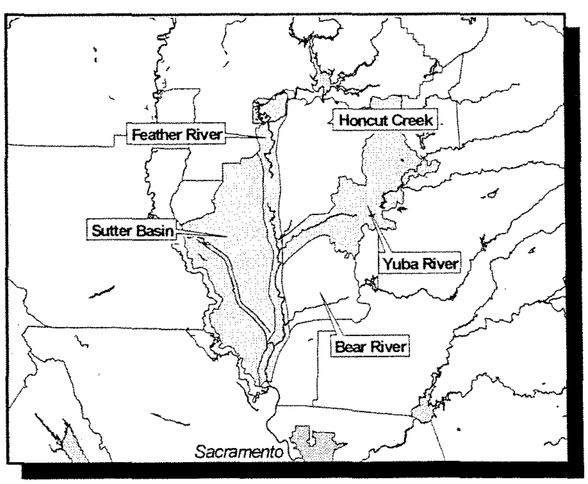
Important habitats include riparian wetlands, shaded riverine aquatic (SRA), freshwater fish habitat, and essential fish habitat. Seasonally flooded wetlands are common through the lower basin portions and are extremely important habitat areas for waterfowl, shorebird, and wading bird guilds. Important species include all runs of chinook salmon, steelhead trout, sturgeon, American shad, resident native fish guilds, waterfowl guilds, shorebird and wading bird guilds, and riparian wildlife guilds. Stressors, including flood control improvements, urbanization (floodplain encroachment), dams, legal and illegal fish harvest, insufficient flow in the lower portions of most streams, high water temperature during salmon spawning and egg incubation, poor water quality, stranding in flood bypasses and flood plains, hatchery stocking of salmon and steelhead, and unscreened or poorly screened water diversions, have affected the health of anadromous fish populations.

DESCRIPTION OF THE MANAGEMENT ZONE

The Feather River/Sutter Basin Ecological Management Zone includes the following Ecological Management Units:

- Feather River Ecological Management Unit
- Yuba River Ecological Management Unit
- Bear River and Honcut Creek Ecological Management Unit, and
- Sutter Bypass Ecological Management Unit.
-

These units provide habitat for a wide variety of fish, wildlife, and plant species.



Location Map of the Feather River/Sutter Basin Ecological Management Zone and Units.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE FEATHER RIVER/SUTTER BASIN ECOLOGICAL MANAGEMENT ZONE

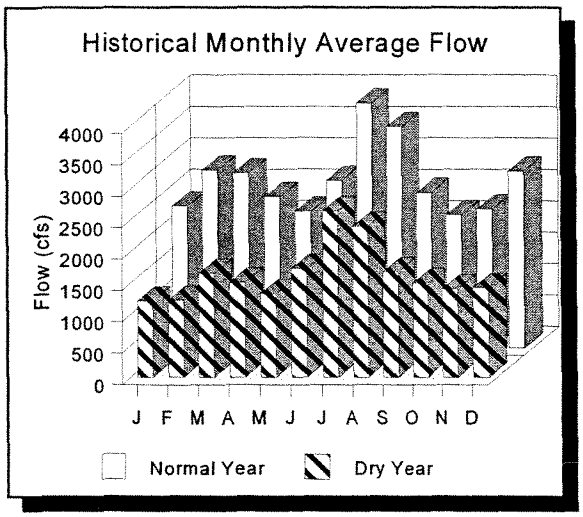
- green sturgeon
- white sturgeon
- chinook salmon
- steelhead trout
- striped bass
- American shad
- lamprey
- splittail
- waterfowl
- neotropical migratory birds
- plants and plant communities.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

FEATHER RIVER ECOLOGICAL MANAGEMENT UNIT

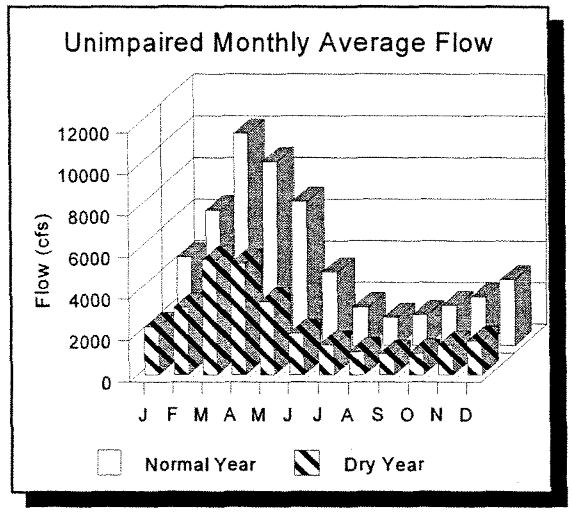
The Feather River, with a drainage area of 3,607 square miles, is the largest Sacramento River tributary downstream of Shasta Dam. Watersheds of the various forks drain high-elevation ranges of the Cascade Range and Sierra Nevada. Numerous storage reservoirs are located on the river, including Lake Almanor and Butt Valley Reservoir on the North Fork, Lake Davis and Bucks Lake on the Middle Fork, and Little Grass Valley Reservoir on the South Fork. Oroville and Thermalito Reservoirs are on the mainstem below the forks, and major water diversion take place at both reservoirs. The lower Feather River downstream of Oroville picks up the flow of major tributaries, including Honcut Creek, the Yuba River, and the Bear River.

The Feather River has a natural (unimpaired) streamflow pattern typical of streams that drain the higher Cascade Range and Sierra Nevada elevations on the east side of the Sacramento Valley. Flows peak in winter and spring. Lower flows in summer and fall are sustained by snowmelt and foothill and mountain springs. In the wettest years, unimpaired monthly average flows in winter months average 24,000 to 48,000 cubic feet per second (cfs), whereas spring inflows are slightly lower at 18,000 to 28,000 cfs. In dry and normal years, winter and spring unimpaired flows range from 2,000 to 10,000 cfs. In the driest years, unimpaired flows in winter months average 1,100 to 1,500 cfs and spring flows average slightly higher at 1,500 to 2,000 cfs. The lowest unimpaired flows are 800 to 1,000 cfs in August through October of the driest years. Summer and early-fall flows are normally 1,000 to 2,000 cfs, except in years of high rainfall, when they range from 2,000 to 6,000 cfs.



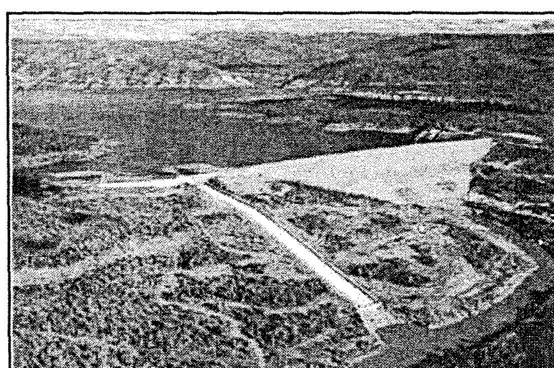
Historical Streamflow on the Feather River below Oroville, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

The natural flow pattern has been altered by storage reservoirs in the middle and upper watersheds and diversions in the lower river. Comparing recent historical flows (1972 through 1992) and unimpaired flows for the same period near Oroville indicates impaired flow extent. With winter and spring inflows stored in reservoirs for summer and fall irrigation releases, there has been a shift in the river's flow pattern. In dry years, winter and spring flows have been reduced from 2,000 to 6,000 cfs to 1200 to 1,600 cfs. In normal years, the shift has been from 4,000 to 10,000 cfs to 2,000 to 3,000 cfs. In the driest years, winter and spring flows average about 800 to 900 cfs, compared to 1,100 to 1,500 cfs for unimpaired flow. The opposite pattern is seen in summer and fall, when storage releases for irrigation increase base flows. Summer and fall flows in dry and normal years are approximately 50% to 60% higher than unimpaired flows. Highest flows are similar to unimpaired flows. In late summer and fall of driest years, unimpaired and historical flows are both in the 800 to 1,000 cfs range.



Unimpaired Streamflow on the Feather River at Oroville, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Oroville Reservoir, the lowermost reservoir on the Feather River, is the keystone of the State Water Project (SWP) operated by the California Department of Water Resources (DWR). Water is

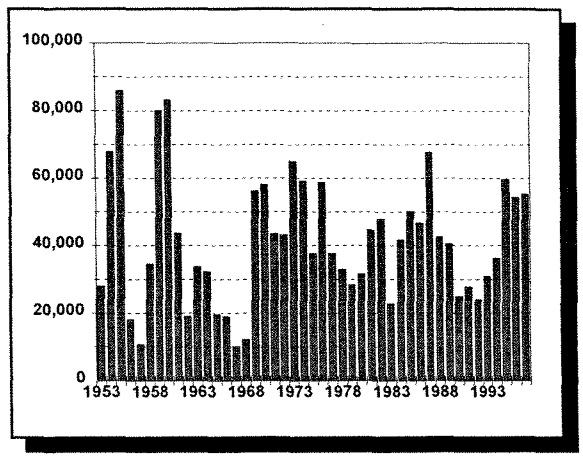


Oroville Dam on the Feather River (DWR Photo).

released from Oroville Dam through a multilevel outlet to provide appropriate water temperatures for the Feather River Hatchery and to protect downstream fisheries. Approximately 5 miles downstream from Oroville Dam, water is diverted at the Thermalito Diversion Dam into the Thermalito Power Canal, from there into the Thermalito Forebay and another powerhouse, and finally into Thermalito Afterbay. Water can be pumped from the Thermalito Diversion Pool back into Oroville Reservoir to generate peaking power. The Fish Barrier Dam, located approximately 1 mile below the Thermalito Power Canal intake, is the upstream limit of anadromous fish migration. The Oroville-Thermalito complex, completed in 1968, provides benefits to water conservation, hydroelectric power, recreation, flood control, and fisheries.

Feather River flows between the Thermalito Diversion Dam and the Thermalito Afterbay outlet are a constant 600 cfs. This river section is often referred to as the low-flow section. Water is released through a powerhouse, then through the fish barrier dam to the Feather River Hatchery, and finally into the low-flow section. Thermalito Afterbay serves both as an afterbay for upstream peaking-power releases to ensure constant river and irrigation canal flows, and as a warming basin for irrigation water being diverted to the rice fields. Because of warm water releases into the Feather River from Thermalito Afterbay, water temperatures in the approximately 14-mile section of salmon spawning area from the Thermalito Afterbay outlet to the mouth of Honcut Creek (referred to as the high-flow section) are higher than in the 8 miles of the low-flow section. In recent years, the low flow section has been heavily used by fall-run chinook salmon spawners to the extent that overuse is a problem due to redd superimpostion (a situation in which fresh spawners dig up existing salmon nests in order to deposit their eggs).

Juvenile chinook salmon and other species of fish may become stranded on flood plain depressions, shallow ponds, and toe drains or borrow pits along the base of levees. In April 1998, thousands of young chinook salmon were found stranded in broad, shallow ponds on the flood plain near Nelson Slough. Stranding, under certain flow condition, may be a source of mortality to naturally produced chinook salmon in the Feather Basin. The losses probably occur from two sources, entrapment by which young fish are prevented from migrating downstream and through predation by resident warmwater gamefish such as largemouth black bass and other members of the sunfish family and predation by wading birds in the broad, shallow ponds. This flood plain stranding needs further evaluation, but limited engineering/technical evaluations indicate that many of the levee borrow pits could be hydrologically reconnected to the river to allow



Naturally Spawning Fall-run Chinook Salmon Returns to the Feather River, 1953-1997 (does not include hatchery returns).

juvenile chinook to resume their seaward migration.

Important resources in the Feather River Ecological Management Unit include fall- and spring-run chinook salmon, steelhead, white and green sturgeon, striped bass, American shad, and lamprey. The Feather River Hatchery is the only Central Valley egg source for spring-run chinook salmon. Spring-run chinook salmon adults ascend the river in spring, hold over during summer in deep pools in the low-flow section, and are allowed into the hatchery in September. These fish are artificially spawned in the hatchery and also spawn naturally on the riffles in the low-flow section from late September to late October. Introgression (hybridization) of fall- and spring-run chinook salmon is a problem in the Feather River. About 20% of the tagged juvenile chinook salmon from females identified as spring run when returned were misidentified as fall-run. Similarly, about 29% of tagged juveniles from spring-run parents were misidentified as fall run when they returned as adults (Brown and Green 1997). A more recent analysis shows that in some years misidentification may be as high as 74%. Requirements for adult spring-run chinook salmon holding and early spawning influence the California Department of Fish and Game's (DFG's) water temperature and flow recommendations for the low-flow section.

Feather River spring-run chinook salmon population estimates during 1982 to 1991 averaged 2,800 fish. This is greater than the pre-project (i.e., SWP) average of 1,700 fish, primarily because of consistent cold-water deliveries to the hatchery and the low-flow section of the river. The Feather River spring-run chinook salmon's genetic status is uncertain. This stock may have hybridized with fall-run chinook salmon, but the extent of hybridization and the potential effect on spring chinook genetics in the Central Valley is unknown.

Most Feather River chinook salmon are fall-run fish that spawn in the low-flow section and below from October through December. As with spring-run fish, the present average run of fish returning to the hatchery and spawning in the river exceeds the pre-project population. In addition to spawning escapement, about 10,000 salmon (fall and spring runs combined) are harvested by anglers each year. During 1968-1993, Feather River Hatchery produced about 7.4 million fall-run and 1.2 million juvenile spring-run chinook salmon and about 750,000 juvenile steelhead annually.

Feather River steelhead are primarily hatchery stock, natural production of juveniles in the low-flow section appears to be limited, possibly due to elevated water temperatures in summer or scouring of redds. The 2,000 steelhead hatchery mitigation goal is comparable to the present 10-year (1982 to 1983 through 1991 to 1992) average return to the hatchery of 1,454 steelhead and an angler catch in the Feather River estimated as high as 7,785 fish. Steelhead juveniles must remain in the river or be held in the hatchery for at least one year until they are large enough to begin their anadromous journey. Appropriate water temperature and flow in the low-flow section are vital to continued Feather River steelhead program success.

American shad ascend the Feather River to spawn from April through June. The number of shad in the river, and thus the success of anglers, depends on the relative flow magnitude at the mouth of the Feather and Sacramento Rivers. In the 1987 to 1992 drought, Feather River flows in April through June were relatively low and the number of shad returning to the river was lower than average.

Striped bass spawn in the lower Feather River downstream of the Yuba River's mouth from April through June. Striped bass are found in the river during much of the year with a peak occurrence in July and August. Lamprey enter in the spring and early summer to spawn and their young remain for up to several years before migration to the ocean.

YUBA RIVER ECOLOGICAL MANAGEMENT UNIT

The Yuba River watershed drains 1,339 square miles of the western Sierra Nevada slope and includes portions of Sierra, Placer, Yuba, and Nevada Counties. The Yuba River is tributary to the Feather River, which, in turn, feeds into the Sacramento River.

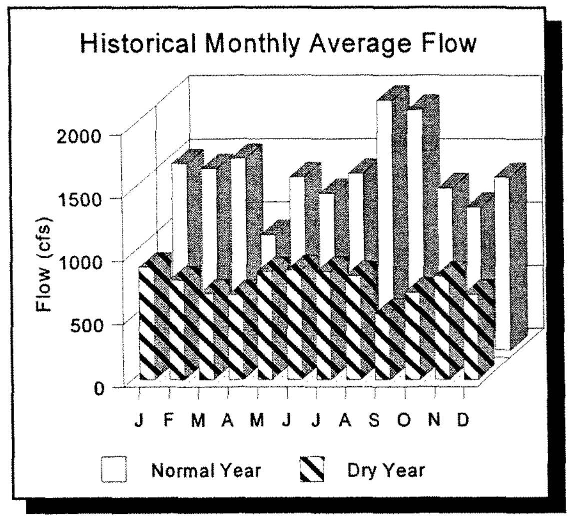
Three dams on the river have altered river flows and fish passage. Englebright Dam was built by the U.S. Army Corps of Engineers (Corps) in

1941 to collect placer mining debris that contributed to flooding in the Central Valley. Englebright Reservoir contributes storage capacity, hydropower, and cool, bottom-released water to the lower Yuba River. Most Englebright Reservoir water, the lowermost storage reservoir on the river and the upstream anadromous fish limit, is released through the Narrows 1 and 2 Englebright Dam powerhouses to generate hydroelectric power. The 0.2 mile of river between the dam and the two powerhouses has no flowing water unless the reservoir is spilling. The 0.7 mile of river from the Narrows 1 and 2 powerhouses to the Deer Creek mouth has steep rock walls; long, deep pools; and short stretches of rapids. Below this area, the river cuts through 1.3 miles of sheer rock gorge called the Narrows, forming a single large, deep, boulder-strewn pool.

The river canyon opens into a wide floodplain several miles beyond the downstream end of the Narrows, where large quantities of hydraulic mining debris remain from past gold-mining operations. This 18.5-mile section is typified as open-valley plain. Daguerre Point Dam, 12.5 miles downstream from Englebright Dam, is the major lower-river diversion point. The open plain continues 7.8 miles below Daguerre Point Dam to beyond the downstream Yuba Goldfields terminus. This section is primarily alternating pools, runs, and riffles, with a gravel and cobble substrate and contains most of the suitable lower Yuba River chinook salmon spawning habitat.

The remaining section of the lower Yuba River extends approximately 3.5 miles to its confluence with the Feather River. This river section is bordered by levees and is subject to Feather River backwater influence.

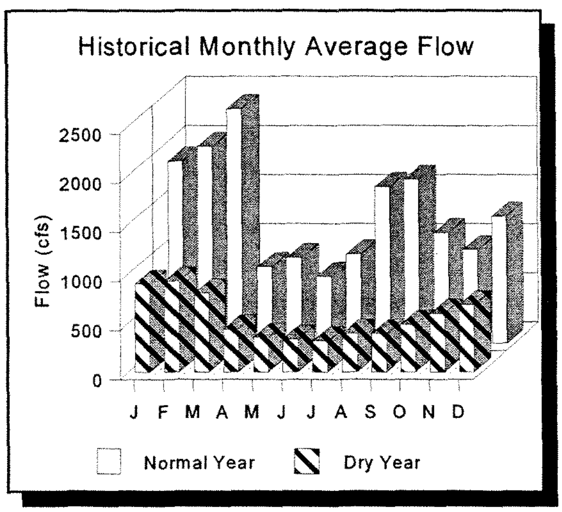
In the upper Yuba River watershed above Englebright Reservoir, storage reservoirs affect the natural flow pattern. The major storage reservoir is New Bullards Bar on the North Fork, with a storage capacity of about 1 million acre-feet (af) and a watershed area of 490 square miles. Fifteen other reservoirs have been constructed in the upper basin, with a combined storage capacity of 400,000 af. Power-generation diversions of about 100 cfs are made into the Feather River basin (from Slate Creek to Sly Creek), and about 600 cfs is diverted to the Bear River and Deer Creek watersheds for power and irrigation (from Lake Spaulding to Drum Canal and the South Yuba Canal). A major portion of the watershed is unregulated, however, and very high flows pass through Englebright Reservoir to the lower watershed during major storms.



Historical Streamflows on the Yuba River below Englebright Dam, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

The natural, unimpaired flow pattern in the Yuba River is typical of Sacramento Valley tributaries with headwaters in the Sierra Nevada. Flows are highest in winter and spring, decreasing quickly in late spring. Annual inflow is highly variable. Basin inflows in winter months of years with the highest rainfall average 15,000 to 25,000 cfs, whereas inflow in the driest years averages 300 to 600 cfs. In the driest years, inflow in summer and early fall averages only 0 to 100 cfs. In dry and normal water years, average monthly inflows in summer and early fall are 200 to 600 cfs.

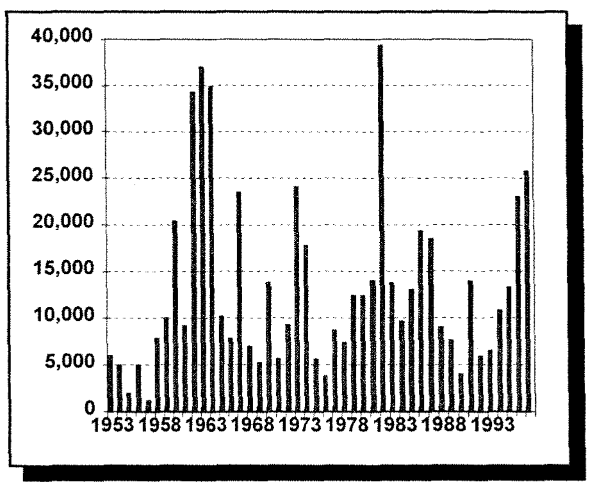
New Bullards Bar and Englebright Reservoirs store winter and spring flows and distribute water more evenly throughout the year and from year to year. Summer and early-fall irrigation releases are substantially higher than unimpaired flows. In the driest years, reservoir releases increase base flows in summer and early fall by 0 to 100 cfs to 70 to 260 cfs. In dry years, summer flows are 500 to 900 cfs compared to unimpaired flows of 190 to 230 cfs. Spring flows in dry and normal years are 300 to 900 cfs, as compared to unimpaired flows of 700 to 1,200 cfs. In years with the highest rainfall, flows are similar to unimpaired flows, averaging 10,000 to 20,000 cfs in winter months. Diversions in the lower river, primarily from just above Daguerre Point Dam, reduce lower river flows during the irrigation season. Flows from August through October at Marysville are generally higher than unimpaired flows, whereas flows from March through June are substantially lower. In the driest years, summer flows are 70 to 90 cfs and winter flows are 190 to 230 cfs. Spring flows in dry years are 340 to 440 cfs compared to unimpaired flows of 800 to 3,700 cfs.



Historical Streamflow on the Yuba River at Marysville, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

The Yuba River is one of the most important Ecological Management Units in the Feather River/Sutter Basin Ecological Management Zone. The river supports highly valued populations of steelhead trout and fall-run chinook salmon, as well as populations of other anadromous and resident fish communities. The Yuba River is the only remaining wild steelhead fishery in the Central Valley. All other streams that have wild population, have population that are either so low that they do not support a fishery or are closed to angling. Spring-run chinook salmon abundance and status in the Yuba River is not known. Directed efforts are required to determine if it is a component of the fishery and whether additional management and restoration measures are required.

Fall-run chinook salmon is the most abundant anadromous fish species in the lower Yuba River. Historically, the Yuba River supported as much as 15% of the annual fall-run chinook salmon run in the Sacramento River system. Run sizes in the Yuba River have varied over the period of record (1953 to 1989), ranging from 1,000 fish in 1957 to 39,000 fish in 1982. Approximately 60% of those salmon spawned between Daguerre Point Dam and the Highway 20 bridge, with most of the remaining fish spawning above Highway 20 or below the dam. Presently, fall-run chinook salmon spawning runs average 13,050 fish annually.



Fall-run Chinook Salmon Returns to the Yuba River, 1953-1997.

Historically, there has been a small spring-run chinook salmon spawning population in the Yuba River. The run had almost disappeared by 1959, presumably because of diversions and hydraulic development projects. A remnant of the spring-run chinook salmon population persists in the lower Yuba River. It is maintained by fish produced in the river, salmon straying from the Feather River, and infrequent stocking of hatchery-reared fish by DFG (a practice that has been discontinued).

The lower Yuba River supports a seasonal American shad sport fishery from late April to July. The fishery is confined to the area between Daguerre Point Dam and its confluence with the Feather River. Studies have shown that the shad fishery on the Yuba River has declined significantly in the past two decades. The run was estimated at 30,000 to 40,000 spawning adults in 1968 and 40,000 adults in 1969. In recent years, however, the shad run has been only a fraction of that level. Daguerre Point Dam limits the upstream migration of American shad. The dam is equipped with two conventional pool-and-weir-type fishways. Shad do not generally enter fish ladders; therefore, most of the population is restricted to the river sections below the dam. Reduced flows below Daguerre Point Dam, particularly in spring and early summer, are a primary factor in the decline of the American shad run.

The three most significant diversions along the lower Yuba River are at or just upstream of Daguerre Point Dam. Water is generally extracted from late March through October. Hallwood Irrigation Company, Cordua Irrigation District, and Ramirez Water District share one diversion; the Brophy and South Yuba Water Districts share another; and Browns Valley Irrigation District operates a third. The combined diversions can reach a maximum of 1,085 cfs (see table below).

Table 6. Diversion Rates in Acre-Feet per Month for the Major Water Districts Supplied by the Yuba County Water Agency on the Lower Yuba River

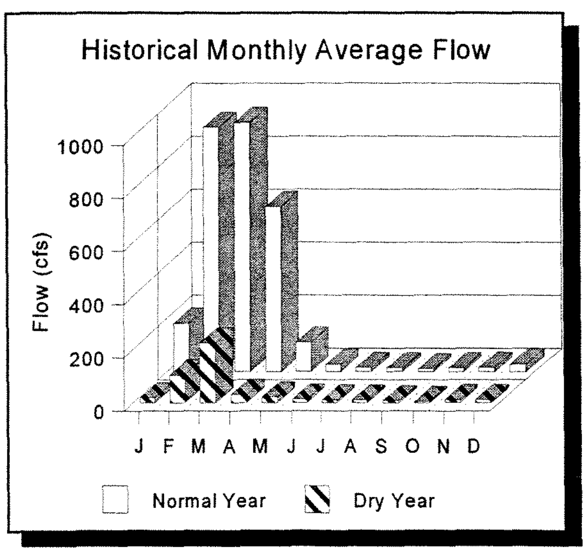
	Hallwood Irrigation Company	Corda Irrigation District		Ramirez Water District	Browns Valley Irrigation District		Brophy Water District	South Yuba Water District
Month	WR	WR	P	WR	WR	P	P	P
March	0	0	0	0	0	0	520	300
April	10,000	4,500	900	2,010	2,269	1,667	4,795	3,000
May	14,500	10,600	2,120	3,270	2,345	1,666	6,460	4,000
June	14,100	10,400	2,080	2,745	2,269	1,667	6,670	4,200
July	13,600	11,100	2,620	1,920	2,345	2,500	6,985	4,400
August	12,900	11,000	2,600	1,755	2,345	2,000	5,525	3,400
September	8,000	5,900	1,180	1,500	2,269	0	3,750	2,400
October	4,900	6,500	500	700	2,345	0	625	400
Total	78,000	60,000	12,000	13,900	16,187	9,500	35,330	22,100
Maximum cfs	275	--	275	75	38.2	42	230	150

Notes: WR = basic water right of water district.
P = purchase water through contract with Yuba County Water Agency.

Juvenile chinook salmon, and likely juvenile steelhead, are lost at all diversion intake structures because of impingement on screens, entrainment into unscreened diversions, or predation in the river adjacent to the intakes. Although losses at individual diversions may not be significant, the cumulative impact of all diversion-related losses may be substantial. DFG estimated that before 1970, approximately 200 steelhead trout spawned in the river annually, and the potential existed for about 2,000 spawning adults after completing New Bullards Bar Reservoir.

Bear River and Honcut Creek Ecological Management Unit

The Bear River is the second largest tributary to the Feather River, with a watershed area of 300 square miles. It enters the Feather River at river mile (RM) 12, immediately upstream from the town of Nicolaus. Honcut Creek flows into the Feather River from a small foothill watershed approximately 15 miles below Thermalito. In highest rainfall years, winter flows average 3,400 to 5,600 cfs. In normal years, winter inflows are 600 to 800 cfs. In the driest years, watershed inflows average only 20 to 65 cfs in winter months and 0 cfs in all other months.



Historical Streamflow on the Bear River near Wheatland, 1962-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year)

The natural or unimpaired Bear River flow pattern is typical of foothill streams, with high winter and spring flows and very low summer and fall flows in wet years. Summer and early-fall inflows remain near 0 cfs in dry and normal years. Honcut Creek has a similar unimpaired flow pattern that includes low annual flow in dry years and very low summer and fall flows in most years.

Bear River flows are almost entirely regulated by several storage reservoirs and numerous diversions. Camp Far West is the largest storage reservoir, followed by Rollins Reservoir in the upper watershed near Grass Valley and Auburn. The South Sutter Irrigation District (SSID) Diversion Dam is the largest diversion. Minimum flow releases below the diversion into the Bear River are 25 cfs in spring and 10 cfs during the rest of the year. Flows from June through December are generally 0 to 40 cfs except in the wettest years. Flows in years of high rainfall are similar to unimpaired flows from fall to spring, averaging 3,500 to 5,200 cfs in winter; summer flows are 30 to 50 cfs, compared to unimpaired flows of 70 to 150 cfs.

The upstream anadromous fish limit is the SSID Diversion Dam, approximately 15 miles above the Feather River confluence. The Bear River once supported substantial salmon and steelhead runs, but because of low flows in the lower river below the SSID Diversion Dam, no self-sustaining salmon runs presently exist, and the status of steelhead is unknown. Occasionally, when heavy fall rains and sufficient spillage take place at the SSID Diversion Dam, hundreds of fall-run chinook salmon and steelhead may ascend and spawn in the lower Bear River. In addition to the effects of Camp Far West Reservoir and the SSID diversion, other factors have contributed to streamflow problems in Bear River. These include numerous small water diversions and hydroelectric projects in the lower and upper watersheds. Agencies involved in these projects are the Nevada Irrigation District, Pacific Gas and Electric Company, Placer County Water Agency, and SSID. Portions of the water supply go to

Auburn and Grass Valley. The proposed Garden Bar project, which would capture more of the winter streamflow for water supply, is currently inactive.

The major attribute of the Honcut Creek is its linkage to the District 10 area immediately north of Marysville. This area encompasses thousands of acres of private wetlands and flooded rice fields which provide important wintering and foraging habitat for waterfowl.

The Bear River and Honcut Creek Ecological Management Units are presently less ecologically important for anadromous fish species than the other units in this Ecological Management Zone because of the extensive water development and inadequate natural summer and fall base flows. In some years, these streams provide habitat for fall-run chinook salmon, steelhead, and resident native fish populations. The overall ecological health of the Bear River and Honcut Creek Ecological Management Units, however, is poor.

SUTTER BASIN ECOLOGICAL MANAGEMENT UNIT

The Sutter Bypass section of the Sutter Basin provides important waterfowl habitat and serves as a migratory route for salmon and steelhead in the upper Sacramento River and its tributaries, particularly Butte Creek. Salmon and steelhead migrating to Butte Creek use Butte Slough, which originates at the Butte Slough Outfall Gates and ends at the north end of the Sutter Bypass. The reach within the Sutter Bypass is generally referred to as the East and West Barrows and the connection with the Sacramento River is the Sacramento Slough. In wet years, when Sacramento River overflows into the bypass, both upstream-migrating adults and downstream-migrating juvenile salmon and steelhead use Butte Slough, the East and West Barrows, and Sacramento Slough. Native resident fish, including splittail, also use the bypass as spawning and rearing habitat. In wet years, some salmon, steelhead, and native resident fish may become stranded (trapped) in isolated pockets and die when floodwaters recede from the bypass and respective overflow weirs (Tisdale, Colusa, and Moulton).

Sutter Bypass is also an important area for waterfowl and wildlife. The bypass has remnant riparian woodlands and wetlands and is part of the Sutter National Wildlife Refuge. Sutter Refuge is the only publicly owned waterfowl habitat in the Sutter basin. It consists of 2,590 acres of seasonally and permanently flood marsh and scattered uplands. Private duck clubs provide an 1,500 acres of habitat of which about 500 acres are natural wetland. Most of the private duck clubs and nearly all of the natural wetlands in this area are located in the Sutter Bypass (Central Valley Habitat Joint Venture 1990). The northern end of the bypass is connected to the extensive marshlands of Butte Sink. Large areas of the bypass are used to grow irrigated crops, such as rice.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Feather River/Sutter Basin Ecological Management Zone includes restoring and enhancing important fishery, wildlife, and plant communities by restoring ecological processes and habitats and reducing stressors. Attaining this vision requires restoring or reactivating important ecological processes that create and maintain fish, wildlife, and plant community habitats throughout the Ecological Management Zone.

The vision for this Ecological Management Zone focuses on maintaining and improving floodplain and flood processes, streamflow, coarse sediment recruitment and transport, and seasonally flooded aquatic habitats that provide important wintering areas for waterfowl and shorebird guilds. Actions to reduce stressors include the installation of screen on diversions, upgrading or installing fish passage facilities at diversion dams or other obstacles to fish migration, providing suitable water temperatures for summer rearing, reducing the extent of stranding loss of juvenile fish, and limiting the adverse effects of introducing hatchery fish on endemic aquatic species.

Hatcheries in this and adjacent Ecological Management Zones will be operated to preserve the genetic identity of endemic, naturally spawning chinook salmon and steelhead trout stocks. Hatchery-produced fish will be used to support sustainable ocean recreational and commercial fisheries and directed fisheries in the natal streams. Marking techniques will enable sport and commercial anglers to distinguish between hatchery-produced and naturally produced fish. Additional genetic analyses of the Feather River and Yuba River spring-run chinook populations are necessary to determine the value and role of these stocks in efforts to rebuild Feather River and other basin populations. In addition, the hatcheries may play an extremely important role in the propagation of genetically pure, wild spring-run chinook salmon and steelhead. These fish would be used to reestablish populations in areas that formerly supported the species.

Green sturgeon and white sturgeon use the Feather River for spawning, but additional studies are needed to identify and describe the species' habitat requirements and status in this basin. The Feather River could contribute more substantially to the overall sturgeon health and abundance if the species' life history and habitat requirements were known and habitat conditions maintained to benefit sturgeon along with other important species. Splittail would benefit from improvements in riparian and stream meander corridors, wetlands with connection to the rivers, and floodplain overflow basins and flood bypasses.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

FEATHER RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Feather River Ecological Management Unit is to improve natural spawning populations of spring- and fall-run chinook salmon and steelhead. This involves improving spring (March) flows below Oroville in dry and normal water-years, improving spring through fall base flows, providing suitable water temperatures for summer rearing, and improving spawning and rearing habitat in the lower river below Oroville. The vision also includes implementation of adaptive management components of monitoring and research to collect the scientific information required to best judge the merits of additional flows and the timing for additional flows that would provide the highest benefit for aquatic species and habitat maintenance.

The vision for the Feather River includes reactivating or maintaining important ecological processes that create and sustain habitats for anadromous fish. The Feather River must not only contribute substantially to the growth of many fish populations, but provide better support for naturally spawning steelhead, fall- and spring-run chinook salmon, American shad, white and green sturgeon, lamprey, and striped bass. The most important processes include floodplain and flood processes and a natural streamflow pattern in the river, to which most of the anadromous and resident native fishes are adapted.

Higher, more natural spring flow events may encourage spring-run chinook salmon, steelhead, sturgeon, American shad, and striped bass move upstream into the Feather River during their traditional migrations in spring. Higher flows may also benefit juvenile fall-run chinook salmon migrating downstream and juvenile salmon migrating out of lower Feather River tributaries. These flows will also benefit stream-channel and riparian vegetation in the lower river and, consequently, will benefit fish. Improved riparian habitat will also benefit riparian-associated wildlife, such as those in the neotropical migratory bird guild. The added flows coming from the Feather River will also benefit juvenile salmon and steelhead from other Feather and Sacramento River tributaries in their journey through the lower Sacramento River below the Feather River and through the Delta and Bay.

Improving habitat in the lower Feather River will encourage natural production of these anadromous fish. Improving spawning habitat will increase young salmon and steelhead production. Restoring or maintaining stream-channel and riparian vegetation and reducing the extent of juvenile fish stranding will increase the survival and production of juvenile salmon and steelhead. Providing suitable water temperatures for summer rearing by managing cold water releases from Lake Oroville will significantly improve natural steelhead production.

YUBA RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Yuba River is to improve spring streamflows for spawning runs of spring-run chinook salmon (potentially), steelhead, sturgeon, and American shad. These flows will also benefit downstream migration of juvenile fall-run chinook salmon, steelhead, and sturgeon. Improving streamflows will also benefit stream-channel and riparian habitat; native resident species, including splittail, that spawn farther downstream in the Feather River; and other species that reside further downstream in the Bay-Delta estuary. The vision also includes evaluation of gravel recruitment and sediment transport processes, stream-channel configuration, and riparian habitats in the lower Yuba River floodplain to improve anadromous and resident fish production and survival.

At present, sufficient stored water remains in the Yuba River system (in New Bullards Bar Reservoir) to help restore and maintain the river's anadromous fish runs. Providing the needed streamflow, temperature, and screens for the lower Yuba River will affect storage in the reservoir and require operation changes at diversions in the lower river. An early spring flow event in the lower river during dry and normal water years will improve upstream passage for spring-run chinook salmon, and improve spawning conditions for steelhead, sturgeon, and American shad. Such a flow event would also improve downstream migration conditions for juvenile fall-run chinook salmon, steelhead, and sturgeon. The higher flows will also improve natural stream-channel and riparian habitat conditions in the lower river, consequently benefitting fish as well as a variety of other aquatic and terrestrial wildlife species. Reducing mortality at diversions and improving stream-channel and riparian habitat will also improve fish production. Restoring or maintaining riparian habitat will provide substantial benefits to riparian-associated wildlife species in the neotropical migratory bird guild.

High water temperatures in late spring, summer, and fall in the lower river can be improved by constructing a multiple-level outlet on Englebright Dam. Water temperature control will also be improved by maintaining the stream channel configuration and riparian vegetation of the lower river. A channel with more diversity, including islands, backwaters, and shaded riverine aquatic habitat, will reduce river heating and provide cool-water refuges for juvenile fish. Reducing the number of ponds linked to the lower river (e.g., in the Yuba Goldfields) will reduce the input of warmer water. Encouraging the flow of cool groundwater from the Goldfields through small stream channels lined with riparian vegetation may not only reduce heating, but also provide cool-water refuges for juvenile steelhead. The potential benefits of constructing exclusionary devices to prevent adult chinook salmon and steelhead from entering the Goldfields should be evaluated.

Gravel sources will be protected and the natural supply supplemented where and when necessary. Existing and past gravel mining operations in the stream channel, which affect the natural fluvial sorting and cleansing of gravel and inhibit gravel recruitment downstream, will be changed to limit their effects.

Stream-channel and riparian habitat will be improved by promoting conservation of the lower river meander zone and active floodplain, rapidly phasing out gravel mining in the floodplain, and protecting shorelines and levee riparian vegetation from any damaging activities. Vegetation may need to be planted or the disturbed channel and floodplain regraded in certain areas to hasten and sustain recovery. Major efforts will be required to control or eradicate tamarisk and giant reed infestations, which prevent natural vegetation succession by native tree species. Improving the stream-channel configuration, such as shaded side channels and backwater areas that are heavily influenced by cool groundwater, will increase available spawning and rearing habitat and improve juvenile salmon and steelhead production in the lower river. Improving woody and other cover types in and along the stream margin will also increase juvenile salmon and steelhead production.

Steelhead and spring-run chinook salmon may greatly benefit from actions to restore access to historical holding, spawning and rearing areas upstream of Englebright Dam. Evaluations are needed on the extent and quality of habitat above Englebright Dam, the nature and quantity of sediments in the reservoir, the presence of any chemical contaminants in the sediments, and short- and long-term economic impacts. These evaluations are required so that decisions can be formulated regarding the efficacy of restoring fish access to stream reaches above Englebright Dam and are an integral element of the CALFED adaptive management approach to ecosystem restoration.

Stressors, such as unscreened diversions, fish passage problems, and illegal and legal harvest, should be reduced to improve health of salmon and steelhead populations. A cooperative will be developed program to evaluate the feasibility of screening irrigation diversions along the lower Yuba River. Upstream and downstream fish passage at Daguerre Point Dam should be improved and entrainment of juvenile steelhead into the diversion should be eliminate.

Measures being considered to reduce harvest of naturally produced chinook salmon in sport and commercial fisheries include restricting harvest and marking all hatchery-produced fish to permit selective harvesting of hatchery fish. Enforcement and public education measures will be undertaken to ensure that harvest rates for salmon and steelhead are minimal. The current practice of stocking spring- and fall-run chinook salmon and steelhead using fish reared in the Feather River Hatchery should be reconsidered. The ramifications of this practice for wild stocks in the Feather River and adjacent Central Valley watersheds require careful consideration. Efforts to evaluate the genetic integrity of spring-run chinook salmon stocks in the Feather River will be expanded to include fall-run chinook salmon and steelhead. Criteria used to select genetic types of adult salmon and steelhead for the hatchery will be carefully evaluated to minimize possibly damaging effects on the genetic integrity of wild populations in the Central Valley.

Bear River and Honcut Creek Ecological Management Units

The vision for the Bear River and Honcut Creek Ecological Management Units is to improve conditions for fall-run chinook salmon and steelhead by maintaining and improving stream-channel, riparian, and floodplain habitat; ensuring adequate spawning gravels; and, where possible, improving late-fall flows for adult salmon spawning migrations and late-winter flows to support young salmon emigrating from the river. In addition, improving gravel recruitment and riparian habitat would provide adequate habitat for salmon and steelhead in years when they use these streams. In addition to improving floodplain habitats, upper watershed health should be improved by reducing forest fuels and implementing other practices to protect streamflows, stream channels, and riparian habitat and minimize sediment input to the streams.

SUTTER BYPASS ECOLOGICAL MANAGEMENT UNIT

The vision for the Sutter Bypass Ecological Management Unit is to restore adequate streamflows, as well as stream channel, riparian, and wetland habitats in the floodplain, and to ensure passage of adult salmon migrating upstream through the Sutter Bypass. In addition to improving conditions for migrating salmon and steelhead in the Sutter Bypass and eliminating stranding, actions taken to benefit salmon and steelhead will improve waterfowl and wildlife habitat in the bypass. Fish passage and unscreened diversion problems should be resolved where possible.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Streamflows shape stream channels. Riparian vegetation, provides habitat for fish, moderates water temperature in rivers, attracts anadromous fish to spawning streams, and transports young anadromous fish to downstream nursery areas in the Sacramento River, Bay-Delta estuary, and ocean. Streamflow in each of these rivers is impaired by upstream storage reservoirs and diversions, particularly in dry and normal rainfall years. A healthy streamflow pattern in the rivers and in the Sutter Bypass would emulate (imitate) the natural runoff pattern, with a late-winter/early-spring flow event and summer-fall base flows that maintain important ecological processes, functions, habitats, and important species. The vision for streamflows is to evaluate the ecological benefits of a short-term (10-day) flow event in late winter or early spring that typically occurred at least once in dry and normal years prior to water supply development on the rivers.

COARSE SEDIMENT SUPPLY: Gravel recruitment from basin watersheds is important to provide a natural stream channel configuration and stream substrate (bottom material), as well as essential spawning gravels for salmon and steelhead. A natural sediment supply is also important to natural stream meander and to riparian habitat regeneration. Sediment transport and gravel recruitment has been eliminated below major dams in zone rivers. The vision is to supplement the gravel supply below major dams on the three rivers where needed for salmon and steelhead spawning habitat, riparian habitat, and natural stream channel and meander development.

STREAM MEANDER: In their floodplains, Central Valley rivers naturally meander through floodplain sediments, progressively eroding the next bank while adding to the previous bank. This process, called a stream meander, occurred in the stream corridors of the Feather, Yuba, and Bear Rivers. A natural stream meander process in the lower Feather, Yuba, and Bear River floodplains provides much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species. Today, the natural meander process in each stream is inhibited by dams, bank protection, bridge abutments, flood control levees, and the reduction or elimination of natural coarse sediments now trapped behind the large dams. In some places, bank erosion occurs, but lack of sediment precludes adding to the previous banks. The vision is to restore a portion of the natural meander to the rivers by setting back levees where they are necessary and by removing structures from the floodplain where possible.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: The Sacramento Valley formerly had many natural overflow basins that retained floodwaters, permitted sediment deposition, and provided fish and waterfowl habitat. Partially reactivating these important ecological functions will contribute to system health and provide for prolonged periods of natural streamflow and sediment input. Natural overflow basins would also supply important habitat for fish, including chinook salmon and splittail, as well as nesting and foraging habitat for many waterfowl. The vision is to restore natural overflow basins within the lower floodplains of the four rivers and Sutter Basin. This would provide additional flood control protection for other areas in this zone and downstream, as well as valuable natural wetland, riparian, and aquatic habitats for fish and wildlife.

CENTRAL VALLEY STREAM TEMPERATURES: Salmon and steelhead depend on cool water for their survival. In the Feather, Yuba, and Bear Rivers, salmon and steelhead are confined to the floodplains below the dams. Maintaining cool water below the dams is essential to maintaining salmon and steelhead in these rivers. Summer and early fall water temperatures in floodplains of these rivers are naturally warm, but are kept cool by cold-water releases from deeper bottom waters of the major reservoirs. The extent of cool water habitat below the dams depends on the amount of cold water released from the dams, the extent of shade along the river channels provided by riparian vegetation, and the amount of warm water discharge into the rivers from urban and agricultural drainage. Improving water temperatures below the major impoundments in this zone can contribute to ecological system health and promote sustainable fisheries. Steelhead and spring chinook particularly depend on cool summer water temperatures as they remain in the rivers through the summer. High fall water temperatures in the lower rivers hinder upstream migrations of fall-run chinook salmon and steelhead. The vision for water temperatures in these rivers is to provide sufficient summer and early-fall base flows from the dams and restore the riparian corridors and natural stream channel characteristics that limit river heating. Maintaining sufficient cool water storage in the reservoirs in droughts will also be important to maintain a minimum of cool-water habitat in the rivers.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: Seasonal flooding of leveed lands and flood bypasses provide important habitat for waterfowl, native fish, native plants, and wildlife. Flooding and draining seasonal wetlands also contributes to the aquatic foodweb. The vision is to increase the frequency and extent of over-bank flooding in the river floodplains and Sutter Basin.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian and shaded riverine aquatic habitats are important to the health of the rivers by providing shade, insects and organic debris important to the aquatic foodweb, and soil and bank protection. The riparian corridors and related riparian and shaded riverine aquatic habitats are impaired by lack of natural stream meander; river channel confinement by levees; and streamside vegetation loss to animal grazing, levee construction, and agricultural clearing. The vision is to improve and restore riparian habitat along the rivers and Sutter Bypass, where possible and needed.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The lower reaches of the Feather, Yuba, and Bear rivers are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The quality of freshwater fish habitat in these streams will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Feather, Yuba, and Bear rivers have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these rivers include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Feather River/Sutter Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions along the rivers and Sutter Bypass divert not only water but small fish. Many diversions are screened to reduce young fish losses. Reducing losses to screened and unscreened diversions will contribute to overall ecosystem health by promoting sustainable fisheries and higher population levels. The vision is to screen those diversions presently with no screens or with inadequate screens that where there is a potential to screen young fish in significant numbers, and for diversions where the fish screens are not operated continually throughout the irrigation season, to extend the operation throughout the period of diversion.

DAMS AND OTHER STRUCTURES: Instream structures can impair up- and downstream adult and juvenile fish passage. The vision for the Feather River/Sutter Basin Ecological Management Zone is that the connections between upstream fish holding, spawning, and rearing areas and the Sacramento River are improved and maintained to permit unobstructed or unimpaired fish passage. Fish passage at Daguerre Point Dam on the Yuba River needs to be improved to permit easier up and downstream passage for steelhead and chinook salmon. The vision also includes evaluating the potential of restoring access to historical habitats presently blocked by impassable dams.

HARVEST OF FISH AND WILDLIFE: The legal and illegal anadromous fish harvest in the river, estuary, and ocean constrains recovery of wild anadromous fish populations. Reducing the harvest would likely be necessary to allow recovery of wild populations to a healthy condition. The vision is to continue to take actions that will reduce the wild anadromous fish harvest and focus legal harvest on hatchery stocks of salmon and steelhead.

ARTIFICIAL PROPAGATION OF FISH: Stocking hatchery-reared salmon and steelhead in the Feather River supports important sport and commercial fisheries and helps to mitigate salmon and steelhead losses caused by large dams and reservoirs. Hatchery fish also supplement naturally spawning salmon and steelhead in the river. However, hatchery salmon and steelhead may impede the recovery of wild populations by competing with and preying on young wild fish and reducing the genetic integrity of the wild populations. The vision is to improve hatchery practices of adult fish selection, spawning, rearing, and release to minimize potential conflicts with naturally-spawning salmon and steelhead populations.

STRANDING: Biological and technical evaluations will be completed to fully assess the potential adverse effects of stranding and the resultant loss of juvenile chinook salmon. The vision is that stranding losses will be minimized such that stranding will not impair efforts to maintain self-sustaining populations of anadromous fish in the rivers and streams of this ecological management zone.

VISIONS FOR SPECIES

GREEN STURGEON: The vision for green sturgeon is to recovery the California species of special concern by maintaining and restoring population distribution and abundance to historical levels. Green sturgeon are known to inhabit and possibly spawn in the Feather River. Improved flows and stream channel and floodplain processes will benefit sturgeon populations through improved habitat and food supply. Higher peak late winter and spring flows will provide attraction for adult sturgeon moving upstream from the lower rivers, Delta, Bay, and ocean. Stream channel improvements will provide greater amounts and improved quality of spawning and early rearing habitat. Screening unscreened diversions will reduce young sturgeon losses to water diversions. Limiting the adult sturgeon harvest will also protect the populations.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels and support a sport fishery. White sturgeon are known to inhabit and possibly spawn in the lower Feather River. Improved flows and stream channel and floodplain processes will benefit sturgeon populations through improved habitat and food supply. Higher peak late winter and spring flows will provide attraction for adult sturgeon moving upstream from the lower rivers, Delta, Bay, and ocean. Stream channel improvements will provide greater amounts and improved quality of spawning and early rearing habitat. Screening unscreened diversions will reduce young sturgeon losses to water diversions. Limiting the adult sturgeon harvest will also protect the populations.

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries. Spring- and fall-run chinook salmon will benefit from improved flows. Late-winter and spring flows will provide attraction for upstream migrating adult spring chinook and downstream migrating spring- and fall-run chinook. Summer and fall base flow improvements will benefit over-summering adult and juvenile spring-run chinook salmon, as well as upstream migrating fall-run chinook salmon. Improvements in wetland and riparian habitats; stream channel and meander; and coarse sediment recruitment will also improve spring- and fall-run chinook salmon spawning and rearing habitat. Screening unscreened and poorly screened diversions will improve young salmon production. Limiting harvest will help ensure adequate numbers of spawners.

STEELHEAD: The vision for steelhead trout is to recover this species listed as threatened under the ESA, and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat. Steelhead will benefit from improved peak flow events, especially in dry and normal years. Summer-fall base flows are needed to maintain over-summering juveniles and will also provide water temperatures low enough to allow juvenile steelhead to survive. Steelhead will also benefit from improved gravel spawning habitat, and stream rearing habitat, especially if summer river heating is reduced in the process. Screening unscreened and poorly screened diversions will improve young steelhead production. Limiting harvest to hatchery steelhead will help to protect wild steelhead.

Steelhead in the Feather River as supported by a hatchery propagation program at Feather River Hatchery. The hatchery program will continue, but improved environmental conditions in the river, the Sacramento River, and Delta will allow for more reliance on the wild, naturally spawning population.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring native species, to their 1980s level of abundance to support a sport fishery in the Bay, Delta, and tributary rivers. Striped bass will indirectly benefit from larger late winter, early spring flow events provided in the lower Feather River to benefit chinook salmon and steelhead. The higher flow will provide upstream attraction flows and improve transport of eggs from spawning areas in the lower Feather and Sacramento Rivers.

American Shad: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Improved spring flows should benefit American shad runs in the lower Feather and Yuba Rivers. Greater magnitude flow events in spring will provide attraction flows for adults to lower river spawning areas. Higher spring through fall base flows should improve spawning and early rearing, post-spawning adult survival, and juvenile shad survival and downstream migration. Although American shad require warmer temper tures for spawning, stream temperatures will be driven by the requirements of native chinook salmon and steelhead.

Splittail: The vision for splittail is to recover this federally listed threatened species. Improvements in the riparian and stream meander corridors, wetlands, and floodplain overflow basins will improve spawning and early rearing habitat of splittail and other native resident fish species. Improved late winter and early spring flows will provide attraction flows for upstream migrating adult splittail from the Delta, and improve transport of larvae splittail downstream to the lower rivers and Bay-Delta.

Waterfowl: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Waterfowl will benefit from improved riparian corridors, floodplain overflow basins, and more wetlands.

Plant Species and Communities: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

Integration with Other Restoration Programs

Maintaining and restoring the health of the Ecological Management Units in the Feather River/Sutter Basin Ecological Management Zone will depend on the efforts of local and State water management agencies. Efforts in the Sutter Basin will be linked to activities of the California Waterfowl Association, Ducks Unlimited, The Nature Conservancy, and the California Rice Industry. Overall, these efforts will require cooperation from resource agencies, such as DFG, the California Department of Water Resources (DWR), the U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service, as well as participation and support from the U.S. Bureau of Reclamation (Reclamation), the U.S. Natural Resources Conservation Service (NRCS), and other private organizations, water districts, and landowners. These groups will work together to maintain and restore streamflows and fish and wildlife habitat, reduce impacts of diversions, minimize poaching, and minimize habitat and water quality degradation in basin streams. Funding may be provided to enhance streamflows, reduce fish-passage problems, screen diversions, restore habitats, and increase California Fish and Game Code enforcement to protect recovering salmon and steelhead populations. The U.S. Army Corps of Engineers owns and operates the Daguerre Point Dam on the Yuba River and is undertaking evaluations to improve fish passage and fish screening opportunities.

Central Valley Project Improvement Act

Restoring and maintaining ecological processes and functions in the Feather/Sutter Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. The program proposed by the Central Valley Project Improvement Act (CVPIA) will complement efforts of the USFWS's Anadromous Fish Restoration Program (USFWS 1997). The goal of the program is to double the average anadromous fish population that was produced naturally in the system from 1967 through 1991.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT (SB 2261)

The vision will also help the DFG to reach its goal, under this program, of doubling the number of anadromous fish that were produced in 1988.

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 Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

CALFED BAY-DELTA PROGRAM

CALFED has funded four ecosystem restoration projects in Feather River and Sutter Basin. One project screened the Browns Valley Irrigation District diversion. Another project developed a watershed plan for the Yuba River.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Many of the resource elements in the Feather River/Sutter Basin Ecological Management Zone depend extensively on conditions or elements in other zones. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem Sacramento River, the Delta, San Francisco Bay, and the nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, toxic contaminants, degraded water quality, and harvest, restoring populations in the Feather River/Sutter Basin Ecological Management Zone will require corresponding efforts in other zones.

Reducing or eliminating stressors in the downstream Ecological Management Zones and improving or recreating habitat in those zones are important steps in restoring healthy fish, wildlife, and plant communities in the Feather River/Sutter Basin Ecological Management Zone. Efforts in the Sutter Basin, particularly those relating to the Sutter Bypass and Butte Slough, will greatly benefit the other Ecological Management Zones and units of the upper Sacramento River.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: More closely emulate the seasonal streamflow pattern in the Feather River by providing March flow events of 4,000 to 6,000 cfs in dry years, 6,000 to 8,000 cfs in below-normal years, and 8,000 to 10,000 cfs in above-normal years. In addition, evaluating the minimum flows recommended by DFG (1993) will provide a basis to better refine the flow needs in the Feather River. Flow events will be provided only if they are less than or equal to Oroville Reservoir inflow (♦♦).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of supplemental Feather River flows to ecological processes and riparian and riverine aquatic habitats.

PROGRAMMATIC ACTION 1B: Evaluate alternative flow schedules in the Feather River to optimize the ecological benefits for fish and plant communities and ecological processes such as stream meander, sediment transport, and temperature control.

TARGET 2: Evaluate the potential benefits to increased natural production of salmon and steelhead in the Feather River of releasing 2,500 cfs from Oroville Dam during September through May and 1,100 cfs during June through August in wet and normal years, and 1,700 cfs during September through May and 800 cfs during June through August in dry years (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to supplement Feather River flows with water acquired from new water sources, water transfers, and willing sellers in accordance with applicable guidelines or negotiated agreements.

TARGET 3: Supplement flows in the Yuba River with March flow events of 2,000 to 3,000 cfs in dry years and 3,000 to 4,000 cfs in normal years to improve conditions for all chinook salmon, steelhead, and American shad life stages. In addition, provide minimum flows recommended at Marysville by DFG (1993). See table below. Flows will be provided only if inflow to Englebright and New Bullards Bar Reservoirs is sufficient to meet the flow requirements (◆◆).

Minimum Streamflow Recommendations for Yuba River at Marysville

Period	Flow in All Water-Year Types
October 1-March 31	600-700 cfs
April 1-June 30	1,000 cfs minimum
July 1-September 30	450 cfs

PROGRAMMATIC ACTION 3A: Supplement flows in the Yuba River below Englebright Dam with water acquired from new water sources, water transfers, and willing sellers, consistent with applicable guidelines or negotiated agreements to provide flows recommended by DFG (1993) to improve conditions for all of chinook salmon and steelhead life stages. See table above.

TARGET 4: Supplement flows in the Bear River to improve conditions for all chinook salmon and steelhead life stages. Provide a flow event of 300 to 500 cfs in dry years. See table below for recommended minimum streamflows (◆◆).

PROGRAMMATIC ACTION 4A: Supplement flows in the Bear River with water acquired from new water sources, water transfers, and willing sellers consistent with applicable guidelines or negotiated agreements to provide flows that will improve conditions for all chinook salmon and steelhead life stages.

Minimum Streamflow Recommendations for Bear River

Month	Flows (cfs)
October 1-14	100
October 15-December 15	250
January-March	250
April-June	250
July-September	10

RATIONALE: *The streams in the Feather River/Sutter Basin Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. Key benefits of streamflow in this Ecological Management Zone are successful upstream of adult fish passage and downstream passage of juvenile fish. In addition, flow drives many ecological functions and processes linked to stream-channel morphology, riparian communities, and fish habitat. The best flow schedule for providing maximum ecological benefits in the Feather River has not been agreed upon. The California Department of Fish and Game (1993) recommended the following flows and temperatures below Thermolito Afterbay:*

Period	Streamflow (cfs)	Temperature
Jan-Apr	2,000	56°F
May 1 - 15	3,000	60
May 16 - June 15	4,000	60
June 16 - Oct 15	1,000	NF
Oct 16 - Dec 31	1,700	56

The increased flow in the DFG recommendation is partially designed to provide a large flow for American shad spawning. The temperature recommendation, however, is too low for shad as they require a spawning temperature about 5 °F higher than recommended.

Technical agreement on Feather River flows and temperatures has not been reached. This is an area that needs to be addressed by the CALFED approach to adaptive management. Additional monitoring and/or research may be required to develop consensus on these issues. The CALFED approach also goes beyond the flow and temperature requirements of anadromous fish by also including the flows needed for coarse sediment transport, overbank flooding, and riparian maintenance and regeneration. The recommended flow targets provide a basis for on-going and future evaluations using adaptive management as a tool to reach agreement.

Supplementing flows on the Yuba River by acquisition of water from willing sellers depends on whether or not there are any willing sellers. Findings from a detailed hydrologic and operations assessment of the Yuba River system to develop water-year-type-specific instream flow recommendations indicate that, with the exception of wet years, insufficient water would be available within the system to always meet the recommended flows (Beak 1996). In years when flow augmentation is required, a decision will have to be made regarding use of acquired water in the spring to either meet DFG's recommendation of 1,000 cfs at Marysville during the April-June period, or to use this water to 1) provide higher flows and , therefore, greater thermal protection to steelhead during July-September, or 2) supplement flows during the October-December period to benefit fall-run chinook salmon spawning.

Studies conducted in the lower Yuba River during 1976-1978 revealed that the lower Yuba River is not a season-long nursery area for American shad (Meinze 1979). That may reflect drought condition during part of the study period but the study did reveal that newly hatched shad fry are rapidly transported downstream and into the Feather River. Larvae are swept out by currents before they grow large enough to maintain their position in the river. Juvenile shad spend several weeks to several months in the Feather and Sacramento rivers and in the Delta, which is considered the primary rearing habitat for American shad (Painter et al. 1977, Painter et al. 1979, Meinze 1979, SWRCB 1992). Consequently, higher spring flows in the lower Yuba River may provide minimal increased benefits for young shad.

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain existing erosion and gravel recruitment levels in tributaries that sustain an adequate level of gravel recruitment, or restore desirable levels by directly manipulating and augmenting gravel supplies where the natural fluvial process has been interrupted by dams or other features that retain or remove the gravel supply (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate spawning gravel quality in areas used by chinook salmon and steelhead in the Feather River. If indicated, renovate or supplement gravel supplies to enhance substrate quality by importing 4,000 to 8,000 tons of additional gravel below the hatchery as conditions require.

PROGRAMMATIC ACTION 1B: Evaluate spawning gravel quality in areas used by chinook salmon and steelhead in the Yuba River. If indicated, renovate or supplement gravel supplies to enhance substrate quality.

PROGRAMMATIC ACTION 1C: Evaluate the quality of spawning gravel in areas used by chinook salmon and steelhead in the Bear River. If indicated, renovate or supplement gravel supplies to enhance substrate quality

RATIONALE: *Sediment transport is the process whereby flows carry away finer sediments that fill gravel interstices (i.e., spaces between cobbles). Gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing, by flushing most fines and moving bedload, are important processes to maintain the amount and distribution of spawning habitat in the Sacramento-San Joaquin River basin. Human activities have greatly reduced or altered these processes. Opportunities to maintain and restore these processes include changing water flow, sediment supplies, and basin geomorphology; removing stressors; or manipulating channel features and stream vegetation directly. Gravel deposits in Feather River/Sutter Basin Ecological Management Zone streams are essential to maintain spring- and fall-run chinook salmon, steelhead trout, and other resident native fish spawning and rearing habitats. Although additional evaluations are required to better define the magnitude of flows required to move coarse sediments in each of the streams in this ecological management zone, it appears that flows exceeding 20,000 cfs in the Feather River are probably sufficient to achieve this important ecological event.*

Opportunities to maintain and restore gravel recruitment include manipulating natural processes and controlling or managing environmental stressors that adversely affect recruitment.

STREAM MEANDER

TARGET 1: Preserve and expand the stream-meander belts in the Feather, Yuba, and Bear Rivers by adding a cumulative total of 1,000 acres of riparian lands to the meander zones (◆◆◆).

PROGRAMMATIC ACTION 1A: Acquire riparian and meander-zone lands by purchasing them directly or acquiring easements from willing sellers, or provide incentives for voluntary efforts to preserve and manage riparian areas on private land.

PROGRAMMATIC ACTION 1B: Build local support for maintaining active meander zones by establishing a mechanism whereby property owners would be reimbursed for lands lost to natural meander processes.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to improve opportunities for natural meander by removing riprap and relocating other structures that impair stream meander.

RATIONALE: *Preserving and improving the stream-meander belts in the Feather River/Sutter Basin Ecological Management Zone will ensure that this important natural process is maintained. Typically, these reaches are important for spawning and rearing salmon and steelhead. A natural meander process will provide near-optimal habitat for spawning (through gravel recruitment), rearing (channel configuration, cover, and foodweb), and migration. There is limited potential for natural channel migration in narrowly leveed sections. Overall, the program must be consistent with flood control requirements and in the longer term, should reduce need for future flood control efforts by using natural system resilience and flood control characteristics.*

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore and improve opportunities for rivers to seasonally flood their floodplain (◆).

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to construct setback levees in the Feather, Yuba, and Bear lower river floodplains.

PROGRAMMATIC ACTION 1B: Restore, as needed, stream channel and overflow basin configurations within the floodplain.

PROGRAMMATIC ACTION 1C: Minimize effects of permanent structures, such as bridges and diversion dams, on floodplain processes.

PROGRAMMATIC ACTION 1D: Develop a floodplain management plan for the Feather River.

PROGRAMMATIC ACTION 1E: Develop a floodplain management plan for the Yuba River.

PROGRAMMATIC ACTION 1F: Develop a floodplain management plan for the Bear River.

PROGRAMMATIC ACTION 1G: Develop a floodplain management plan for the Sutter Basin and Sutter Bypass.

RATIONALE: *Setback levees will provide greater floodplain inundation, room for stream meander, and more riparian forest and seasonal wetland habitats along the lower rivers. Channel configuration adjustments may be necessary to accelerate natural floodplain habitat restoration and to restore and maintain configurations that may not occur naturally due to remaining constraints from new setback levees. Permanent structures, such as bridges and diversions dams, can interrupt and impair natural floodplain processes and habitat development and succession. Thus, it may be necessary to remove or rebuild some structures or require continuing maintenance or mitigations to minimize their effects.*

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Improve water quality conditions in the Feather, Yuba, and Bear rivers to benefit anadromous fish (◆◆).

PROGRAMMATIC ACTION 1A: Develop and use a temperature model as a tool for managing the Feather River.

PROGRAMMATIC ACTION 1B: Maintain a daily average water temperature of 60°F in the low-flow section of the Feather River from June 1 through September 30 to benefit over-summering steelhead juveniles.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to identify and remove physical and water quality barriers in the Feather River that impede access for white and green sturgeon to spawning habitat, or facilitate passage around these barriers.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to maintain mean daily water temperatures below 65°F for at least 1 month from April 1 to June 30 for American shad spawning in the Feather River. This is consistent with actions to protect chinook salmon and, steelhead and, when hydrologic conditions are adequate, to minimize adverse effects on water-supply operations.

PROGRAMMATIC ACTION 1E: Develop a cooperative approach to operating reservoirs in the Yuba River watershed to provide adequate water temperatures for anadromous fish.

PROGRAMMATIC ACTION 1F: Evaluate whether improving water temperature control with shutter configuration and present coldwater pool management at New Bullards Bar Dam on the Yuba River are effective. Modify the water release outlets at Englebright Dam if these improvements are effective.

PROGRAMMATIC ACTION 1G: Maintain a daily average water temperature of 60°F from Englebright Dam to Daguerre Point Dam in the Yuba River from June 1 through September 30 to benefit over-summering steelhead juveniles.

PROGRAMMATIC ACTION 1H: Develop a cooperative program to maintain mean daily water temperatures below 65°F for at least 1 month from April 1 to June 30 for American shad spawning in the Yuba River. This is consistent with actions to protect chinook salmon and steelhead and, when hydrologic conditions are adequate, to minimize adverse effects on water-supply operations.

PROGRAMMATIC ACTION 1I: Develop a cooperative approach to providing adequate water temperatures in the Bear River (see following table) for all chinook salmon and steelhead life stages.

RATIONALE: *Aquatic species have very specific water temperature requirements that vary by stage in their life cycles. Water temperatures are typically high during the late summer and early fall, when water management flexibility below the major reservoirs is typically limited. Water temperatures should be addressed through integrated water and temperature management*

Required Water Temperatures in the Bear River for Chinook Salmon and Steelhead

Month	Flows (cfs)	Temperature (°F)	
		Wheat-land	Highway 70
October 1-14	100	60	60
October 15-December 15	250	58	57
January-March	250	56	57
April-June	250	60	60
July-September	10	65	65

programs that seek to conserve cool water reservoir pools for release later in the summer and by investigating feasibility of modifying water release outlets on existing dams to provide a greater ability to fully utilize the cold water in the reservoir.

Operating to provide specific water temperatures at the appropriate times in systems where aquatic resources have differing temperature requirements can be difficult. In situations where water temperature requirements may conflict, water temperature operations should first address the needs of listed species, then native species, and then introduced species. On the Feather and Yuba rivers, the water temperature requirements of anadromous salmonids (chinook salmon and steelhead) have priority. After their temperature needs are met, then the temperature requirements of American shad can be addressed.

HABITATS

SEASONAL WETLANDS

TARGET 1: Assist in protecting 500 acres of existing seasonal wetland habitat through fee acquisition or perpetual easements consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 500 acres of existing, degraded seasonal wetland habitat in the Sutter Bypass Ecological Management Unit.

TARGET 2: Develop and implement a cooperative program to enhance 3,090 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Sutter Bypass Ecological Management Unit.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Feather River/Sutter Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Colusa Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET: Provide conditions for riparian vegetation growth along river sections in the Feather River/Sutter Basin Ecological Management Zone (◆◆).

PROGRAMMATIC ACTION 1A: Purchase streambank conservation easements from willing sellers or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Yuba River.

PROGRAMMATIC ACTION 1B: Evaluate the benefits of restoring stream-channel and riparian habitats on the Yuba River, including creating side channels to serve as spawning and rearing habitats for salmonids.

PROGRAMMATIC ACTION 1C: Purchase streambank conservation easements from willing sellers or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Feather River.

PROGRAMMATIC ACTION 1D: Purchase streambank conservation easements from willing sellers or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Bear River.

RATIONALE: *Many wildlife species, including several listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian habitats support a greater wildlife species diversity than all other habitat types in California. Riparian habitat degradation and loss has substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

Improving low- to moderate-quality shaded riverine aquatic habitat will benefit juvenile chinook salmon and steelhead by improving shade, cover, and food. Wildlife in this Ecological Management Zone will also benefit from improved habitat. Protecting and improving shaded riverine aquatic habitat may involve changes in land use that will require the consensus of local landowners and local, State, and federal agencies. Limitations on land suitable or available for restoration will require establishing priorities, with efforts directed at acquiring high-priority, low-cost sites first.

Freshwater Fish Habitat and Essential Fish Habitat

Target 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

Programmatic Actions: No additional programmatic actions are recommended.

Rationale: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the Feather, Yuba, and Bear rivers and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

Agricultural Lands

Target 1: Cooperatively manage 57,578 acres of agricultural lands consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

Programmatic Action 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

Rationale: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980)

Reducing or Eliminating Stressors

Water Diversions

Target 1: Improve the survival of juvenile anadromous fish in the Yuba River by installing, upgrading, or replacing fish screens (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to upgrade or construct screens that meet current Department of Fish and Game and National Marine Fisheries Service screening standards at the Hallwood-Cordua and Brophy-South Yuba Canal water diversion, and other unscreened diversions on the Yuba River.

TARGET 2: Improve the survival of juvenile anadromous fish in the Bear River by installing, upgrading, or replacing fish screens (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to evaluate and screen diversions in the Bear River to protect all anadromous fish life stages.

TARGET 3: Improve the survival of juvenile anadromous fish in the Feather River by installing, upgrading, or replacing fish screens (◆◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to evaluate and screen diversions in the Feather River to protect all anadromous fish life stages.

RATIONALE: *Water diversion, storage, and release in the watershed directly affect fish, aquatic organisms, and nutrient levels in the system and indirectly affect habitat, foodweb production, and species abundance and distribution. Unscreened diversions cause direct mortality to young fish; the level of mortality is likely influenced by the number of young fish present, diversion size, and diversion timing.*

The fish screens on the water diversions at Daguerre Point Dam on the Yuba River (Hallwood-Cordua and Brophy-South Yuba Canal) are inadequate and do not meet current DFG or NMFS screening criteria (DFG 1991). The Hallwood-Cordua Fish Screening Facility is funded and staffed by DFG, but because of limited funding, DFG does not operate the facility after the peak of chinook salmon emigration has occurred (sometime in June). Unscreened diversions continue throughout the summer and fall, and significant numbers of juvenile steelhead are entrained and lost. The Brophy-South Yuba diversion utilizes a rock levee to prevent fish from entering the diversion, however, the levee has been shown to be permeable to small fish even when the diversion is not operating, and significant numbers of juvenile chinook salmon are entrained (DFG 1991). Fully-functioning fish screens that meet current criteria and are adequately funded, staffed, and operated throughout the irrigation season need to be implemented at both diversions.

DAMS AND OTHER STRUCTURES

TARGET 1: Increase adult and juvenile anadromous fish passage in the Yuba River by providing access to 100% of the available habitat below Englebright Dam (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to improve anadromous fish passage in the Yuba River by removing dams or constructing fish ladders, providing passage flows, keeping channels open, eliminating predator habitat at instream structures, and constructing improved fish bypasses at diversions.

PROGRAMMATIC ACTION 1B: Facilitate passage of spawning adult salmonids in the Yuba River by maintaining appropriate flows through the fish ladders or modifying the fish ladders at diversion dams.

PROGRAMMATIC ACTION 1C: Conduct a cooperative study to determine the feasibility of allowing spring-run chinook salmon and steelhead access to historical spawning and rearing habitats above Englebright Dam on the Yuba River.

TARGET 2: Improve chinook salmon and steelhead passage in the Bear River by providing access to 100% of the available habitat below the SSID diversion dam (◆◆).

PROGRAMMATIC ACTION 2A: Improve chinook salmon and steelhead passage in the Bear

River by negotiating with landowners to remove or modify culvert crossings on the Bear River.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrologic and sediment processes. Other structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern.*

It is estimated that 82% to 95% of historical salmon and steelhead spawning and rearing habitat in the Central Valley has been lost due to impassable dams (Reynolds et al. 1993; Yoshiyama 1996). Perhaps the greatest potential for anadromous fish restoration in the Central Valley can be realized by reestablishing access to some of these former habitats, especially for those fish that are dependent upon habitat in mid- to upper-elevation stream reaches, such as steelhead and spring-run chinook salmon. Restoring access at Englebright Dam would allow salmon and steelhead to utilize a considerable amount of historical habitat in the Yuba River system, primarily in the South and Middle forks, and would have a substantial effect on restoration on a basin-wide level. Providing access to historical habitats could also reduce the reliance on low-elevation, valley-floor reaches that require large amounts of water to maintain suitable temperatures, thus could potentially reduce overall water costs for anadromous fish restoration. Compared to other major Central Valley tributaries, the Yuba River has greater potential than most to reestablish access to a substantial amount of former habitat. However, potential spawning and rearing habitat above the dam must first be assessed, and if it is determined that suitable habitat exists, then a feasibility study of the best means to provide access (dam removal, passage facility installation, trap-and-truck operation, etc.) should be initiated.

HARVEST OF FISH AND WILDLIFE

IMPLEMENTATION OBJECTIVE: The implementation objective for harvest is to regulate fish and wildlife harvest as necessary to avoid impairing reproductive capacity in relation to available habitat.

TARGET 1: Develop harvest management strategies that allow wild, naturally produced fish spawning populations to attain levels that make full use of existing and restored habitat, and focus harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by increasing enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet target levels.

PROGRAMMATIC ACTION 1C: Reduce harvest of wild, naturally produced steelhead populations, by continuing to mark all hatchery-reared fish and continuing to institute selective harvesting.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations to levels that take full advantage of habitat may require restricting harvest during and after the recovery period. Involving the various stakeholder organizations should help ensure a balanced and fair harvest allocation. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery-reared fish, selective harvesting may be necessary to limit wild fish harvest while harvesting hatchery-produced fish to reduce their potential to disrupt the genetic integrity of wild populations. The Fish and Game Commission recently adopted DFG* *recommendations to establish a selective fishery for hatchery steelhead and to reduce incidental hooking of wild steelhead on all Central Valley streams.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: To protect naturally produced salmon and steelhead, minimize the likelihood that hatchery-reared salmon and steelhead produced in the Feather River Hatchery will stray into non-natal streams (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Feather River. Stocking levels may be reduced in years when natural production is high.

TARGET 2: Reduce superimposition of chinook redds in the low flow section of the Feather River.

PROGRAMMATIC ACTION 2A: Develop a cooperative program to evaluate alternative means of reducing the number of spawners in the upper section and increasing the number of spawners in the high flow section below Thermolito.

TARGET 3: Limit hatchery stocking if populations of salmon or steelhead can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 3A: Augment fall-run chinook salmon and steelhead populations only when alternative measures are deemed insufficient to provide population recovery.

TARGET 4: Minimize further threats of hatchery-produced fish interbreeding with wild chinook salmon and steelhead stocks (◆◆◆).

PROGRAMMATIC ACTION 4A: Adopt methods for selecting spawning adults for the hatchery from an appropriate cross section of the adult population available to the hatchery.

RATIONALE: *In watersheds such as the Sacramento River and Feather River, where dams and habitat degradation have limited natural spawning, hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. Hatchery augmentation, however, should be limited to protect recovery and maintain wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery-produced fish may also threaten the genetic integrity of wild stocks by interbreeding with wild fish. Although irreversible contamination of wild stocks has taken place, additional protective measures would minimize further degradation of genetic integrity. Development on the Sacramento and Feather Rivers might necessitate stocking of chinook salmon and steelhead to rebuild and maintain stocks that will sustain sport and commercial fisheries.*

Superimposition of chinook salmon redds in the low flow section of the Feather River is a problem that reduces the success of naturally spawning fish. The mechanisms leading to overuse of the low flow (upper) section of the Feather River are poorly understood. Potential causes may be linked to hatchery release practices such as trucking to distant release sites, differing flows between the low flow and high flow stream reaches, or genetic history of fish using the upper section. Spring-run chinook have adapted to moving further upstream than their fall-run counterparts. The fall spawning chinook in the Feather River are know to by introgressed with spring-run which may provide one avenue of research to determine why the upper section is over-utilized by spawners while high quality spawning gravel in the high flow section is highly underutilized.

STRANDING

TARGET 1: Reduce or eliminate the stranding of juvenile chinook salmon on floodplains, shallow ponds, and levee borrow areas.

PROGRAMMATIC ACTION 1A: Conduct surveys of stranding in the Feather River under a range of flow conditions and develop recommendations to resolve the problem.

PROGRAMMATIC ACTION 1B: Conduct surveys of stranding in the Sutter Bypass under a range of flow conditions and develop recommendations to resolve the problem.

RATIONALE: *Under many flow conditions, stranding is likely a minimal problem. However, under conditions in which rivers reach high flows and flow is diverted into the flood bypasses, and then flow quickly recede, stranding is likely a serious problem. Timing also plays a important role in determining the severity of the problem. Flood plain inundation prior to young salmon emerging is less of a problem that inundation after most of the fry have emerged.*

REFERENCES USED TO DEVELOP TARGETS AND ACTIONS IN THE FEATHER RIVER/SUTTER BASIN ECOLOGICAL MANAGEMENT ZONE

Beak (Beak Consultants Incorporated) 1996. Anadromous fish enhancement actions recommended for the lower Yuba River. Prepared by Beak Consultants Inc. In association with Bookman-Edmonston Engineering, Inc. Prepared for the Yuba County Water Agency, Marysville, California. Draft report dated July 1996.

Brown. R. and S. Green. 1997. An evaluation of the Feather River Hatchery as mitigation for construction of the California State Water Project's Oroville Dam. California Department of Water Resources.

California Department of Fish and Game. 1993. Restoring Central Valley Streams: a plan for action. November 1993.

California Dept. of Fish and Game. 1991. Lower Yuba River fisheries management plan. Stream Evaluation Rpt. No. 91-1.

Central Valley Habitat Joint Venture. 1990. Central Valley Habitat Joint Venture Implementation Plan, a component of the North American Waterfowl Management Plan. February 1990.

Jones and Stokes Associates 1990. 1009 field investigations of Yuba River American shad (JSA 90-098). Prepared by W.T. Mitchell and P.L. Dunn. Sacramento, California. Prepared for the Yuba County Water Agency.

Madrone Associates. 1980. Sacramento-San Joaquin Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and U.S. Fish and Wildlife Service.

Meinze. M. 1979. American shad, Alosa sapidissima, sport fishery in the Sacramento river system, 1976-1978: catch and effort. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report Number 81-1. 19 p.

Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

Painter, R.E., L.H. Wixom, and M. Meinze. 1979. American shad management plan for the Sacramento River drainage. Final Report, Job No. 5, California Department of Fish and Game. Anadromous Fisheries Conservation Act, AFS-17. 22 p.

Painter, R.E., L.H. Wixon, and S.W. Taylor. 1977. An evaluation of fish populations and fisheries in the post-Oroville Project Feather River: a report submitted to the Department of Water Resources. California Department of Fish and Game, Sacramento, California. 56 p.

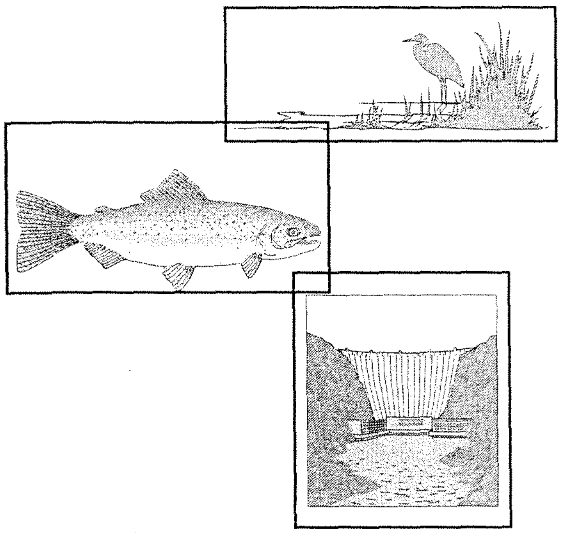
SWRCB (State Water Resources Control Board). 1992. State Water Resources Control Board Water Rights Hearing on the Lower Yuba River, Yuba County Water Agency v. State Water Resources Control Board. February-June, 1992.

U.S. Fish and Wildlife Service. 1996. Recovery plan for the Sacramento/San Joaquin San Joaquin Delta native fishes.

U.S. Fish and Wildlife Service. 1997. Revised draft anadromous fish restoration plan: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: Final report to Congress, vol.III. Centers for Water and Wildland Resources,

◆ AMERICAN RIVER BASIN ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

The American River Basin Ecological Management Zone is located east of the Sacramento River and lies between the Bear River to the north and the Cosumnes River to the south (Figure 14). The total watershed encompasses about 2,000 sq. mi. (California State Lands Commission 1993). The zone consists of several watersheds adjacent to and including the American River. These watersheds includes smaller creeks that drain into the Natomas Cross Canal (NCC), the Natomas East Main Drainage Canal (NEMDC), Morrison Creek, and the lower American River below Folsom and Nimbus Dams. The NCC and NEMDC form the watersheds of the American Basin including the Natomas Basin, located east of the Sacramento River between the Bear River and American River watersheds. Morrison Creek is a small watershed located just south of Sacramento and the American River that drains into the north-eastern portion of the Delta in the Stone Lakes area.

The health of the Sacramento-San Joaquin River Delta (Delta) depends on the condition of the streams that make up its watershed. The American River is one of the largest tributaries within the Delta's watershed. The other streams of the basin are minor but potentially important contributors. Water, sediment, and nutrients from the American River and the other watersheds are important factors governing the ecological health of San Francisco Bay (the Bay) and Delta, including many estuarine fish species and their foodwebs. The American Basin was once an important wintering area of waterfowl the use the Central Valley portion of the Pacific flyway.

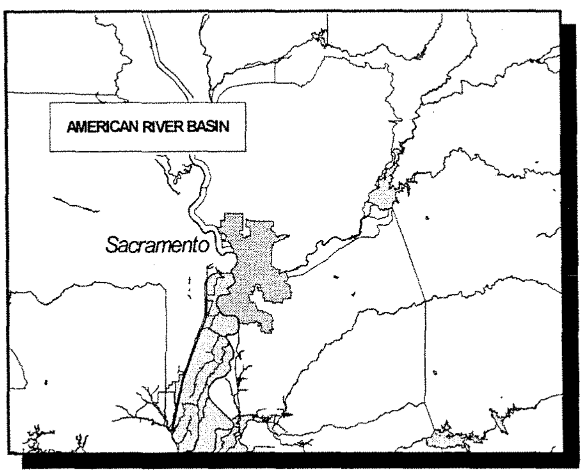
The American River is also an essential watershed for the spawning, rearing, and migrating fall-run chinook salmon, steelhead, striped bass, and American shad, which must pass through the Bay and Delta during portions of their life cycle. Although their period of residence in some cases (e.g., steelhead) in the Bay and Delta may be brief, it constitutes an important part of the life cycles of these fish species. Hence, the population status of these anadromous fish species is influenced by human activities that affect both their freshwater riverine and Bay-Delta estuarine habitats.

The two ecological factors with the greatest influence on anadromous fishes of the lower American River are seasonal stream flow and water temperature. In addition spawning gravel, stream-channel dynamics, shaded riverine aquatic (SRA) and riparian habitats also are important factors. Stressors such as dams, legal and illegal harvest, water quality (e.g., water temperature and toxins from urban runoff), and artificial propagation of anadromous fish further affect the population dynamics of anadromous fish in watersheds of the zone.

Description of the Management Zone

The American Basin Ecological Management Zone is located in the east-central portion of Central Valley. Its eastern boundary is the Sierra foothills. The western boundary is the Sacramento River and Delta. The northern boundary is the Feather River Ecological Management Zone. The southern boundary is the Cosumnes River Ecological Management Zone. This Ecological Management Zone has two Ecological Management Units:

- American Basin, and
- Lower American River



Location Map of the American River Basin Ecological Management Zone.

List of Species to Benefit from Restoration Actions in the American River Basin Ecological Management Zone

- fall-run chinook salmon
- steelhead trout
- splittail
- native resident fishes
- lamprey
- American shad
- giant garter snake
- neotropical migratory birds
- Swainson's hawk
- waterfowl
- non-native warmwater gamefish
- plants and plant communities.

Descriptions of Ecological Management Units

American River Basin Ecological Management Unit

The American River Basin Ecological Management Unit includes the watersheds between the American and Feather River systems on the east side of the Sacramento Valley. The streams included from North to South are Coon Creek, Markham Ravine, Auburn Ravine, Pleasant Grove Creek, Curry Creek, Dry Creek, and Arcade Creek. These creeks enter the floodplain drainage systems of the Natomas Cross Canal (NCC) and the Natomas East Main Drainage Canal (NEMDC) in southern Sutter and northern Sacramento counties. The NCC drains into the Sacramento River just south of the Feather River, while the NEMDC drains into the Sacramento River just to the north of the American River. The NEMDC watershed is comprised of the Dry Creek and Arcade Creek watersheds. Dry Creek's headwater watersheds include Linda Creek, Cirby Creek, Miners Ravine, and Antelope Creek, which come together and form Dry Creek near the City of Roseville in southern Placer County. Dry Creek then flows southwest through Sacramento County to the NEMDC in the City of Sacramento. The NCC watershed includes Coon Creek with its main tributary Doty Creek, Markham Ravine, Auburn Ravine with its main tributary Dutch Ravine, Pleasant Grove Creek, and Curry Creek.

Once large wetland areas, the American Basin floodplain is now principally rice fields in the north and central areas, with the metropolitan area of the City of Sacramento in the south. The Sacramento River levee marks the western boundary of the unit. The northern boundary is the Bear River watershed. The southern boundary is the American River watershed. The eastern boundary is the upper watersheds of the Bear and American Rivers. Above the floodplain the creeks pass through the rolling hills of Placer County, and the cities of Lincoln, Roseville, and Rocklin. This central portion of the creek watersheds is a mixture of agricultural lands, grasslands, and oak woodlands. The upper eastern portion of the unit consists of the upper watersheds of Coon Creek, Auburn Ravine, and Dry Creek that extend upslope into Sierra foothills near the City of Auburn. Here lands are a mixture of oak-pine woodlands and orchards, intermixed with other agricultural and municipal developments.

The unit has a Mediterranean climate with wet winters and dry summers. With only a maximum elevation of about 1,500 ft, little or no snow melt enters the upper watershed of the unit. The eastern foothill portion of the unit receives more rainfall (about 40 inches) than the valley portion (about 20 inches). Of the streams, Coon, Doty, Auburn Ravine, Dry Creek, Linda Creek, Miners Ravine, Secret Ravine, and Antelope Creek have sufficient summer flow from diversions from other basins, ground water, storm drains, irrigation returns, or sewage treatment effluent to be considered perennial. Water is also diverted from the upper Bear and American River watersheds into the Coon Creek, Auburn Ravine, and Dry Creek watersheds for irrigating lands in the American Basin.

Stream flows have been modified by water diversions, subsidence in ground water tables, and watershed activities such as grazing, road building, wetland management, forest management, and agriculture. In wetter periods all the streams are essential in carrying stormflow. Drains and ditches in the lower floodplain convey floodwaters to the NCC, NEMDC, and RD 1000 pumping plants on the Sacramento River.

In drier periods, creeks of the unit are used to carry drain water, convey irrigation water, or are intermittent. During the spring through fall irrigation season, much of the water in these streams is diverted along their paths to irrigation. In the lower floodplain, water is pumped into the basin from the Sacramento River and dispersed through the system of irrigation canals maintained by the Natomas Central Mutual Water Co. (NCMWC) for irrigation.

In all but wetter years, winter-spring rainwater is conveyed from the natural floodplain of the American Basin to the Sacramento River via the NCC, NEMDC, and drainage ditches. In wettest years large portions of the floodplain are subject to flooding from overtopping levees or simply filling with rainwater. Floodwaters are eventually drained and pumped to the Sacramento River.

The American Basin Ecological Management Unit has two distinct geomorphological areas: the hilly east side in the Sierra Foothills and the valley floodplain on the western side adjacent to the Sacramento River. The western portion of the unit in the Sacramento Valley floodplain is best described as an agricultural belt with some managed wetlands. Most of the land is in rice production and is 20 to 30 feet of elevation or less.

The NCC's northern extension, the East Side Canal, and its southern extension, the Pleasant Grove Creek Canal capture the flows of the creek's of the NCC watershed and convey them to the NCC and west to the Sacramento River. The NCC has a capacity of 22,000 cfs, which in high water years is insufficient to carry flood flows, thus water tends to back up into the lower creek drainages despite channel capacities totaling 36,000 cfs. The NEMDC captures the flows of Dry and Arcade Creeks and conveys them to the Sacramento River just upstream from the mouth of the American River.

Lands west of Pleasant Grove Creek Canal and the NEMDC to the Sacramento River are in the Natomas Basin. These lands and those west of the East Side Canal were once floodplain marshes connected to the Sacramento River, and are now protected from flooding by levees and a series of drainage canals operated by Reclamation District 1000 that drain rainwater, floodwaters, and irrigation return water back to the Sacramento River via a system of drainage ditches and pumping stations. In the southern portion of Natomas Basin there are extensive developments including the Sacramento Metropolitan Airport, Arco Arena, Interstate Highways 5 and 80, and the City of Sacramento. Of the approximately 50,000 acres in Natomas Basin, approximately 40,000 are croplands (mostly rice), 5,000 are urban, 1,500 are roads, 1,500 are vacant, and 3,000 are wetlands or open water.

East of the Natomas Basin and East Side Canal the floodplain extends up the watersheds of the creeks. Rice field dominate the low lands, while grasslands and oak woodlands with mixed agriculture and pasture lands occur between the creek bottoms. Elevation rises gradually from west to east from 30 feet to about 100 feet elevation. Lincoln, Roseville, and other Sacramento suburbs are located in this portion of the unit.

Further to the east begins the foothills to the east of Lincoln, Roseville and Sacramento. Here the watersheds of Coon Creek, Auburn Ravine, and Dry Creek tributaries rise quickly to elevations near 1,000 feet near the City of Auburn in Placer County. The creeks flow through forested ravines. The hills are a mixture of orchards, woodlands, grasslands, pastures, and other agricultural and municipal developments. In some locations the creeks are dammed creating small ponds and wetlands. Some areas have quality riparian forests, while others are degraded from livestock grazing or other land use activities.

Important habitats in the unit are wetlands, riparian forests, and grasslands. Marshes, once the most widespread habitat in the American Basin floodplain, are now restricted to remnant patches. There have been extensive reclamation of emergent wetland habitat to agricultural development. Most of the remaining wetlands lack adjacent upland transition habitat and other attributes of fully functioning wetlands. Seasonal wetlands include portion of the floodplain that flood in winter and spring, especially in high rainfall years. Most of this habitat is located in the Valley floor adjacent to the Sacramento River. Seasonal wetlands once covered large areas of the Basin during the winter rainy season or after seasonal flooding. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from inflow to the basin of flood waters carried by the foothill creeks, or from water diverted to leveed lands (e.g. rice lands and managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and wildlife. Vernal pool habitat is common in the central and eastern portion of the floodplain.

Riparian habitat, both forest and shrub, is found on the water and land side of levees and along creek channels of the unit. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide shaded riverine aquatic habitat on which many important fish and wildlife depend on during some portion of the life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, disturbed by livestock grazing and watering, resulting in a sparse, habitat structure with low diversity. Riparian habitat is used by more wildlife than any other habitat type. From about 1850 to the turn of the century most of the riparian forests in the Central Valley were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, along stream channels, and along the margins of marshes. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many species of fish and wildlife. There is little riparian habitat in the western, floodplain portion of the unit. Riparian habitat is more prevalent along the creeks from the valley floor to the basin headwaters, but suffers in places from effects of livestock grazing and watering, as well as urban development.

Upland habitats are found on the eastern floodplain and foothills and consist primarily of grasslands and oak woodland and oak savanna. Of these perennial grasslands are an important transition habitat for many wildlife species and are buffers to protect wetland and riparian habitats. Much grassland habitat associated with wetland and riparian habitat has been lost to agriculture (i.e. pasture, grain, vineyards, and orchards) and development (i.e., airports, sports complexes, industrial parks, home construction, golf courses). Grasslands are important buffers of wetland and riparian habitat and provide habitat for many plant and animal species.

Agricultural habitats are also important habitat as they support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging shorebirds, waterfowl, and raptors. Nonflooded fields and pastures are also habitat for pheasants, quail, and doves. Preferred habitat of raptors consists of tall trees for nesting and perching in proximity to open agricultural fields, which support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations. Rice lands provide invertebrates and amphibians for shorebirds, waterfowl, and snakes.

Important biological resources in this Ecological Management Unit include the giant garter snake, Swainson's hawk, fall-run chinook salmon, steelhead, waterfowl, as well as many other native plants and wildlife found within the diversity of habitat types. Though creeks of the basin contain chinook salmon and steelhead in small numbers, the creeks are primarily warm water habitats that sustain largemouth and smallmouth bass, catfish, sunfish, suckers, and minnows including squawfish and carp.

The giant garter snake (GGS) is a State and federally listed threatened species whose habitat is marsh lands with adjacent uplands used for shelter from flooding and winter hibernation. There have been numerous observations of the GGS in this unit. They appear to do well in the systems of drainage and irrigation canals and rice fields, and other seasonal wetlands.

Swainson's hawks are a State listed threatened species found primarily along the riparian corridor of the Sacramento River on the west side of this unit. At one time they were likely found in the riparian corridors of the floodplains of the creeks of this unit. They forage widely over the unit in grasslands and agricultural areas.

Wild juvenile fall-run chinook salmon have been found in small numbers in Coon Creek, Doty Creek, Auburn Ravine, and the upper creek watersheds of Dry Creek, including Secret Ravine, Antelope Creek, and Miners Ravine. Juvenile salmon raised in the Feather and American River hatcheries have been stocked since 1983 in several streams including Coon Creek, Auburn Ravine, and tributaries of Dry Creek. With Bear and American water present in many of these creeks, salmon from these rivers may stray into the creeks of the American Basin. Both Coon Creek and Auburn Ravine have been stocked with fingerling fall-run chinook salmon during the 1990s. Dry Creek, Auburn Ravine, Doty Ravine, Secret Ravine, and Coon Creek received plants of Feather River spring-run chinook salmon in the mid 1980's. Adult salmon carcasses have been observed in Antelope Creek, Miners Ravine, and Secret Ravine in the late fall. In 1963 and 1964 DFG surveys indicated 300-800 wild fall-run chinook salmon spawned successfully in Secret Ravine, where spawning gravels were once adequate for over 1,000 salmon. DFG surveys indicate that Doty Ravine has sufficient spawning habitat for 400 salmon redds. Salmon are limited by low flows and high water temperatures in the fall during the upstream migration of adults and in the spring during the downstream migration of juveniles.

Rainbow trout/steelhead fry have been found in Coon Creek, Auburn Ravine, Dry Creek and, tributaries of Dry Creek, particularly Secret Ravine and Miners Ravine. Adult steelhead have been observed in Auburn Ravine and steelhead smolts have been found in Dry Creek, Secret Ravine, and Miners Ravine.. Steelhead/rainbow trout require cool waters and sufficient flow through the summer and fall to sustain their populations. Such habitat still exists in the upper watersheds of these creeks. Inter-basin diversions into these creeks from the Bear and American River watersheds probably helps sustain steelhead.

Native fishes resident in the creeks of the unit include Sacramento squawfish, Sacramento sucker, hitch, California roach, and hardhead. These fish are adapted to higher winter-spring and low summer fall flows and warmer summer-fall water temperatures of the creeks.

Splittail migrate from the Bay-Delta into the lower rivers to spawn in late winter and early spring. They seek flooded lands to spawn including those of the Yolo and Sutter Bypasses. In wet years they likely migrate upstream into the lower NCC and NEMDC and spawn in flooded portions of creeks of this unit.

LOWER AMERICAN RIVER ECOLOGICAL MANAGEMENT UNIT

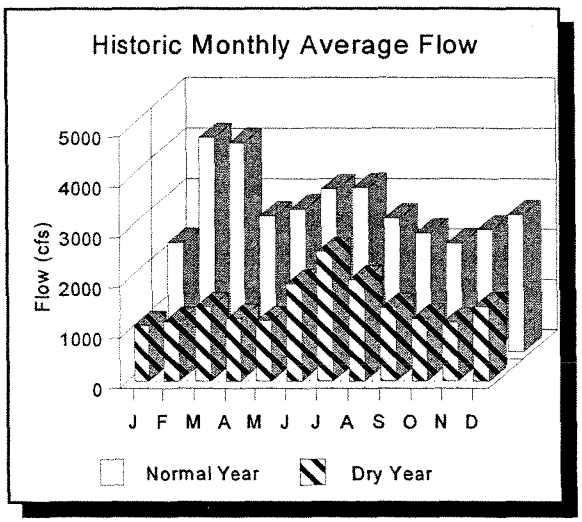
The American River is a major tributary to the Sacramento River, with their confluence located at the City of Sacramento. It provides approximately 15% of the total Sacramento River flow. The American River ranges in elevation from 23 feet to more than 10,000 feet and drains a watershed of approximately 1,900 square miles. Average annual precipitation in the watershed ranges from 23 inches on the valley floor to 58 inches at the headwaters. Approximately 40% of American River flow results from snowmelt. The American River has three major branches: the South, Middle, and North Forks, all of which drain into Folsom Reservoir. Average historical unimpaired runoff at Folsom Dam is 2.8 million acre-feet (af).

The American River meanders through a 4,800-acre floodplain that is bordered, for the most part, by low bluffs in its upper course and levees along its lower course. Most of the floodplain between the levees and opposite the bluffs has been acquired by either the City or County of Sacramento and is managed cooperatively as the American River Parkway. The lower American River, below Nimbus Dam, is also listed as a State and federal Wild and Scenic River and designated as "recreational".

Development on the American River began in the early days of the Gold Rush when numerous small dams and canals were constructed. Today, the drainage has three major and 10 smaller reservoirs with a total storage capacity of 1.9 million af. Folsom Lake, the largest reservoir in the drainage, was constructed in 1956 and has a storage capacity of 974,000 af. Proposed additional water project developments in the basin are the 2.3-million-af Auburn Dam and the 225,000-af South Fork American River project. Folsom Dam, located approximately 30 miles upstream from the mouth of the American River, is a major element of the federal Central Valley Project (CVP), operated by the U.S. Bureau of Reclamation (Reclamation) as an integrated system to meet contractual water demands and instream flow and water quality requirements.

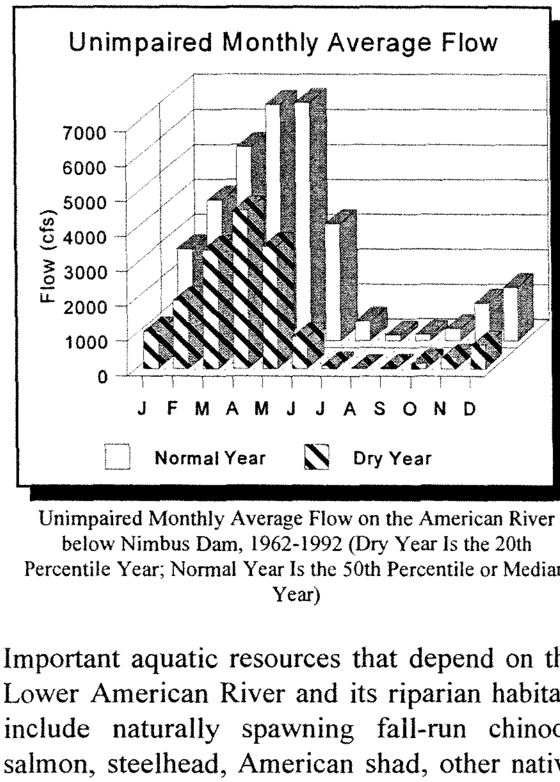
The American River has a natural pattern of moderate flows in winter, high flows in spring, very low flows in summer, and low flows in fall. This pattern is atypical of northern Sacramento Valley streams, which are fed by springs from the Cascade Range, and more similar to San Joaquin River tributaries. Flows in the Sacramento River and tributaries usually peak in March, whereas flows on American and San Joaquin River tributaries peak progressively later in spring from north to south. Natural (unimpaired) flows on the American River in dry and normal rainfall years generally peak from March to May.

Annual rainfall in the watershed is also highly variable. In the wettest years, unimpaired flows average 20,000-34,000 cubic feet per second (cfs) in winter months. In the driest years, unimpaired flows in winter months average only 200-800 cfs. Unimpaired spring flows, particularly in March through May, are generally more dependable, ranging from 1,300-1,500 cfs in driest years, 3,500-4,500 cfs in dry years, and 5,000-6,500 cfs in normal years. Unimpaired flows during summer and early fall are 0 cfs in the driest years, increasing to 1,000-6,000 cfs in the wettest years. In median rainfall years, unimpaired summer and early fall flows are generally 100-500 cfs.



Historic Monthly Average Flow on the American River below Nimbus Dam, 1962-1992 (Dry Year Is the 20th Percentile Year; Normal Year Is the 50th Percentile or Median Year)

Because the watershed contains 13 reservoirs, the natural flow pattern of the lower American River has been altered extensively. Spring flows have been greatly reduced, summer and fall flows have increased substantially, and winter flows are relatively unchanged. Annual variability has been reduced by the release of water from Folsom Reservoir in drier years. Peak average monthly flows in high rainfall years remain unchanged from unimpaired flows. Summer and early fall flows in the driest years average 300-900 cfs, whereas unimpaired flows average 0 cfs. Dry- and normal-year flows in summer and early fall months consistently average 1,200-3,200 cfs, whereas unimpaired flows average less than 500 cfs. Fall and winter flows have increased slightly in dry and normal years. Spring flows (March through May) have decreased from an unimpaired level of 3,500-4,500 cfs to 1,200-1,500 cfs in dry years. In normal rainfall years, spring flows are 2,800-4,200 cfs, compared to unimpaired flows of 5,500-6,800 cfs. A similar decline in spring flows has occurred in wet years.

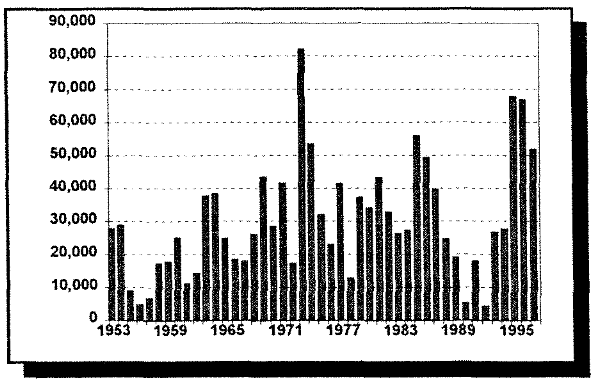


Unimpaired Monthly Average Flow on the American River below Nimbus Dam, 1962-1992 (Dry Year Is the 20th Percentile Year; Normal Year Is the 50th Percentile or Median Year)

Important aquatic resources that depend on the Lower American River and its riparian habitats include naturally spawning fall-run chinook salmon, steelhead, American shad, other native fish assemblages, amphibian populations, and lower trophic organisms. Important aquatic habitats include holding, spawning, rearing, and migration habitats for all fish species; sufficient quantities of high-quality water at the appropriate temperature; and riparian and SRA habitats.

The American River historically supported steelhead trout and chinook salmon that spawned principally in the upper watershed above the valley floor. There is historical documentation of chinook salmon in the North, Middle, and South forks, and steelhead in the North Fork and Middle Fork as far upstream as the rubicon River

(Yoshiyama et al. 1996). Each population probably exceeded 100,000 fish. Salmon and steelhead runs have declined significantly in the lower American River because of the combined effects of dams blocking traditional spawning and rearing areas (nearly all of the steelhead historical spawning and rearing habitat is located above Nimbus Dam [McEwan and Nelson 1991]), altered seasonal flow regimes resulting from dam operations, severe flow fluctuations that dewater redds and strand juveniles, and high water temperatures during crucial periods of salmon and steelhead development.



Naturally Spawning Fall-run Chinook Salmon Returns to the American River, 1953-1997 (Hatchery returns are not included).

Historically, over 125 miles of riverine habitat were available for anadromous fish in the American River system. Since the 1890s a dam, which included a semi-functional fish ladder which passed relatively low numbers of spring-run chinook salmon and steelhead, was located at Folsom. A relatively large run of fall-run chinook salmon became established in the reach of the river below the old Folsom Dam (Clark 1929). Counts of steelhead passing through the fishway on the old Folsom Dam from 1943 to 1947 indicate that the majority of the steelhead were spring-run which ranged in number from 200 in 1944 to 1,252 in 1948 (USFWS and CDFG 1953). These fish passed through the fishway from May through July en route to their upstream spawning and rearing areas. In 1950, flood waters destroyed the ladder, eliminating upstream spawning and rearing areas and in 1955 Nimbus Dam was closed and became the upstream terminous of anadromous fish migration. The native spring-run steelhead was probably eliminated at this time.

Decision 893 (D-893), issued by the California State Water Resources Control Board (SWRCB), established the minimum allowable riverflow in the lower American River as 500 cfs from September 15 through December 31 and 250 cfs from January 1 through September 14. This flow regime is inadequate to maintain anadromous fish in the present spawning and rearing areas of the lower American River below Nimbus Dam. Except for drought years such as 1976-77 and water-years 1989-1992, flows have seldom dropped to these minimum levels.

Since Folsom Dam and Reservoir were constructed, Reclamation has made releases that are legally constrained by the outdated fish flow requirements of D-893, which allows flows in the river during dry years to be as low as 250 cfs. Nevertheless, Reclamation voluntarily releases amounts sufficient to meet D-1400 (discussed below) when water is available. In recent years, Reclamation has made an attempt to voluntarily implement the flow objectives established by the Anadromous Fish Restoration Program (AFRP).

SWRCB Decision 1485 (D-1485) established water quality standards for the Delta that require additional releases from upstream storage facilities, including Folsom Reservoir. Reclamation has relied on releases from Folsom Reservoir to help meet the standards imposed by D-1485 because of its location near the Delta and the high probability of refill in the winter. This change in operation has reduced the carryover storage in Folsom Reservoir, which has resulted in less cold water being retained through summer and fall in the reservoir. This, in turn, has often resulted in high summer and fall water temperatures (above 70°F) in the lower American River.

In 1993, the Sacramento Area Flood Control Agency (SAFCA) prepared and distributed environmental documentation associated with operating to a new flood control diagram, known as the 400-670 Variable Flood Control Diagram. As part of the SAFCA work to provide a net beneficial effect to the salmonid resources of the American River, water temperature modeling and hydrologic modeling were conducted to evaluate the beneficial effect of the shutter reconfiguration at Folsom Dam.

The California Department of Fish and Game (DFG) recently completed the Lower American River Steelhead Management Plan, which identifies poor habitat conditions in the lower American River as a problem for steelhead. Cold water temperatures cannot be maintained year round in the lower American River because of the limited amount of cold water present in Folsom Reservoir that is available for releases to the river. In addition, the practice of clearing trees and other objects from the river to eliminate hazards to recreationists reduces instream cover for juvenile steelhead rearing in the river.

Among the most significant factors affecting the American River ecosystem are altered natural runoff patterns, impaired channel maintenance processes, and loss of connectivity between upstream spawning and rearing habitats and the lower river following construction of Folsom and Nimbus Dams. These changes have resulted in the following:

- exclusion of salmon and steelhead from many of their historic upstream spawning and rearing areas,
- altered seasonal river flow and water temperature,
- significant reduction in high-quality spawning and rearing habitats,
- armoring of existing instream gravel resources,
- elimination of natural stream meanders, and
- loss of islands and riparian vegetation.

Because of these changes, the lower American River is managed to provide or emulate, as much as possible, the conditions that formerly existed upstream of Folsom Dam.

Other important habitats have been severely disrupted by water storage and diversions, as well as levee construction and maintenance. Rapid flow fluctuations strand salmon and steelhead eggs and juveniles on higher terraces and in side channels. The present condition of migration, spawning, and nursery habitat for American River salmon and steelhead limits and impairs recruitment and survival of juvenile fish. Boating and rafting safety programs remove woody debris and overhanging SRA habitat from the river, thereby reducing the quality of important rearing habitats

Rearing habitat quality for young salmon and steelhead also has been reduced by low flows and associated high water temperatures, especially in drought years. Folsom Dam has a limited capacity for selective withdrawal of cold water from deeper portions of the reservoir to control downstream water temperatures. At Nimbus Dam, turbine intakes draw in the heated surface waters of Lake Natoma rather than the cooler, deeper flows from Folsom Dam. When turbines are not operating at Nimbus Dam, heated surface water from Lake Natoma is released over spillways to the river below the dam.

Some of the gravel beds in the river below Nimbus Dam have either been washed downstream or become armored and, therefore, are no longer moved by seasonal peak flows. Floods wash gravel downstream or onto high terraces along the river, where it is of little value. Many natural side channels still retain the scars of extensive dredger mining from nearly a century ago; others have been eliminated and no longer provide nursery or rearing habitat for juvenile salmon and steelhead. In some cases the river is connected to former dredger ponds (e.g., near

Arden Pond and at the Sailor Bar pond), that may increase already high river water temperatures locally, and can provide refuges for predatory, non-native warm water fishes such as smallmouth and largemouth bass. Reduced river flows, rip-rap bank protection, and levees contribute to the decline or impairment of natural sediment transport and channel maintenance processes, which have combined to substantially reduce natural gravel recruitment and transport in the river.

Another factor limiting production of naturally spawning salmon and steelhead is the presence of large numbers of native and non-native predators and competitors. The highly modified flow regime and altered instream habitat have provided potential advantages to striped bass, Sacramento squawfish, suckers, smallmouth and largemouth bass, resident trout, and American shad. Sport and commercial harvest also remove chinook salmon and steelhead adults from the natural spawning population.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the American River Basin Ecological Management Zone includes restoring important fishery, wildlife, and plant communities by restoring ecological processes, habitats and reducing the adverse affects of stressors. The vision for this Ecological Management Zone focuses on restoring an ecologically based streamflow plan, improving the supply and accessibility of sediments, maintaining the existing stream meander configurations, maintaining water temperatures in the lower American River to support anadromous fish, and supporting the development of locally sponsored watershed planning. The vision also encourages restoring a variety of aquatic, riparian, and terrestrial habitats for fish, wildlife, and plant communities.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

AMERICAN BASIN ECOLOGICAL MANAGEMENT UNIT

The vision for the American Basin Ecological Management Unit includes improved water quantity and quality from the basin to sustain aquatic, wetland, riparian, and upland habitats that support natural production of an abundance of resident fish and wildlife, as well as waterfowl and other migrant birds that use the Pacific Flyway each winter. The vision includes improving, restoring, and enlarging areas of remaining native habitats and establishing connectivity of those areas. Native habitats include riparian, emergent wetlands, season wetlands, and grasslands.

The vision focuses on improving watershed, stream channel, and floodplain processes that would lead to increased seasonal flows of quality water in the creeks, and area wetlands, and reducing the input of agricultural waste runoff and associated contaminants into unit watersheds and wetlands, and the Sacramento River. Improvements in the quality and quantity of water supplies provided to publicly and privately managed wetlands will reduce stresses on waterfowl populations. Additional water quality improvements can be achieved by tertiary water treatment plants to improve effluent discharges. Improvements in water quality and quantity to unit creeks and the Sacramento River will directly benefit fish and wildlife of the Sacramento River and the Bay-Delta.

Floodplain habitat improvement would be the focus of efforts in the western portion of the unit. Riparian and stream channel improvements would be the focus of efforts in the middle and upper watersheds. Seasonal wetlands for migratory species such as waterfowl and shore birds would be expanded and improved. Present restoration efforts can be expanded by ensuring adequate supplies of high quality water to the seasonal wetlands. Water supplies can be improved by reducing or eliminating diversions in streams and sloughs that flow into wetlands. Restoring natural watershed, stream, and floodplain processes along creek watersheds will promote natural habitat restoration. Emphasis should also be placed on connecting habitats and providing habitat corridors necessary for species such as the giant garter snake, Swainson's hawk, waterfowl, and neotropical birds.

Throughout much of the central and upper (eastern) portion of the unit creek restoration would provide higher quality water and improved habitats for salmon and steelhead. Exclusion of cattle along the streams and creeks, limitation of gravel mining, and reduction of diversions would improve stream channels and riparian corridors. Reforestation of cottonwood and other riparian forest species has not been possible because cattle range through the creek bottoms and land owners divert water for irrigation. Facilitating passage at numerous seasonal dams would allow better access to upstream spawning and rearing habitat.

The narrow strips of grasslands and riparian vegetation along levees, irrigation canals, and drainage ditches would be protected and restored where possible. More environmentally sound means of applications of pesticides and herbicides will be sought throughout the unit. Vegetation control practices would be modified to support the recovery of native plants such as perennial grasses and wetland species. The health of the upper creek watersheds will be enhanced by reducing the potential for wildfires in riparian and forest woodlands through forest fuels management and improved fire suppression.

Limited wetland areas located in the eastern portions of the unit adjacent to the Sacramento River should be protected and expanded. Stream flow into the wetland-slough complexes should be improved. Water quality should also be improved. Natural floodplain processes should be enhanced through set-back levees, stream meanders, and seasonal flood overflow basins, which in turn should reduce peak flood flows to the Sacramento River and water levels in flood-prone portions of the unit.

LOWER AMERICAN RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Lower American River Ecological Management Unit focuses on restoring important fishery, wildlife, and plant communities to a condition in which the status of specific resources is no longer considered to be of concern within the unit. Restoration within the American River will, in turn, contribute to restoring aquatic resources of the Bay-Delta. This vision will be accomplished by restoring or reinitiating important ecological processes and functions that create and maintain important habitats for fish, wildlife, and plant communities along the lower American River. Numerous and diverse actions may be implemented taken on a broad scale to restore and maintain sustainable, naturally spawning stocks of chinook salmon and steelhead in the American River, including improving seasonal flow and temperature regimes, in-channel and riparian habitats, fishery regulations, and hatchery operations.

Restoration efforts will emphasize benefits to naturally spawning chinook salmon and steelhead populations, which coexist with non-native American shad and striped bass and hatchery stocks of chinook salmon and steelhead. Harvest of naturally produced chinook salmon and steelhead will be regulated to ensure sustained recovery. Recreation along the river will be enhanced by improving flows and habitats and expanding populations of salmon, steelhead, American shad, and striped bass. These actions will also help to sustain the natural aesthetic quality of the stream channel and the associated riparian corridor and floodplain while allowing both consumptive and nonconsumptive uses of the fish, wildlife, and plant resources of the area.

The American River Flood Control Project, the lower American River Parkway, operations of

Folsom and Nimbus dams of the CVP, and the designation of the parkway as a State and federal Wild and Scenic River are essential elements that will guide the restoration of ecological health of the American River Basin Ecological Management Zone.

Restoration activities are directed at improving seasonal stream flow and water temperatures, spawning gravel resources, and stream channel configuration and habitat, and riparian corridor management. These processes, in turn, will support development and maintenance of spawning and rearing habitat (e.g., physical habitat, water temperature, and food supply). To support populations of naturally spawning steelhead trout, fall-run chinook salmon, American shad, and resident native fishes, the natural stream flow pattern and spawning and rearing habitat need to be improved. Of these actions, improving seasonal stream flow and water temperature have been identified by the Lower American River Technical Team as being of greatest importance in restoring anadromous fish populations in this river.

For the American River, improving spring (i.e., March through May) flows would help steelhead and American shad move upstream into the American River during their traditional spring migrations. Such flows during these months could also benefit older juvenile fall-run chinook salmon and steelhead migrating downstream to the estuary and ocean after rearing for an extended time. Moreover, improved spring flows would also benefit stream channels, gravel transport and cleansing, and riparian vegetation in the lower river, which, in turn, will benefit fish. Improved flow from the American River in spring would also enhance survival of American and other river anadromous fish during their passage downstream through the Delta to the Bay and ocean.

In addition to spring flows, flows are also needed in other seasons to protect juvenile salmon and steelhead rearing and migrating in the river. In some cases, flow needs exceed natural, unimpaired river flows below Nimbus Dam, because these juvenile fishes must rear in the non-traditional habitats of the lower river instead of the upstream reaches above the dams. Managing flows and water temperatures is necessary to optimize use of limited water resources. Doing so would require alternative operation of the water release shutters at Folsom Reservoir's power penstocks and physical modifications to the urban water intake structures to facilitate the diversion of water from Folsom Dam at elevations other than 317 ft (msl).

Habitat improvements in the lower American River are necessary to increase spawning and rearing habitat quality and quantity for salmon and steelhead to improve natural production of these anadromous fish species. Improved spawning habitat will lead to increased production of young salmon and steelhead. Improved stream channel and riparian vegetation will increase the availability of essential spawning and rearing habitat available for chinook salmon and steelhead. Some changes to the stream channel could reduce warming of the river and provide fewer refuges for warm water predators.

Many of the deficiencies identified in ecosystem processes in the American River can be remedied by improving water management and modifying aquatic and terrestrial habitats. For example, side channels can be restored along with SRA habitat to provide rearing habitat and reduce heating of the river. Much of the needed gravel for the river is stored in and along the river but is unavailable because of armoring or is stored on higher terraces and in dredger tailings. Restoration efforts can focus on reconfiguring the existing channel, redistributing available gravel supplies and restoring riparian vegetation while maintaining or improving the flood capacity of the channel.

Ameliorating or eliminating these problems would require long-term intervention and maintenance beyond simply replenishing the gravel supply of the American River. Although redistributing available gravel and improving the gravel permeability of salmonid spawning grounds is an important element of the vision, reconstructing and maintaining the channel also would be critical aspects of the effort. For example, much of the natural channel has become incised and armored, because sand and gravel appropriate for spawning have been continually eroded without being replaced.

Adequate seasonal flows to sustain salmon and steelhead populations are not always available in the American River. This is especially true for flows during spring through fall in drier than normal water-years. Additional water releases will be made possible from Folsom Lake storage, through purchases of CVP water from willing sellers for fish and wildlife, revised guidelines for operation of the CVP and State Water Project (SWP), water transfers, and/or purchases of water conserved from other sources using available restoration funds.

Reaching this vision for the American River Ecological Management Unit will also require reducing the adverse effects of illegal and legal harvest, hatcheries, and contaminants from urban drainage on lower American River aquatic resources. The following section describes additional visions or objectives for restoring key ecological processes, habitats, and important species of the American River.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Though many of the streams in the American Basin are naturally intermittent, maintenance of the natural winter and spring flows in the streams is important for maintaining floodplain processes such as meander belts and stream channel configurations, as well as riparian and wetland habitats. Stream flows also attract salmon and steelhead to the creeks of the basin beginning in fall, and transport young salmon and steelhead downstream in winter and early spring. Adequate streamflows are important for maintaining native rainbow trout/steelhead through the summer in upper Coon Creek, Auburn Ravine, and Dry Creek (tributaries). Some stream flow is also needed to support native resident fishes through the summer-fall irrigation season. The vision for stream flow is where possible natural streamflows will be retained in creeks to support riparian habitat and important species. This may involve reduced diversions or increased inflows either from increased inter-basin diversions or other sources of water (i.e., groundwater or recycled water).

Streamflows shape river channels, support riparian vegetation, and provides habitat for fish and other aquatic organisms. The vision for streamflow in the American River below Nimbus Dam is to more closely emulate the natural flow regime of the river through operating changes in the allocation of the available water supply of reservoirs and reducing demands on water supply in drier years to maximize direct benefits to lower American River anadromous fishery resources. Improvement in spring flows also will provide indirect benefits by supporting naturally occurring seasonal flow patterns in dry and normal years that supports many ecological processes/features essential to the health of anadromous fish populations.

COARSE SEDIMENT SUPPLY: Sediment supply is an important watershed attribute that contributes to stream channel meander and maintenance of riparian systems. Sediment supply and gravel recruitment on the American River is impaired because recruitment from upstream is blocked by Folsom and Nimbus Dams. The vision is to redistribute and/or supplement gravel to provide continual replenishment of gravel for chinook salmon and steelhead spawning habitat. Activities implemented to reach this vision will be consistent with flood control requirements.

STREAM MEANDER: A natural stream-meander process in the American River is no longer possible because of dams, flood-control levees, remnant effects of dredger mining, and altered flow patterns. The vision is to sustain some semblance of a natural stream meander corridor to the extent possible to sustain the diversity of habitats that depend on a natural meander, and to dissipate the energy of the river.

NATURAL FLOODPLAIN PROCESSES: In addition to changes in stream flow, floodplains processes have been altered by floodplain development including flood control levees, reclamation of wetlands for agriculture, gravel mining, and other land uses. The vision is where possible natural floodplain processes will be preserved by allowing winter-spring flows to overflow into riparian and wetland habitats. Natural stream meanders will be encouraged by removing where possible constraints on meander belts such as levees and bank protection in the lower floodplain portions of the creeks. Natural floodplain overflow will help to collect floodwaters and sediment, and help to dissipate the erosive forces of flood waters.

CENTRAL VALLEY WATER TEMPERATURES: Beginning in spring when streamflows in the creeks decline after the rainy season, water temperatures in the creeks increase naturally with the warm Valley air temperatures. The creeks do not cool again until fall. Water diversions, irrigation returns, riparian habitat degradation, and urban runoff alter this natural pattern. Springs, diversions from other watersheds, and higher elevations maintain cool water habitat in the upper watersheds of Coon Creek, Auburn Ravine, and Secret Ravine. The vision is provide cooler spring through fall water temperatures in these watersheds by protecting and enhancing stream flow where possible, enhancing riparian vegetation along creeks, reducing warm water discharges to the creeks, and reducing diversions from the creeks.

High summer and fall water temperatures limit salmon and steelhead production in the American River. The vision is to control water temperatures in the lower American River, to the extent possible, to maintain and contribute to the restoration of chinook salmon and steelhead populations and to avoid high water temperatures which cause mortality or result in other adverse effects to young steelhead (e.g., reduced growth), or delay fall spawning of salmon.

VISIONS FOR HABITATS

SEASONAL WETLANDS: Seasonal wetlands, including vernal pools, are important habitat for many species of fish, wildlife, and waterfowl. The vision is to protect existing areas of seasonal flooding and to maintain or expand sources of water to promote higher quality wetlands especially in drier years. Areas where seasonal flooding develops seasonal wetlands will be expanded. Flooding easements will be obtained from willing landowners to provide seasonal wetlands in flood prone areas such as Natomas Basin and lowlands to the east.

RIPARIAN AND RIVERINE AQUATIC HABITAT: The vision is to fully protect and restore riparian and riverine aquatic habitats to maintain and enhance to support aquatic and terrestrial species, particularly those of primary management concern.

Riparian habitats are important to fish, wildlife including giant garter snake, and waterfowl. The vision is to protect and expand riparian and riverine aquatic habitat, both forest and shrub, along creeks, drainage ditches, irrigation canals, and wetlands. Remnant patches of high-quality riparian habitat will be protected. Areas of disturbed habitat will be restored where possible. Agricultural and grazing practices will be modified in riparian zones to encourage recovery of riparian and SRA habitat along the creeks. Improvements in stream flows will also benefit riparian zones. Riverine aquatic habitat is essential to spawning and rearing salmon and steelhead in the upper basins of Coon Creek, Auburn Ravine, and Secret and Miners Ravines. Stream channel and SRA habitat should be protected and enhanced.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The Lower American River is typical of a fall chinook salmon spawning stream (Moyle and Ellison 1991). The quality of freshwater fish habitat in the Lower American River will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Lower American River has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in the Lower American River include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

PERENNIAL GRASSLANDS: Upland habitats are important for waterfowl, giant garter snakes, and raptors such as the Swainson's hawk. The vision for upland habitats is to protect and expand around the outer edges of wetlands, and to restore grasslands and remnant oak woodland and oak savanna where possible.

AGRICULTURAL LANDS: Agricultural habitats are important to waterfowl and wildlife. The vision is to foster agricultural practices that provide valuable wildlife habitat. Where sufficient water is available, rice lands will be flooded after harvest rather than burned to provide winter waterfowl areas and reduced air pollution. Riparian and upland habitats will be protected and expansion encouraged. Wildlife friendly agricultural practices will be encouraged.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: The vision for water diversions is to: 1) prevent loss of fish at diversion facilities; and 2) prevent the take of water from inhibiting the maintenance and/or restoration of riparian and riverine aquatic habitats. Water diversions from streams and adjacent marshes divert streamflow that is important to habitat and species of the unit. The vision is to reduce water diversions along creeks and floodways where possible to protect fish and enhance riparian and wetland habitats. Greater streamflows especially in drier years will provide for greater amounts of riparian habitat and sustain salmon and steelhead, as well as native resident fishes.

LEVEES, BRIDGES, AND BANK PROTECTION: Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat along the river and adjacent marshes. The vision is to restore riparian vegetation along levees and protected banks. The vision is to selectively remove or setback levees and limit bank protection along streams and marshes to allow natural stream processes and habitat development.

INVASIVE RIPARIAN AND MARSH PLANTS: Invasive plant species can outcompete and displace valuable native species. Invasive plants often have little or no value to native wildlife and are de-stabilizing natural ecosystem functions and processes. The vision is that invasive plants will be controlled to allow native riparian plant species to naturally propagate.

CONTAMINANTS: Toxins continue to enter the river from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of waterfowl, fish, and wildlife. The vision is to reduce the input of toxins entering the streams and wetlands to improve health, survival, and reproduction of many important waterfowl and other wildlife, as well as reduce contaminant effects on fish in the American River, the Sacramento River, and the Bay-Delta.

HARVEST OF FISH AND WILDLIFE: The vision is to reduce or eliminate that illegal harvest of anadromous fish and to assure that legal harvest will not compromise efforts to rebuild fall-run chinook salmon and steelhead populations in the lower American River.

ARTIFICIAL PROPAGATION OF FISH: The vision for the artificial propagation of fish is that Nimbus Hatchery will contribute to the rebuilding of fall-run chinook salmon and steelhead populations without impairing the genetic identity of naturally spawning populations. Also, minimizing the interactions of wild and hatchery fish will contribute to reducing the potential for predation on and competition with the natural spawning populations.

STRANDING: The vision for stranding is to implement remedial measures that will reduce the frequency and extent of stranding losses within the American Basin Ecological Management Zone.

VISIONS FOR SPECIES

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries. Fall-run chinook salmon will benefit from improved flows. Late winter and spring flows will provide attraction for downstream migrating fall-run chinook. Summer and fall base flow improvements will benefit over-summering juvenile steelhead as well as upstream migrating fall-run chinook salmon. Improvements in wetland, riparian, and SRA habitats; stream channel and meander; and gravel recruitment will also improve and fall-run chinook salmon spawning and rearing habitat. Screening unscreened and poorly screened diversions will improve young salmon production. Limiting harvest will help ensure adequate numbers of spawners.

STEELHEAD TROUT: The vision for steelhead trout is to recover this species listed as threatened under the ESA, and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat. Steelhead will benefit from improved peak flow events, especially in dry and normal years. Late winter, early spring flow events will provide attraction for upstream migrating adults and support downstream migrating juveniles. Improved summer-fall base flows are needed to maintain over-summering physical habitat and lower water temperatures. Steelhead will also benefit from improved gravel spawning habitat, and stream rearing habitat, especially if summer river heating is reduced in the process. Screening unscreened and poorly screened diversions will improve young steelhead production. Limiting harvest to hatchery steelhead will help to protect wild steelhead.

STRIPED BASS: The vision for striped bass is to maintain healthy populations, consistent with restoring native species, to their 1960s level of abundance to support a sport fishery in the Bay, Delta, and tributary rivers. Striped bass will benefit from larger late winter, early spring flow events in the lower American River. The higher flow will provide upstream attraction flows and improve transport of eggs from spawning areas in the lower American and Sacramento Rivers.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Improved spring flows should benefit American shad runs in the lower American River. Greater magnitude flow events in spring will provide attraction flows for adults to lower river spawning areas. Higher spring through fall base flows should improve spawning and early rearing, post-spawning adult survival, and juvenile shad survival and downstream migration.

SPLITTAIL: The vision for splittail is to achieve the recovery of this federally listed threatened species. ESA. Improvements in the riparian and stream meander corridors, wetlands, and floodplain overflow basins will improve spawning and early rearing habitat of splittail and other native resident fish species. Improved late winter and early spring flows will provide attraction flows for upstream migrating adult splittail from the Delta, and improve transport of larvae splittail downstream to the lower rivers and Bay-Delta.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Waterfowl will benefit from improved riparian corridors, floodplain overflow basins, and more wetlands.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

LAMPREY: The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the American Basin Ecological Unit will help in the recovery of these species by increasing habitat quality and area.

SWAINSON'S HAWK: The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species to contribute to the overall species richness and diversity. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected in the Delta as a result of improved habitat.

NON-NATIVE WARMWATER GAMEFISH: The vision for non-native warmwater gamefish is to maintain self-sustaining populations, consistent with restoring native species, in order to provide opportunities for consumptive uses such as angling.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

In restoring the stream channel and riparian habitats, close coordination is required with government agencies responsible for the lower American River and American Basin. The City and County of Sacramento, which administers the American River Parkway Plan, and the Secretary for Resources and the Secretary of the Interior, who administer the State and federal Wild and Scenic Rivers Acts, will be essential participants in the restoration program for the lower American River. In addition, the Corps and the Sacramento Area Flood Control Agency are responsible for ensuring the flood control capacity of the river and American Basin is retained, while retaining as much as possible the ecological resources of the river. Both agencies are cooperating to develop plans to improve habitat and flood control on the lower river and American Basin.

The following list includes the most active programs in the American Basin Ecological Management Zone that can contribute to restoring ecological health to the basin. Attaining the visions described above for the American River will require cooperative and coordinated efforts on the part of stakeholders and agencies with management interests in the river.

Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture is a component of the North American Waterfowl Management Plan of the USFWS with funding and cooperative projects of the federal, State, and private agencies. New sources of funding including CALFED restoration funds are being sought to implement the Joint Venture. The Joint Venture has adopted an implementation plan that includes the American Basin. Objectives include protection of wetlands through acquisition of fee-title or conservation easements, enhancement of waterfowl habitat in wetlands and agricultural lands. The objectives and targets of the Joint Venture have been adopted by the ERPP.

Sacramento Water Forum

The Water Forum is a diverse group of business and agricultural leaders, environmentalists, citizen groups, water managers, and local governments. Together, the participants in the Water Forum have agreed upon two co-equal objectives for the lower American River to address future water shortages, environmental degradation, contamination, threats to groundwater reliability, limits to economic prosperity, and competition for American River water. The dual Water Forum objectives are to: 1) provide a reliable and safe water supply for the region's economic health and planned development through to the year 2030; and 2) preserve the fishery, wildlife, recreational, and aesthetic values of the lower American River.

Important elements sponsored by the Water Forum that will contribute to improving ecological health of the lower American River include an improved pattern of fishery flow releases from Folsom Reservoir and habitat mitigation. The flow pattern being developed will be 'fish friendly' and would significantly benefit fall-run chinook by improving river flows and temperatures at critical times. Changes in the operations of the water release shutters at the power penstocks of Folsom Dam is anticipated to improve water temperatures in the lower American River in summer and fall. In addition, the Water Forum, in partnership with other management agencies on the lower American River, is proposing a series of fishery studies and pilot projects to determine what additional operations, modifications, and mitigation projects should be implemented to help restore lower American River chinook salmon and steelhead populations.

American River Operations Group

The American River Operations Group is composed of representatives of fishery agencies, water agencies, local governments, and stakeholders. The Ops Group meets regularly to identify and recommend actions involving water operations on the American River that will optimize conditions for steelhead and chinook salmon.

Sacramento Area Flood Control Agency (SAFCA)

SAFCA with other resource agencies and private entities is developing a Floodway Management Plan (FMP) for the lower American River. A Lower American River Task Force has been working toward developing a FMP that provides protection to resources in the floodway. Their focus is on protection and restoration of riparian habitat in the floodplain of the lower American River. SAFCA is also active in protecting and restoring habitat in the Natomas Basin of the American Basin Ecological Management Unit. Planning efforts are being conducted to improve flood protection for the Natomas Basin. SAFCA has developed a Natomas Area Flood Control Improvement Project that provides additional levee protection and surface transport of floodwaters, and also addresses special status plant and animal species, vernal pool and wetland habitats, and upland and riparian habitats.

SAFCA has funded extensive work on designing environmental features into bank protection projects. SAFCA and the U.S. Army Corps of Engineers continue to develop habitat conservation/mitigation/enhancement elements to be incorporated into the levee improvement and bank protection program for the Lower American River. These elements include design and construction of multi-stage bench areas at specific water surface elevations in order to provide littoral rearing habitat for salmonids, as well as increasing the habitat complexity and diversity in portions of the Lower American River.

Natomas Basin Habitat Conservation Plan (HCP)

A habitat conservation plan was developed in 1996 to provide a practical program to promote biological conservation along with economic development and continuation of agriculture in the Natomas Basin, the south-west subunit of the American Basin Ecological Management Unit. The program outlined in the Plan establishes a multi-species, multi-habitat conservation program to mitigate the expected loss of habitat values and incidental take of protected species that would result from urban development, operation of irrigation and drainage systems, and agricultural activities in the Natomas Basin. Funds are obtained from developers to purchase habitat reserves and conduct studies. The HCP establishes a Natomas Basin Conservancy to cover activities associated with managing reserves, populations status surveys, and general scientific research. The HCP covers wetlands, riparian, and upland habitats and associated plant and animal species, and does not cover aquatic habitat or fish species.

Coordinated Resource Management and Planning (CRMP)

CRMP programs are being established at least for the Auburn Ravine Creek watershed. Coordinated land management and planning activities are being undertaken between agencies and private entities and MOU's developed to focus on water quality, fisheries improvement, and fire safe communities in order to promote public safety, watershed stability, and high quality waters in Auburn Ravine through cooperation, information development, and education. The CRMP deals with erosion and sedimentation, habitat quality, habitat loss and depletion of biodiversity, rural homes and fire hazards, and the need to maintain overall stability of the watershed. Watershed quality is to be improved through forest fuels management, preventing discharge of pollutants, sustaining fish and their habitats, and creating and sustaining diverse habitat and wildlife diversity. The role of the creek for conveying irrigation water and as a flood channel are also to be protected.

CALFED Bay-Delta Program

CALFED has funded two ecosystem restoration projects in the American River Basin. One project developed a watershed plan for the American

River. Another Restoration project planned watershed restoration actions on the Middle and North Forks of the American River, Auburn Ravine Creek, and Coon Creek.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The CVPIA added 'mitigation, protection and restoration of fish and wildlife' as a purpose of the Central Valley Project and required the implementation of a program that makes all reasonable efforts to increase the natural production of anadromous fish in Central Valley rivers and streams to not less that twice the average levels present from 1967-1991.

The U.S. Fish and Wildlife Service and the Bureau of Reclamation are implementing the CVPIA which provides for restoration of habitats and species and minimization of stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1995) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment on the lower American River, water acquisition, and other measures that will contribute to restoring the health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

Activities with direct application to the American Basin include a program to restore small tributaries to the Sacramento River. Local entities such as Resource Conservation Districts are being funded to identify problems, develop solutions, and implement actions to address small-scale restoration projects on tributary streams. CVPIA's Comprehensive Assessment and Monitoring Program (CAMP) is funding efforts to provide information on the anadromous fish runs in tributary streams. Funding is also being provided for regional conservation planning of watersheds in the basin that support salmon and steelhead. Funding is also available for evaluating the potential contribution of intermittent tributary streams like those in the American Basin as spawning and rearing habitat for chinook salmon. Funding is also available to reduce fish passage and screening problems.

A Water Management Plan is being developed to guide water supply development for anadromous fish under CVPIA's 3406(b)(2) and (b)(3) projects. Dedicated CVP water and supplemental water purchased from willing sellers will be used to enhance flows for anadromous fish. Such water supply can be used to enhance salmon and steelhead populations in American Basin streams and in the lower American River.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The Department's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and to assist in obtaining funding for feasibility studies, environmental permitting, and project construction. Reaching the goals and targets developed to restore ecosystem functions of the American River Basin and the associated biotic community will require close coordination among State, federal, and local agencies, with participation by water developers and stakeholders.

PLANNING BY CITIES AND COUNTIES

The cities of Roseville, Auburn, Lincoln, Rocklin, and Sacramento, and the counties of Sutter, Sacramento, and Placer are all involved in planning activities that related to ecological resources and restoration in the American Basin Ecological Management Zone. Activities include a Roseville Regional Wastewater Treatment

Service Area Master Plan that involves collection, treatment, and disposal of waste water, water quality, and public health. Cities and Counties of the Basin are pressed with the need to conserve biological resources, habitats, and ecosystem quality, while addressing large scale growth and land use changes in the cities and counties that may affect the flood capacity, water quality, and general environmental health of the watersheds.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Many of the habitats, processes, and stressors found within this Ecological Management Zone are similar to those found in the Feather/Sutter, Cosumnes, Delta, Yolo Basin, and Colusa Basin Ecological Management Zones. Efforts within one Ecological Management Zone should be similar to those in adjacent zones providing connectivity where needed and cumulative benefits to the system.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: Develop and implement an ecologically based streamflow regulation plan for the American Basin creeks and lower American River. The lower American River should meet the recommended minimum flows and flow targets for the lower American River (presented in Tables 7 and 8). Lower American River flow events should be coordinated with similar flows that occur naturally in the Sacramento Valley and with storage releases from Shasta and Oroville Reservoirs (◆◆◆).

PROGRAMMATIC ACTION 1A: Provide target flows by modifying CVP operations and acquiring water as needed from willing sellers, with consideration given to reservoir available carryover storage and flows needed to meet needs determined by the water temperature objective discussed under Target 3 below.

PROGRAMMATIC ACTION 1B: Develop and implement a comprehensive watershed management plan for the American Basin and lower American River to protect the channel (e.g., maintain flood control capacity and reduce bank erosion) and preserve and restore the riparian corridor. Upper watershed health should be improved by reducing the potential for wildfire and implementing other watershed improvement practices to protect streamflows, stream channel morphologies, spawning gravel condition, and riparian habitats, and minimize sediment input to the stream.

PROGRAMMATIC ACTION 1C: Acquire water from willing sellers to augment river flow during dry years to provide fishery benefits.

TARGET 2: Minimize flow fluctuations below Nimbus Dam that can dewater salmonid redds and reduce survival of juvenile anadromous fishes due to stranding and/or isolation from the main channel. (◆◆◆).

PROGRAMMATIC ACTION 2A: Complete ongoing collaborative efforts to develop flow ramping criteria and operationally implement these criteria to reduce adverse affect of flow fluctuations on lower American River fishery resources.

PROGRAMMATIC ACTION 2B: To minimize dewatering of salmon and steelhead redds, flows exceeding 2,500 cfs after the onset of chinook salmon spawning should be maintained at least at this level until April 30.

TARGET 3: Provide flows of suitable quality water that more closely emulate natural annual

Table 7. Average Monthly Minimum Flow Targets (cfs) on the American River.

Month	Water-Year Type			Critical Relaxation
	Wet	Above and Below Normal	Dry and Critical	
October	2,500	2,000	1,750	800
November-February	2,500	2,500	1,750	1,200
March-May	4,500	3,000	2,000	1,500
June	4,500	3,000	2,000	500
July	2,500	2,500	1,500	500
August	2,500	2,000	1,000	500
September	2,500	1,500	500	500

Table 8. Average Flow Targets for 10-Day Pulse (cfs) on the American River, Coordinated with Flows from Shasta and Oroville Reservoirs.

Month	Water-Year Type			Exceptions
	Wet	Above and Below Normal	Dry	
March	6,000-7,000	4,000-5,000	3,000-3,500	Only when inflows are sufficient
Late April or early May	7,000-8,000	5,000-6,000	3,500-4,000	Only when inflows are sufficient

and seasonal streamflow patterns in American Basin watersheds (◆◆).

PROGRAMMATIC ACTION 3A: Enter into agreements with water districts and wetland managers to provide return flows of high quality water from irrigated agriculture and seasonal wetlands to the American Basin.

PROGRAMMATIC ACTION 3B: Enter into agreements with landowners and water districts to limit diversions of natural flows from creeks to improve stream flows.

PROGRAMMATIC ACTION 3C: Limit diversion of natural stream flows from American Basin creeks into irrigation canals and ditches by providing other sources of water or through purchase of water rights from willing sellers.

RATIONALE: *Natural streamflow patterns are important in maintaining geomorphology of watersheds, as well as riparian and floodplain vegetation along stream banks. Streamflow is also essential for the well being of valley wetlands and for upstream passage of adult anadromous fish, spawning, successful rearing, and downstream migration of juveniles. In addition, streamflows influences stream channel* *morphology, riparian communities, and fish habitat. Base flows and flow events will be provided by releasing water from Folsom Reservoir, reducing diversions from the American River. Flood-control releases from Folsom Reservoir that occur during winter and spring months are beneficial in sustaining gravel recruitment, transport and cleaning processes. Late non-flood control releases during the winter and/or early-spring period flow will be maintained at levels events of sufficient magnitude to attract and sustain adult steelhead and American shad spawning runs. Moreover, spring and early summer flows will be maintained at levels that provide sufficient physical space for improve transport of juvenile salmon, steelhead, and shad rearing as well as favorable downstream migration conditions. Both high-level flood-control releases and lower base-flow releases from reservoir storage during winter and spring will be managed within the operational constraints of the reservoir to sustain riparian habitats and sustain gravel recruitment, transport, and cleansing processes. Sufficient minimum*

flows are necessary to maintain adequate conditions for adult holding, spawning, egg incubation, and juvenile rearing and migration, especially because these functions must now occur below Nimbus Dam. The target minimum flows (Table 8) are consistent with historic and unimpaired flows for the American River in dry and normal years that, in some years, may not occur under the present level of project development and operation.

Opportunity to succeed in providing optimum, rather than minimum, flows will rely on collaborative efforts that include stakeholder groups such as the American River Water Forum, State and federal agencies, and local governments. Developing a long-term water management plan for the American River will meet a diversity of needs, including providing streamflows needed to maintain ecological processes and functions; maintaining habitats; and supporting restoration of chinook salmon, steelhead, and other anadromous and resident fish populations below Nimbus Dam. This plan may involve options presently being considered by the American River Water Forum, including diverting water from near the mouth of the river or at the Fairbairn Water Treatment Plant, rather than from Nimbus Dam, or Fairbairn Water Treatment Plant to meet the needs of water users. Opportunities for adjusting seasonal streamflow and carryover storage patterns to benefit fish and lower American River habitats, while maintaining other beneficial uses, will be explored. These opportunities may include acquiring water rights from willing sellers or developing supplemental supplies (e.g., conjunctive use and/or recycled water programs).

The target level of the flow events must be implemented conservatively because of the potential impact on water supply. If a flow event equal to or greater than the target flow has not taken place during uncontrolled releases from Folsom Dam by March, then supplementing base flows or augmenting small, natural flow events or reservoir spills with additional reservoir releases is the only means to provide the necessary flows. Such releases would be allowed only if an equivalent or greater inflow to Folsom Lake occurs. Flow fluctuations within the range of 1,000 to 4,000 cfs can desiccate redds and fluctuations within the range of 3,000 to 10,000 cfs can strand juvenile salmon and steelhead in pools that become isolated from the main channel. Flow reduction criteria (ramping rates) need to be implemented to minimize this problem.

March through May is the logical period during which to provide such flow events because this is the period when natural flow events occurred historically in dry and normal years, and because opportunities for such flow to occur naturally as a function of normal project operation would have passed. Forecasts regarding the water-year type (dry or normal) would also be available by February or March and will be used as the basis for decisions that balance fishery flows with water-supply needs.

The March flow event would be expected to travel unimpaired to the Delta because few if any diversions from the American and Sacramento Rivers occur during March. (Note that additional flow events are prescribed for the Feather and Sacramento Rivers in March, which will further enhance Sacramento River flows below the confluence with the American River.) A March flow event would also help satisfy Delta outflow requirements. Further, the prescribed flow event in late April and early May would add to flow events prescribed from the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers to the south, which together will also satisfy Delta outflow requirements.

These prescribed flows cannot usurp individual water rights established subject to California law. ERPP does not include any adjudication or involuntary reallocation of water rights.

Managing for appropriate seasonal flow regimes in the lower American River and American Basin creeks will restore and sustain anadromous and resident fish populations, help promote natural channel formation processes, establish and maintain riparian vegetation, and will sustain numerous foodweb functions. Minimum flows also attract adult steelhead and fall-run chinook salmon during fall and winter.

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain, improve, or supplement gravel recruitment and natural sediment transport in the lower American River and American Basin watersheds to maintain natural ecological processes linked to stream channel maintenance, erosion and deposition, maintenance of fish spawning areas, and the regeneration of riparian vegetation (◆◆).

PROGRAMMATIC ACTION 1A: Monitor spawning gravel conditions in the lower American River and American Basin watersheds, and identify specific sites where mechanical cleaning or gravel introductions would be beneficial to enhance or increase gravel spawning habitat.

PROGRAMMATIC ACTION 1B: Implement a pilot study to assess the benefits of mechanical cleaning to improve gravel permeability.

PROGRAMMATIC ACTION 1C: Develop a collaborative program to investigate erosion, bedload movement, sediment transport, and depositional processes and their relationship to the formation of point bars and riparian regeneration in the lower American River and American Basin watersheds.

RATIONALE: *Gravel is an essential element of spawning and rearing habitats for salmon, steelhead trout, and other native fishes. Gravel supplies are not thought to currently limited salmonid production in the lower American River but may become limiting in the near future, especially in the area immediately below Nimbus Dam. Some gravel is provided naturally when the river cuts into dredger tailings during high flows; however, this input is not sufficient to maintain high-quality spawning habitat for the target levels of naturally produced fall-run chinook salmon and steelhead. Gravel recruitment can be supplemented by providing additional gravel for the river to capture under its controlled flow regime.*

The Lower American River Technical Team reported that the availability of spawning habitat does not appear to be an immediate problem as there are adequate amounts of appropriately sized gravel in the river; and there is a large amount of gravel along the banks and in the bars of the lower American River that provide sources for gravel recruitment.

Simply adding gravel to the stream channel may not improve spawning conditions because an impermeable clay lens under the deposited gravel could limit upward percolation and , therefore, fish use for spawning., and other site-specific habitat characteristics. Hence, the specific river *location were gravel deposition occurs will largely dictate the benefits to fishery resources of deposition gravel.*

Natural sediment supply from the watershed above Folsom Dam has been eliminated. The long-term adverse effects of this have not been adequately investigated. Lack of sediment recruitment from the upper watersheds, ranging from fine sands to cobbles, may adversely influence the structural characteristics of the stream channel, impair riparian and riverine aquatic habitats, and reduce habitat complexity required by anadromous and resident fish species. Investigations into these issues will provide additional insight into finer resolution of long-term opportunities to improve the ecological health of the American River.

The sediment regimes of American Basin creeks have not been investigated. However, because these streams do not have dams on them, natural sediment supplies are probably available. The condition of the watershed and spawning habitats in the upper watersheds of Coon Creek, Auburn Ravine, and Dry Creek should be investigated.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Maintain the existing stream meander configuration along the American River between Nimbus Dam and the Sacramento River (◆).

PROGRAMMATIC ACTION 1A: Maintain a stream meander configuration along the lower American River by working with involved parties to develop a floodplain management program consistent with flood control needs. These parties include the Corps, the California Reclamation Board, the Sacramento Area Flood Control Agency, the Lower American River Task Force, and the American River Water Forum.

PROGRAMMATIC ACTION 1B: Where possible, maintain mainstem and side channel habitats typical of a natural river that provide salmon and steelhead spawning and rearing habitat.

TARGET 2: Restore natural stream meanders in the floodplains of American Basin creeks (◆).

PROGRAMMATIC ACTION 2A: Where possible within flood control constraints, restore natural meander belts along the lower creeks through setback of levees or removal of bank protection, or other physical structures impeding a natural meander process.

TARGET 3: Maintain and enhance floodplain overflow areas in the lower American River and floodplain of the American Basin (◆◆).

PROGRAMMATIC ACTION 3A: Setback levees in the floodplains of creeks and canals of the American Basin.

PROGRAMMATIC ACTION 3B: Protect existing overflow areas from future reclamation.

PROGRAMMATIC ACTION 3C: Develop floodway detention basins in the floodplains of the American Basin to temporarily store floodwaters.

PROGRAMMATIC ACTION 3D: Enter into agreements with willing landowners and irrigation districts to set back levees and allow floodplain processes such as stream meander belts.

PROGRAMMATIC ACTION 3E: Expand existing floodplain overflow basins by obtaining easements of titles from willing sellers of floodplain lands.

PROGRAMMATIC ACTION 3F: Reduce or eliminate gravel mining from active stream channels.

RATIONALE: *Natural river floodplain processes permit natural stream-channel development that supports for riparian vegetation and provides spawning and rearing habitat for chinook salmon* *and steelhead. Natural stream processes in alluvial systems transport and deposit sediments; provide transient habitats important to algae, aquatic invertebrates, and fish; and provide surfaces colonized by natural vegetation that support wildlife. Overbank flooding is an important regenerative process needed to maintain riparian forests and woodlands. In addition, much of the nutrient input is derived from infrequent overbank flooding of the riparian/floodplain zone. Opportunities to restore floodplains and flood processes along the lower American River are constrained by the flood control requirements provided by Folsom Dam and the levee system throughout in the lower river reach. Adaptive management including focused research and monitoring will be important elements to guide the level to which floodplain processes can be maintained and restored in the lower American River. These processes are closely linked to maintaining and restoring the riparian corridor which supports a variety of aquatic and terrestrial species.*

Remnant effects of devastating dredger mining along the American River also hinder natural stream-channel processes. Because of these constraints, artificial means are necessary to maintain natural stream-channel processes that will provide the habitats needed by salmon and steelhead normally created by these processes.

In the American Basin project levees channel flows in lower creeks into the NCC and NEMDC, which carry floodwaters to the Sacramento River. Levees along the lower creeks typically fail to hold back water as water backs up at the Sacramento River. Widening the floodplain and setting back levees along the NCC, NEMDC, and lower creeks provides more flood carrying capacity and a more natural floodplain process that would promote riparian and wetland habitat development.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain lower American River water temperatures in the spawning and rearing reach between Arden Bar and Nimbus Dam at or below 60°F beginning as early in October as possible, based on annual coldwater pool availability and maintain water temperatures in the upper portion of the reach between Nimbus Dam and Sunrise Bridge below 65°F from spring through fall (◆◆◆).

PROGRAMMATIC ACTION 1A: Optimally manage Folsom Reservoir's coldwater pool via real-time operation of the water-release shutters to provide the maximum equitable thermal benefits to lower American River steelhead and chinook salmon throughout the year, within the constraints of reservoir coldwater pool availability.

PROGRAMMATIC ACTION 1B: Reconfigure Folsom Dam shutters to improve management of Folsom Reservoir's coldwater pool and maintain better control over the temperature of water released downstream.

PROGRAMMATIC ACTION 1C: Install a temperature control device on the municipal water intakes at Folsom Dam.

PROGRAMMATIC ACTION 1D: Investigate opportunities to improve the manner in which the water-release shutters at Folsom Dam are physically installed, removed, and maintained annually, as well as opportunities to improve their efficiency in releasing water from desired elevations.

PROGRAMMATIC ACTION 1E: Evaluate the potential for creating side-channels thermal refuges for juvenile steelhead rearing over-summer in the lower American River. Such habitat could provide habitat slightly cooler than peak daytime river temperatures.

PROGRAMMATIC ACTION 1F: Evaluate options to reduce releases of warmer surface waters of Lake Natomas through the turbines at Nimbus Dam into the lower American River. Options may include a temperature curtain in the lake near the turbine intakes. Operations of Nimbus Dam during occasional spill events should also be evaluated to minimize the release of warm surface waters from Lake Natomas.

PROGRAMMATIC ACTION 1H: Provide a more direct supply of colder water to Nimbus Hatchery.

TARGET 2: Maintain a daily average water temperature below 65°F from June 1 through September 30 in the lower American River between Nimbus Dam and Watt Avenue and in the upper portions of Coon Creek, Doty Creek, Auburn Ravine, Miners Ravine, and Secret Ravine in the American Basin (◆◆).

PROGRAMMATIC ACTION 2A: Evaluate means of maintaining cool water temperatures as necessary in upper watersheds of Coon Creek, Auburn Ravine, and Dry Creek, including such measures as pumping ground water, enhancing riparian vegetation, reducing drainage inputs of warm water from agriculture and urban runoff, and supplementing creek flows with diversions of waters from the Bear and American River Basins.

RATIONALE: *SAFCA used an iterative modeling approach to develop a monthly target release temperature regime on the Lower American River (as part of the DEIR/EIS for P.L. 101-514 CVP Water Supply Contracts). This effort developed a monthly target release temperature regime that mitigated project-related potential water temperature impacts of steelhead and also reduces average annual early life stage mortality for chinook salmon. Modeling analyses revealed that managing Folsom Reservoir's coldwater pool in this alternative manner would: (1) provide water temperatures during the July through September period that would be lower than those realized under the Base Case condition, thereby providing more favorable conditions for over-summering juvenile steelhead; and (2) reduce average annual early life stage losses of chinook salmon caused by elevated Lower American River water temperature during September, October, and November.*

Improved operation of the water-release shutters configuration at Folsom Dam can reduce the temperature of water released into the lower American River. Improved temperatures of water released from Folsom Dam and improved channel habitats are needed to provide adequate over-summer rearing habitat for juvenile steelhead. Releases from Folsom Reservoir's coldwater pool are also required to provide adequate spawning temperatures for fall-run chinook salmon in October and November. However, the low end-of-year storage levels allowed in Folsom Reservoir currently for flood-control purposes will make temperature control for salmon spawning difficult in late summer and early fall of most water-years.

While managing the cold-water pool in Folsom Lake is a priority for maintaining cool water temperatures in the lower American River, lessor but significant benefits can also attained by managing releases from Nimbus Dam. Surface waters (top several feet) of Lake Natomas can heat up to 5 to 10°F from late spring through early fall. Water released into the lower American could be 1 to 2°F lower if warmer surface waters were not included in releases. Because summer temperatures often reach near or above 65°F, 1 to 2°F additional heating is significant. On rare occasions when water from Lake Natomas spills from the spillways rather than coming from the turbines, an even greater proportion of warmer surface waters from the lake can be released to the river.

Installing a temperature control device at the municipal water supply intake, which is the lowest outlet at Folsom Dam, would allow water from higher elevations of the reservoir to be diverted for municipal purposes, which would preserve the reservoir's cold water pool for releases to the lower American River. The device, which is *estimate to cost about $3 million, was authorized by Congress in 1998, but funding was not appropriated.*

The Nimbus Hatchery water supply does not provide sufficiently cool water at times during the summer months, and this creates disease problems for steelhead in the hatchery. On occasion, water temperatures are so high that all fish must be removed from the hatchery and transported to nearby hatcheries for rearing. Hatchery temperature requirements can also conflict with Folsom Reservoir cold water pool management for in-river salmonids. When cool water is released for the hatchery, it requires that the entire amount being released to the river be at the desired hatchery temperature even though the hatchery uses a very small portion of the flow. This can exhaust the cold water pool before the end of the summer.

The upper watersheds of the American Basin have historically provided sufficiently cool water to sustain naturally produced rainbow trout/steelhead through the summers. Protecting and enhancing remaining cool water habitat is an essential element of restoring steelhead to these watersheds.

To some degree, high water temperatures in summer and fall in the lower American River are natural; in part, they are a consequence of impaired stream-channel configurations that do not provide shaded side channels with cool groundwater flows. Coldwater releases from the dams and improved channel habitats are needed to provide adequate over-summer rearing habitat for juvenile steelhead.

HABITATS

SEASONAL WETLAND HABITAT

TARGET 1: Protect and enhance 5,150 acres of seasonal wetland habitat acreage in the American Basin consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Protect 2,000 acres of existing wetland habitat through fee acquisition and perpetual conservation easements.

PROGRAMMATIC ACTION 1B: Enhance 3,150 acres of existing wetlands.

RATIONALE: *Seasonal wetlands habitats include rice fields and vernal pools, both of which are prevalent in the American Basin. Seasonal wetland habitats provide unique micro habitat conditions that are utilized by fish for spawning and rearing, provide nesting and feeding habitat for waterfowl and wading birds, and provide otters and other mammals with suitable mating, feeding, and rearing habitats. Wetland/slough habitats increase the overall complexity of the aquatic environment, thereby supporting more diverse foodwebs and more diverse fish and wildlife communities. Expansion of seasonal wetlands is important in the Central Valley and American Basin, because much of such habitat has been lost to land reclamation for agriculture and urban development.*

RIPARIAN AND RIVERINE AQUATIC HABITAT

TARGET 1: Establish and/or maintain a sustainable continuous, sustainable corridor of riparian habitat along the lower American River and American Basin creeks (◆◆).

PROGRAMMATIC ACTION 1A: Develop riparian corridor restoration and management plans for the American Basin and lower American River.

PROGRAMMATIC ACTION 1B: Protect riparian habitat along water courses of the American Basin.

PROGRAMMATIC ACTION 1C: Plant riparian vegetation along water courses of the American

Basin.

PROGRAMMATIC ACTION 1D: Reduce land use practices such as livestock grazing and watering along stream channels of the American Basin that cause degradation of riparian habitat.

TARGET 2: Enhance shaded riverine aquatic habitat in American Basin creeks and drainage canals and ditches and along the lower American River (◆◆◆).

PROGRAMMATIC ACTION 2A: Terminate or modify current programs that remove woody debris from the river and creek channels.

PROGRAMMATIC ACTION 2B: Restore side-channels along the lower American River to provide additional riparian corridors for increasing fish and wildlife habitat.

PROGRAMMATIC ACTION 2C: Improve levee management practices to protect and enhance riparian and SRA habitat.

RATIONALE: *Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley, are dependent on or closely associated with riparian habitats. These habitats support a greater diversity of wildlife species than all other habitat types in California. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. In addition, loss of this habitat has reduced water storage and has altered nutrient cycling, and foodweb support functions.*

Controlled flows, lack of gravel recruitment, stream-channel confinement by the flood control system, and remnant dredger tailings limit the possible extent of a natural riparian corridor along the lower American River. Constructing and maintaining restored riparian habitats would improve the habitat needed by fish and wildlife dependent upon the river ecosystem.

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for American River Basin Ecological Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of streams in this zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

PERENNIAL GRASSLANDS

TARGET 1: Restore perennial grasses in the American Basin Ecological Management Unit associated with existing or proposed wetlands (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore perennial grasslands by acquiring conservation easements or purchasing land from willing sellers.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this Ecological Management Zone. Eliminating fragmentation and restoring connectivity will enhance habitat conditions for special-status species.*

AGRICULTURAL LANDS

TARGET 1: Restore and maintain migration corridors (◆).

PROGRAMMATIC ACTION 1A: Purchase land or conservation easements from willing sellers on which to restore wildlife habitat to connect existing grassland or agricultural wildlife habitat.

RATIONALE: *Corridors of habitat are necessary between larger habitat areas to ensure potential recovery of giant garter snake and other wildlife.*

TARGET 2: Enhance 20,948 acres of private agricultural land to better support nesting and wintering waterfowl consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Develop cooperative programs with farmers to conduct wildlife friendly practices.

RATIONALE: *Waterfowl and wildlife using wetlands and aquatic habitats depend on adjoining agricultural lands for foraging and cover.*

STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce losses of juvenile salmon and steelhead in the lower American River and American Basin creeks due to entrainment at water intakes structures (◆◆◆).

PROGRAMMATIC ACTION 1A: Upgrade the fish screens at the Fairbairn Water Treatment Plant to comply with DFG and NMFS fish screening criteria.

PROGRAMMATIC ACTION 1B: Screen diversions from the NCC, NEMDC, Dry Creek, Coon Creek, and Auburn Ravine that operate during times when salmon and steelhead juveniles would be present.

RATIONALE: *Diversion, storage, and release of water directly affect fish, aquatic organisms, and nutrient levels in the system and indirectly affect habitat, foodweb productivity, and the abundance and distribution of species. Diversions cause consumptive loss of water, nutrients, sediment, and organisms juvenile anadromous fishes of management concern. Hence, reducing such losses will contribute to increasing anadromous fish populations of the Central Valley.*

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Reduce the adverse affect of levees and bank protection on aquatic and terrestrial species and their habitats along the lower American River and American Basin canals and creeks (◆◆).

PROGRAMMATIC ACTION 1A: Identify locations in the lower American River and American Basin creeks and canals where existing revetments could be modified to incorporate habitat features such as scalloped embayments and associated hard points, multi-stage bench areas, SRA habitat, and other features to aid in preservation and/or reestablishment of both berm and bank vegetation.

RATIONALE: *Riprap reduces the ability of vegetation to colonize river banks and, thereby reduces shading of river waters, decreases insect production and availability to fishes, reduces habitat complexity and diversity, and reduces instream cover.*

INVASIVE RIPARIAN AND MARSH PLANT SPECIES

TARGET 1: Reduce populations of invasive non-native plant species that compete with the establishment and succession of native riparian vegetation along the American River. This will help to reestablish native riparian vegetation in floodplains, increase SRA cover for fish, and increase habitat values for riparian-associated wildlife (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to monitor the distribution and abundance of non-native plants and develop cooperative control programs as needed.

RATIONALE: *Non-native plant species, such as false bamboo, salt cedar, eucalyptus, water hyacinth, and pepperweed, can undermine riparian habitat value to fish and wildlife, as well as the natural plant succession that contributes to the physical character of the riparian corridors. Arundo has become established in the American River floodway and can seriously alter ecological processes by inducing greater deposition of sediments, increasing evapotranspiration, and altering soil chemistry. Arundo has little value for native species of wildlife and outcompetes native riparian plant species.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies for Central Valley chinook salmon and steelhead populations that allow populations of naturally spawned fish to attain levels that fully use existing and restored habitat (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest of chinook salmon and steelhead by increasing enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans for chinook salmon and steelhead with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet target escapement and production goals for the lower American River and American Basin creeks.

PROGRAMMATIC ACTION 1C: Evaluate the efficacy of a marking and selective harvest program for lower American River chinook salmon.

RATIONALE: *Restoring and maintaining populations of chinook salmon and, steelhead, and American shad to levels that make full use of habitat may require restrictions on harvest during and after the recovery period. Involving the various stakeholder organizations in the planning process should help to ensure a balanced and fair allocation of harvest. Target population levels may require that levels of harvest of naturally produced fish be reduced. For populations supplemented with hatchery-produced fish, selective harvesting may be necessary to limit the harvest of wild fish while harvesting hatchery-produced fish at a level that will reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Evaluate hatchery production and stocking practices at the Nimbus and Feather River Hatcheries that affect American Basin creeks and the lower American River to reduce the proportion of returning, hatchery-origin chinook salmon and steelhead that stray into non-natal streams (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in American Basin creeks and in the lower American River.

TARGET 2: Limit hatchery stocking if populations of salmon or steelhead can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment populations of fall-run chinook salmon and steelhead only when alternative measures are insufficient to permit natural recovery of the populations.

TARGET 3: Minimize further threats of hatchery-reared fish contaminating wild stocks of chinook salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting spawning adults for the hatchery production from an appropriate cross section of the returning adult population available to the hatchery.

PROGRAMMATIC ACTION 3B: Develop a collaborative program to coded-wire tag a representative proportion of all fall-run chinook salmon produced at the Nimbus Hatchery fall-run chinook salmon.

PROGRAMMATIC ACTION 3C: Investigate replacing the Nimbus steelhead broodstock with the most genetically appropriate steelhead stock. This could be a native residualized rainbow trout isolated above Folsom Dam (if one exists) or another putative native steelhead stock from within the Central Valley.

RATIONALE: *In watersheds such as American Basin creeks and the American River where dams and habitat degradation, as well as extreme natural conditions have limited natural spawning, hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a naturally spawning population during droughts. Hatchery augmentation, however, should be limited to avoid inhibiting recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery-reared fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetic integrity of wild stocks has occurred, additional protective measures are necessary to minimize further genetic degradation and recovery of wild stocks. Because of the extent of development on the American River, stocking of chinook salmon and steelhead may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries. Stocking salmon and steelhead may also be necessary on American Basin creeks to build runs to self-sustaining levels and to maintain the runs through adverse conditions such as may occur during droughts.*

Nimbus Hatchery steelhead and naturally spawning fish in the American River exhibit genetic affinity to populations from the Eel River (NMFS 1997), reflecting the origin of this broodstock (McEwan and Nelson 1991). This stock has also been introduced to the Mokelumne River via the Mokelumne River Fish Installation. The feasibility and desirability of phasing-out the Nimbus strain in favor of a stock more genetically similar to the native Central Valley stock should be investigated. The Central Valley Steelhead Comprehensive Genetic Evaluation should be able to identify the most genetically appropriate stock to culture at Nimbus Hatchery, if one exists.

Traditional hatchery stocking programs are detrimental to the recovery of native stocks due to genetic dilution, straying diseases, increased angling pressure, and direct competition. Changes made to traditional hatchery procedures can result in hatcheries becoming a tool to rebuild native stocks rather than one that degrades them. Decreasing the number of hatchery propagated fish in the Lower American River may increase the opportunity for native stock recovery. However, clear restoration goals for the Lower American River must be developed before the efficacy of such an action can be addressed.

Potential changes at the Nimbus Fish Hatchery that could benefit the river's native stock include: (1) use of all available broodstock, including grilse, to increase genetic diversity of propagated fish. The practice of discarding broodstock under some arbitrary minimum length simple reduced the genetic diversity of hatchery propagated fish, and thus should be discontinued; (2) The emphasis must be placed on quality, not necessarily the quantity of hatchery production. This potentially means improving water quality and reducing densities of fish to create conditions *less likely to be conducive to development and proliferation of disease; (3) Nimbus Fish Hatchery should consider treating their effluent waters to further guard against the introduction of new diseases which may impact native stocks. As recommended in the Steelhead Restoration Plan for the lower American River, the Nimbus Fish Hatchery should continue to improve and implement management practices by taking early migrant and late migrant fish for spawning, and randomly selecting egg lots that are to be raised to yearling size.*

Annual hatchery operations and release strategies presently include trucking chinook salmon smolts to release sites in the western Delta. This practice was implemented due to the high loss of juvenile salmon released in the American River as they migrated down the Sacramento River and through the Delta. A long-term goal is to reduce the need to truck chinook salmon by increasing their inland survival. This will accomplished by restoration actions proposed for the American River, Sacramento River, and Sacramento-San Joaquin Delta Ecological Management Zones, and by developing and constructing alternative water conveyance facilities in the Delta.

CONTAMINANTS

TARGET 1: Reduce the application of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife on agricultural lands that have the greatest risk to fish and wildlife populations (◆).

PROGRAMMATIC ACTION 1A: Enter into conservation easements with willing landowners to modify agricultural practices in ways to reduce loads and concentrations of contaminants.

PROGRAMMATIC ACTION 1B: Provide incentives to landowners to modify agricultural or other land use practices that contribute to the input of contaminants into waterways.

RATIONALE: *Reducing the inputs of contaminants into waterways from the lands with the greatest inputs would provide significant improvement in water quality in streams and wetlands, as well as the Sacramento River and Bay-Delta.*

STRANDING

TARGET 1: Reduce or eliminate the stranding of juvenile chinook salmon on floodplains, shallow ponds, and levee borrow areas.

PROGRAMMATIC ACTION 1A: Conduct surveys of stranding in the American River under a range of flow conditions and develop recommendations to resolve the problem.

PROGRAMMATIC ACTION 1B: Conduct surveys of stranding in the Natomas area under a range of flow conditions and develop recommendations to resolve the problem.

PROGRAMMATIC ACTION 1C: Develop a protocol for ramping flow reductions so that flows do not recede so quickly that juvenile fish become isolated and stranded in side-channels in large numbers. Identify threshold flows that define conditions of allowable flow fluctuations.

RATIONALE: *Under some flow conditions, stranding is likely a minimal problem. However, under conditions in which rivers reach high flows and water is diverted into the flood bypasses or spills onto the floodplain, and then quickly recedes, stranding is a serious problem. Stranding of juvenile fish has been a significant problem on the lower American River in the past, and has resulted in significant losses of salmon and steelhead. Timing also plays a important role in determining the severity of the problem for chinook salmon, flood plain inundation prior to young salmon emerging is less of a problem that inundation after most of the fry have emerged. Juvenile steelhead are present year-round, however, so fish are subject to isolating flows at all times of the year.*

References Used to Develop the Vision for the American River Basin Ecological Management Zone

California Department of Fish and Game. 1993. Restoring Central Valley streams: a plan for action. November 1993.

__________. 1990. Central Valley Salmon and Steelhead Restoration and Enhancement Plan. April 1990. 115 pp.

California State Lands Commission. 1993. California's Rivers: A Public Trust Report. 334 pp.

Central Valley Habitat Joint Venture. 1990. Central Valley Habitat Joint Venture Implementation Plan, a component of the North American Waterfowl Management Plan. February 1990.

Clark, G.H. 1929. Sacramento-San Joaquin salmon (*Oncorhynchus tshawytscha*) fishery of California. Division of Fish and Game of California. Fish Bulletin No. 17.

Hallock. R.J. 1987. Sacramento River system salmon and steelhead problems and enhancement opportunities, a report to the California Advisory Committee on salmon and steelhead. June 22, 1987. 92 pp.

McEwan. D. And J. Nelson. 1991. Steelhead restoration plan for the American River. Department of Fish and Game. 40 pp.

McEwan, D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California. Department of Fish and Game. February 1996. 234 pp.

Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1997. Status review update for deferred and candidate ESUs of west coast steelhead. Prepared by NMFS West Coast Steelhead Biological Review Team.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

The Nature Conservancy. 1995. Sacramento Valley and Foothill Bioregion biological scoping project. August 1995.

San Francisco Estuary Project. 1993. Comprehensive Conservation and Management Plan. June 1993. 235 pp.

U.S. Fish and Wildlife Service and California Department of Fish and Game. 1953. A plan for the protection and maintenance of salmon and steelhead in the American River, California, together with recommendations for actions.

U.S. Fish and Wildlife Service. 1997. Revised draft anadromous Fish Restoration Plan: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

Vyverberg, K., B. Snider, and R.G. Titus. 1997. Lower American River chinook salmon spawning habitat evaluation. Department of Fish and Game. October 1994. 44 pp and appendices.

Wixom, L.H., J. Pisciotto, and C. Lake. 1995. Final report for the Sacramento River system sport fish catch. Department of Fish and Game. June 30, 1995. 76 pp.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: Final report to Congress, vol.III. Centers for Water and Wildland Resources, Univ. Cal. Davis. pg. 309-361.

◆ Yolo Basin Ecological Management Zone


Photo © California Department of Water Resources

Introduction

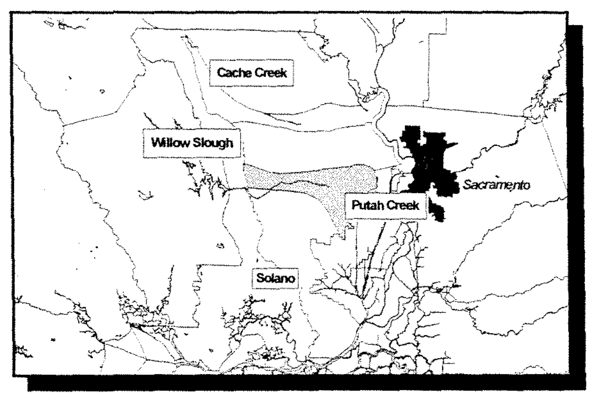
The health of the Sacramento-San Joaquin Delta depends on the health of its distinct watersheds. As with watersheds throughout California, ecological processes within the Yolo Basin Ecological Management Zone have been disrupted during the past century. Due to tenuous hydrological connections, this zone has historically made only marginal contributions to anadromous fish populations. As a result, the major focus in this zone is to increase the health of its important ecological processes, habitats, and fish, wildlife, and plant populations and make substantial contributions to the health of the Delta.

The Yolo Basin Ecological Management Zone provides diverse habitats for a wide variety of fish, wildlife, and plant communities, primarily native resident (nonmigratory) fishes, riparian communities, seasonally and permanently flooded wetlands, wildlife, waterfowl, and occasionally fall-run chinook salmon and possibly steelhead trout. The portion of the Yolo Bypass north of the Interstate 80 causeway is included in this zone and is an important migratory route during wet years for downstream migrant chinook salmon, steelhead, and other native and anadromous originating from up stream areas. When flooded, the Yolo Bypass provides valuable spawning habitat for native resident fish, including splittail.

Description of the Management Zone

The Yolo Basin Ecological Management Zone encompasses the southwest portion of the Sacramento Valley adjacent to the Delta. It includes the following Ecological Management Units:

- Cache Creek
- Putah Creek
- Solano
- Willow Slough



Location Map of the Yolo Basin Ecological Management Zone and Units.

Portions of the Yolo Basin Ecological Management Zone are extensively developed for urban and agricultural land uses. The basin includes the cities of Vacaville, West Sacramento, Woodland, Winters, and Davis. It also includes the northern end of the Yolo Bypass at the mouth of Cache Creek, between the Fremont weir and Interstate 80, and the Sacramento Bypass between the Sacramento River and the Yolo Bypass.

The Cache Creek Ecological Management Unit, at the northern end of the Yolo Basin Ecological Management Zone, encompasses the lower valley watershed of Cache Creek (downstream of Capay Dam near Esparto) and the northern end of the Yolo Bypass. The Putah Creek Ecological Management Unit is in the central portion of the zone, encompassing the Putah Creek watershed downstream of Monticello Dam (near Winters). The Solano Ecological Management Unit includes the nontidal watershed of the Cache-Lindsey Slough complex of the North Delta Ecological Management Unit and the Montezuma Hills.

Important ecological processes within the Yolo Basin Ecological Management Zone include streamflow, stream erosion, and natural sediment supply. The most valuable habitats are riparian and riverine aquatic. Although restoration efforts within the Ecological Management Units have improved portions of the riparian corridors, many specific improvements are needed to more fully restore ecological health throughout the entire Ecological Management Zone. The greatest needs are to maintain processes more closely linked to the natural streamflow regime and to restore connectivity to the Yolo Basin and Delta. Developing additional sources of water to improve low flow conditions and restoring riparian and stream channel corridors will improve the ecological health of the lower basin watersheds. Restoring upper watersheds by reducing forest fuels, improving oak woodland, forest, and rangeland management, and reducing sources of bioavailable mercury will help ensure that a clean water supply is available in the basin.

Historically, fall-run chinook salmon, steelhead trout, many native resident fish species, waterfowl, shorebirds and wading birds, and riparian wildlife were abundant in areas within the basin. Agricultural and urban development, recreation, infrastructure, mining, and flood control projects have eliminated much of the fish and wildlife habitat. Salmon and steelhead migrations within the creeks are now limited to high flow events, when there is connectivity to the Delta. Opportunities to restore these anadromous fish populations should not be overlooked.

Important habitats within the Yolo Basin Ecological Management Zone include stream and slough channels for fish migration and holding, spawning, and nursery habitats. Seasonally flooded wetlands are prevalent throughout the lower basin, and these are important habitat areas for waterfowl, shorebird, and wading bird guilds. Riparian corridors along basin creeks and sloughs are important habitat areas and migration corridors for wildlife and waterfowl.

Notable stressors to ecological functions, processes, habitats, and species in this Ecological Management Zone are:

- water diversions and past gravel mining in the streams,
- insufficient available flow to maintain a continuous riparian corridor,
- mercury contamination from natural and previously mined sources that is taken up through the aquatic food chain, and
- poor quality agricultural tailwater entering the Yolo Bypass canals and sloughs.

The prevalence of non-native plant species (e.g., tamarisk, giant reed, eucalyptus, and water hyacinth) is a major factor limiting the quality and extent of riparian and riverine aquatic habitats, especially in areas adversely affected by past gravel mining, flood scour, and low streamflow.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE YOLO BASIN ECOLOGICAL MANAGEMENT ZONE

- chinook salmon
- steelhead
- native resident fishes
- plants and plant communities.

Descriptions of Ecological Management Units

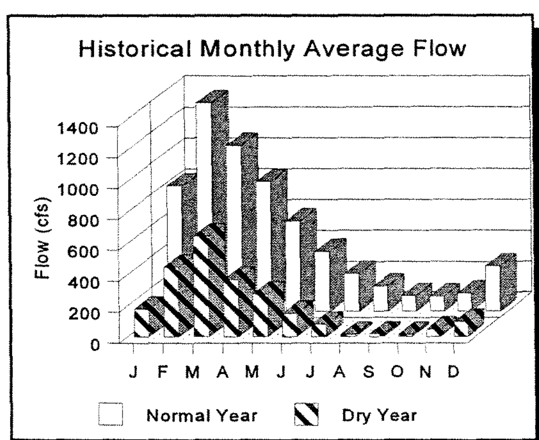
Cache Creek Ecological Management Unit

Cache Creek has a watershed of about 1,300 square miles and flows out of the coastal mountains to enter the Sacramento Valley floor near Esparto. Cache Creek enters the Yolo Bypass at Cache Creek settling basin (a reclaimed tule marsh-seasonal lake area) and then flows south into the Delta through the Conway Canal, Tule Canal, lower Cache Creek and other small sloughs in the bypass. Most of the flow is diverted in the spring and summer for irrigation. High winter and early spring flows move south through the flooded Yolo Bypass or connecting sloughs to enter the Delta through Cache Slough which then flows to the Sacramento River north of Rio Vista.

Cache Creek drains the Clear Lake, North Fork, and Bear Creek basins on the east side of the Coast Ranges. The water levels at Clear Lake and Indian Valley Reservoir are regulated for downstream irrigation diversions with a dam and gates constructed in 1915 and 1978, respectively. A powerhouse was added in 1985. The watershed upstream of Clear Lake is about 530 square miles, and the usable storage is about 300,000 acre-feet. Downstream of Clear Lake Dam is the 30-mile Cache Creek Canyon. The North Fork Cache Creek meets Cache Creek 8 miles downstream of Clear Lake Dam and is regulated by Indian Valley Dam, located 8 miles upstream of Cache Creek, with a watershed of 120 square miles and a capacity of 300,000 acre-feet. Cache Creek enters the valley floodplain at Capay Dam near Esparto, 18 miles upstream of the mouth.

No minimum flow requirements have been set for Cache Creek below Capay Dam. In some places between Capay Dam and the Yolo Bypass, the creek flows through areas where gravel mining has recently occurred, but which have not yet had time to recover naturally. In other areas, deep gravel deposits and low water tables inhibit the establishment of a sustained low-flow channel. Another major barrier to upstream fish migration is the recently enlarged outlet spillway of the Cache Creek Settling Basin. Levees confine the stream channel in the lower 8 miles of Cache Creek. These levees define a wide basin at the lower end and act as a sediment trap to preserve the flood capacity of the Yolo Bypass. The levees were raised 12 feet in 1993 to provide an additional 50 years of sediment capacity. Flows near the town of Yolo are very low during summer and fall of most years, however Cache Creek has a flashy but intermittent natural hydrograph.

Cache Creek has a natural flow pattern of high winter, moderate spring, and low summer-fall flows, typical of many western Sacramento Valley streams that originate from chaparral and oak studded foothills rather than higher snow-laden mountains. Portions of the stream are dry during summer and fall months, except for small sections upstream of Woodland receiving groundwater. Inflows to the lower basin at Rumsey in wettest years have averaged 5,000 to 10,000 cubic feet per second (cfs) in winter months and 300 to 700 cfs in summer months. There was a flood peak of 58,000 cfs in 1995. In driest years, flows may be near 0 cfs the entire year.



Cache Creek Streamflow from Upper Basin at Rumsey, 1962-1992 (Dry year is the 20th percentile year, normal year is the 50th percentile of median year.)

Low flows are further reduced by year-round diversions. The stream in the valley floor downstream of Capay Dam is often dry during summer and fall months. In dry years, average monthly winter flows peaked at 30 to 100 cfs. Unimpaired flows during March in dry years are reduced from an average of 650 to 60 cfs by diversions. Unimpaired flows during May are reduced from 260 to 0 cfs. In normal rainfall years, May flows are reduced from 590 to 10 cfs. Because of barriers, fall-run chinook salmon and steelhead are believed to have migrated up Cache Creek and only on an infrequent basis. Anecdotal historic evidence suggests that in wet years, when flows in Yolo Bypass and Cache Creek are high, some fish may have reached the spawning gravels of lower Cache Creek from the Delta. In dry years, no passable connection exists for salmon and steelhead between the Delta and the mouth of Cache Creek. Fish passage may also impaired at the Cache Creek settling basin spillway and headworks.

Potentially, juvenile salmon and steelhead produced in wetter years may be lost during the spring when Yolo Bypass flows cease and juvenile salmon become trapped in the creek or ponds and dead-end sloughs of the Yolo Bypass and settling basin. In years when Cache Creek flows are high enough in winter or spring, some juvenile salmon and steelhead can migrate downstream to the Delta through the flooded bypass or the network of agricultural drains crossing the Yolo Bypass to Tule Canal.

Numerous studies performed by both state and federal agencies indicate that Cache Creek transports significant amounts of mercury into the Delta. The mercury is often associated with suspended sediment loads that occur during high flow events, when Cache Creek is hydrologically connected to the Yolo Bypass. A powerful neurotoxin, mercury can cause developmental damage in both wildlife and humans. More importantly, mercury bioaccumulates through the food chain, affecting not only aquatic organisms but higher order species that feed upon them.

Improving streamflows, gravel spawning, and riparian habitats and providing permanent connections between the mouth of the creek and the Delta would only marginally help to increase steelhead trout and fall-run chinook salmon populations. Although Cache Creek can make minor contributions to fall-run chinook salmon populations in some years, significant resources would be required to provide the necessary holding, spawning, rearing, and migration habitat. However, steelhead populations, unlike chinook salmon, can exist in streams that have infrequent connectivity to the ocean. The variable life-history of steelhead/rainbow trout populations allow them to persist in the mid- to high-elevation stream reaches indefinitely if there are suitable habitat conditions, despite the loss of connectivity to the ocean. Although these sub-populations may be small, they are important to the persistence of the basin-wide population as a whole and contribute to the overall population viability when access is restored in wet years (IEP Steelhead Project Work Team 1999), and should not be overlooked.

The riparian corridor must be improved significantly in several areas; some areas have been denuded and will require a more intensive revegetation effort. This has been aided by the elimination of commercial instream gravel mining in the creek bed under Yolo County's new Cache Creek Area Plan, with all new mine permits restricted to off-channel sites. In addition, several replanting projects by non-profit organizations and government agencies are currently underway. Recent proposals to create off-channel storage facilities using water conveyed from Cache Creek in winter and spring would also permit recharge of groundwater resources that may improve the survivability of vegetation during low-flow seasons.

There are several factors that combine to constrain efforts to establish salmon and steelhead habitat. The natural geomorphology of the stream is not conducive to supporting a continuous, year-round stream. The need to maintain the flood control capacity of the river floodplain and the Yolo

Bypass restrict the feasibility of creating a natural riparian system in the lower creek. Most important of all, the high levels of mercury contamination measured in the creek are a direct and significant threat to the health of the species. Until such time as the source of the mercury is identified and the contamination remediated, Cache Creek should not be considered as healthy habitat for many aquatic species.

Salmon and steelhead migrations within the creeks have historically been limited to high flood events, when there was connectivity to the Delta. However, salmon and steelhead have not been documented to be present in Cache Creek for many years. Their use of Cache Creek is restricted to occasional efforts at colonization when high flows support up-and downstream migration. Opportunities to restore these anadromous fish populations continue to be limited and restoration efforts will emphasize restoration of ecological processes and the elimination or reduction of stressors such as mercury contamination and invasive plants.

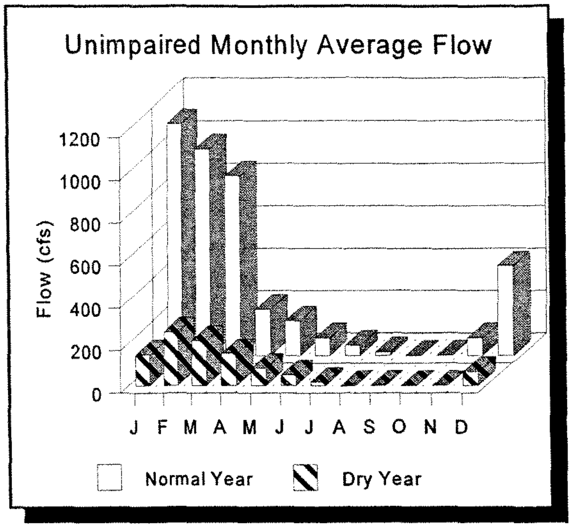
Supporting the involvement of local citizens and interested parties in existing organizations such as the Cache Creek Conservancy and Cache Creek Stakeholders Group would help to restore and maintain Cache Creek. Similarly, developing and implementing a comprehensive watershed management plan as required under the Cache Creek Resource Management Plan (approved in 1996 by Yolo County as a regulatory and planning document to maintain flood control capacity, reduce bank erosion in the channel, and preserve and restore the riparian corridor) could facilitate restoring and maintaining Cache Creek. Upper watershed health can also be improved by reducing forest fuels and implementing other watershed improvement practices to protect streamflows, stream channels, and riparian habitat and minimize sediment input to the stream.

Riparian habitat can be restored by providing adequate streamflows when available, protecting the natural sediment supply, promoting the conservation and expansion of the active floodplain, and protecting shorelines from livestock grazing upstream of Capay Dam. Planting vegetation or regrading the disturbed channel and floodplain will hasten and sustain recovery in some areas. Major efforts are required to control or eradicate tamarisk and giant reed infestations which interfere with natural vegetation succession by native tree species.

PUTAH CREEK ECOLOGICAL MANAGEMENT UNIT

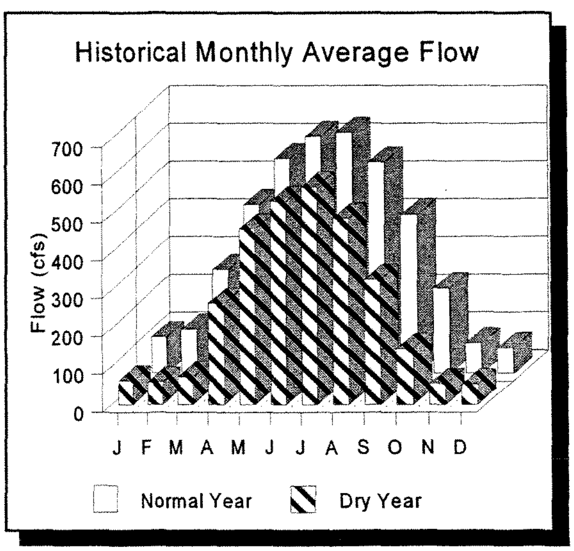
Putah Creek has a watershed of about 710 square miles and flows out of the coastal mountains to enter the Sacramento Valley floor near Winters. Putah Creek flows into the Yolo Bypass at the Putah Creek sinks (a historical tule marsh-lake area). In most wet years, the creek flows to the Yolo Bypass and then flows south through Tule Canal to the Sacramento River. Monticello Dam (constructed in 1956) forms Lake Berryessa from Putah Creek on the east side of the coastal range. Below Monticello Dam, the creek flows into Solano Lake, formed by the Solano Diversion Dam (constructed in 1959). Below Solano Diversion Dam, the creek flows east through Winters and Davis.

Most of Putah Creek's flow below Monticello Dam originates from Lake Berryessa, which has an average outflow of approximately 350 cfs. Unimpaired flows into the Lake Berryessa watershed formerly peaked in winter. In wettest years, winter flows averaged 4,000 to 9,000 cfs. Lowest flows occur in summer and fall. In driest years, flows in winter months averaged only 20 to 70 cfs. In wetter years, summer and early fall flows averaged 20 to 100 cfs.



Putah Creek Unimpaired Streamflow at Lake Berryessa, 1961-1991 (Dry year is the 20th percentile year, normal year is the 50th percentile or median year.)

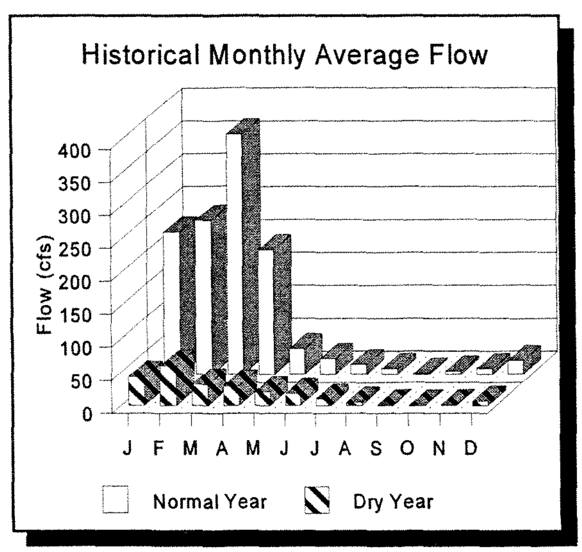
The natural flow pattern has been altered by water storage in Lake Berryessa and spring through fall irrigation releases. Flows from Monticello Dam are high in summer and low in winter in all but the wettest years. Wet-year spillage flows still average 4,000 to 8,000 cfs in winter; however, in normal and dry years, winter flows are generally less than 100 cfs. Even in the driest years, irrigation releases from late spring to early fall are 200 to 400 cfs above Solano Dam but near zero below the diversion dam.



Putah Creek Streamflow below Monticello Dam, 1961-1991 (Dry year is the 20th percentile year, normal years if the 50th percentile year or median year.)

The largest diversion is the Putah South Canal diversion at Solano Diversion Dam; this and other irrigation diversions reduce flows to very low levels in all but wet years and in all months. Flows near Davis are very low during summer and fall of most years, generally 0 to 60 cfs. Spillage flows reach 4,000 to 7,000 cfs in the winter of wet years, but only 4 to 20 cfs in driest years.

Historically, chinook salmon migrated at least as far as the town of Monticello (now under Lake Berryessa) (Yoshiyama et al. 1996). Solano Diversion Dam is now the upstream terminus of salmon and steelhead migration. Some fall-run chinook salmon and steelhead still migrate up Putah Creek in wet years (fall-run chinook adults were observed in 1997 and 1998). In dry years, no viable connection exists between the Delta and Putah Creek for salmon and steelhead. In wet years, when Yolo Bypass and Putah Creek flows are high, fish can reach spawning gravels in lower Putah Creek from the Delta. Significant losses of juveniles can occur in spring if low flows or barriers limit connections in the Yolo Bypass, or in wet years when Yolo Bypass floodflows recede and juvenile salmon become trapped in seasonal



Putah Creek Streamflow near Davis, 1961-1971, 1973-1975, and 1978-1984 (Dry year is the 20th percentile year, normal year is the 50th percentile or median year.)

ponds, disconnected canals, and sloughs in the bypass. If Putah Creek flows are high enough in winter or spring, some juvenile salmon and steelhead can migrate downstream through the Delta through canals along the east side of the Yolo Bypass.

Native fish species, such as hitch, squawfish, and suckers, are an important component of the Putah Creek watershed and are a primary focus for management and restoration efforts. Native fish populations are very low in lower Putah Creek except for the two-mile reach immediately below Solano Diversion Dam. The length of this reach is insufficient to insure the long-term viability of the native fish assemblage and a goal is to restore these native fishes to a stat of "good condition." Good conditions mean that fish of all ages are present in sufficient numbers over a large enough habitat area to afford the population the ability to recover form mortalities caused by unexpected disasters (i.e., pesticide spills; large, rapid sediment releases from Lake Solano, etc.); environmental factors; angling; and predation. Habitat conditions that promote successful reproduction, growth and survival of young fish, and the growth and survival of adult fish are essential (Trihey & Associates 1996).

Improving streamflow, spawning gravel, and riparian habitats and providing permanent connections between the mouth of the creek and the Delta will increase opportunities for steelhead trout and fall-run chinook salmon to use Putah Creek. Putah Creek can make minor contributions to fall-run chinook salmon and steelhead populations if adequate holding, spawning, rearing, and migration habitat are provided. Adequate streamflows are important to maintain and restore the connections between upstream spawning and nursery areas with the Delta.

Actions to restore and improve conditions for chinook salmon and steelhead are more likely to succeed during years of normal to above-normal rainfall. Supplementing flows from Monticello Dam (Lake Berryessa) through the Solano Diversion Dam during critical migration periods would help maintain and improve flows. Providing supplementary flows into and through the Yolo Bypass sloughs, either from the Colusa basin drain through the Knights Landing Ridge Cut Canal or the Sacramento River through the Fremont weir near Verona, would provide the necessary flows in drier years to let fish pass from the creek mouth to the Delta. The goal is to provide adequate flows for adult salmon migration in fall, fry rearing in winter, and spring juvenile outmigration in all but the driest years. Minimum flows in upstream summer rearing areas below Solano Diversion Dam would be required to sustain the steelhead population.

Inadequate spawning gravel may be a significant factor limiting salmon and steelhead production, especially in the upper reach below Solano Diversion Dam. Existing gravel sources should be protected, and the natural supply should be added to the creek where and when necessary. Past gravel mining operations along the stream channel, floodway clearing, and grading and bank protection in the floodplain and along Dry Creek (a major source of gravel to Putah Creek downstream of Solano Diversion Dam) may also inhibit gravel recruitment downstream. This reach offers excellent habitat for oversummer rearing of juvenile steelhead when flows and water temperatures are adequate.

The riparian corridor condition must be improved significantly in several areas. Some areas have been denuded and will require a more intensive revegetation effort. Gravel mining operations in the creek bed were discontinued in the 1960s, but the major gravel and sediment source for the lower creek was eliminated by the construction of Solano and Monticello Dams.

Developing and implementing a comprehensive watershed management plan for both the upper and lower watersheds, and implementing the lower Putah Creek management recommendations prepared in 1994 by the U.S. Fish and Wildlife Service (USFWS) and the Lower Putah Creek

Coordinating Committee, would facilitate restoration and maintenance of Putah Creek. Above Lake Berryessa, upper watershed health should be improved by reducing forest fuels and the opportunity for catastrophic wildfire and implementing other watershed improvement practices to protect streamflows, stream channels, and riparian habitat and minimize sediment input to the stream. Below the lake, efforts should focus on protecting riparian habitat, providing adequate gravel spawning areas for salmon and steelhead, and improving stream channel conditions.

Riparian habitat can be restored or enhanced by providing adequate floodplains along the channel and protecting shorelines from grading, bank filling, and native vegetation removal to expand orchards or urban and industrial facilities. Planting vegetation or regrading the disturbed channel and floodplain will hasten and sustain recovery in certain areas. Major efforts are required to control or eradicate eucalyptus tamarisk and giant reed infestations, which interfere with natural vegetation succession by native tree species. These efforts will involve coordination with the local jurisdictions (Yolo County and the cities of Winters and Davis), University of California (UC) Davis, the U.S. Bureau of Reclamation (Reclamation), Solano County Water Agency, Putah Creek Landowners Association, and the Putah Creek Council.

Adequate screening systems are needed on the Putah South Canal diversion if fish passage is to be provided along Solano Diversion Dam. Small, unscreened diversions in Putah Creek need to be screened to protect juvenile fish.

Providing fish passage at Solano Diversion Dam would allow salmon and steelhead passage into the cold tailwaters of Monticello Dam. The interdam reach—several miles of high-quality riparian and shaded riverine aquatic (SRA) habitat—currently supports a native and stocked trout fishery. With appropriate spawning gravels, the 12-mile reach between Solano Diversion Dam and Monticello Dam could provide good spawning and rearing habitat for salmon and steelhead. This reach offers excellent habitat for oversummer rearing of juvenile steelhead.

SOLANO ECOLOGICAL MANAGEMENT UNIT

The southern portion of the Yolo Basin Ecological Management Zone is the Solano Ecological Management Unit. This unit encompasses small watersheds above the tidal Delta, south of Putah Creek and east to the Delta. Most of this area is within the Cache Slough and Lindsey Slough watersheds. The unit also includes the Montezuma Hills, which are not part of the Delta as it is legally defined.

Although salmon and steelhead are rarely found in this unit, native resident fish do occupy creeks and sloughs. Riparian corridors of these creeks and sloughs support vegetation, waterfowl, and wildlife. Upland habitats include vernal pools, valley oak woodlands, and grasslands. Scattered areas of seasonal and perennial wetlands and aquatic habitats exist throughout the unit.

Many of the vernal pools within this Ecological Management Unit are in a degraded condition due to land use practices (e.g., discing and cultivation) and could be improved. The potential for restoring native perennial bunch grass is high, as well as is restoring some of the rare vernal pool plant species.

WILLOW SLOUGH ECOLOGICAL MANAGEMENT UNIT

Willow Slough Ecological Management Unit is comprised of approximately 131,000 acres of productive farmland. The watershed is bounded and intersected by half a dozen natural riparian waterways, supporting an extensive irrigation and drainage system. Winter runoff from the Vaca foothills to the west enters this series of tributaries to terminate in the Yolo Bypass. Even during years of normal rainfall some downstream areas flood and larger events have involved parts of the cities of Davis and Winters. Very little winter water is held back or captured in the natural systems. Summer use links the natural system with Cache Creek diversions and the Yolo County Flood Control and Water Conservation Districts (FCD) canal system to deliver irrigation water and remove related drainage flows.

No major surface water impoundments exist within the watershed. The creeks have historically been managed by farmers and the FCD to remove water as quickly as possible. As a result, there is frequent downstream flooding, enormous movement of sediment, and lost riparian habitat, wildlife populations, and biodiversity. A consequence of traditional farming practices has been the elimination of functioning seasonal wetlands and loss or degradation of riparian systems. These systems historically transported anadromous species such as chinook salmon and steelhead in years when there was adequate streamflow. As recently as 1986, an adult steelhead was found in Willow Slough. Once health natural streamways are now barren or invaded by exotic plant species that contaminate fields and roadsides requiring high maintenance and chemical use with little ultimate control.

Agriculture is the primary economic enterprise throughout the watershed. Crops include lowland acres of alfalfa, irrigated row crops, and orchards. Dryland grains and rangeland grazing characterize the upland hills. The lower irrigated croplands are made up of highly productive deep alluvial soil as well as heavier clay and alkali soils. The latter are generally used for rice production. Intensive "clean" agricultural practices in the watershed have had significant negative impacts on riparian system, wetlands, upland wildlife habitat, water quality, and flooding. A change in land stewardship practices can correct the negative impacts while maintaining, and in some cases, improving the agricultural's economic base.

The highest elevations of the watershed consist of chaparral and blue oak woodlands. Most of the habitats are in relatively good condition, although heavy grazing pressure impacts the grasslands and riparian areas, especially in the lower reaches. The lower foothills are mixed blue oak woodlands and grassland or dryland grain areas. Much of this acreage is enrolled in the federal Conservation Reserve Program (CRP) and consists of non-native annual grasses and forbs.

Historically, the waterways across the county were rich and biologically diverse because of their system of interconnected streams, wetlands, and dry uplands. Some narrow remnants of these systems can still be found but most have been removed as part of agricultural practices. Much of what remains is of a weedy nature, and is not compatible with adjacent agriculture, and requires continuous maintenance.

Where areas of natural sloughs remain, seasonal flows support riparian vegetation consisting of valley oak, foothill pine, some willows, toyon, buckeye, wild rose, elderberry, and other associated species. Many wildlife species use these corridors including deer, quail, raptors, gray fox, and tree squirrels. The large trees provide important nesting sites for the endangered Swainson's hawk and other species. Thickets of elderberry, rose, button willow, mulefat, sedges, rushes, and grasses provide important food, cover, and migration corridors of many species. Intact riparian systems also provide important bio-filtering of runoff waters. By trapping sediments and chemicals, water quality improves in downstream aquatic systems of the Yolo Bypass and Sacramento River.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Yolo Basin Ecological Management Zone is to protect natural ecological processes and habitats to a sufficiently healthy condition to support native resident fish populations in basin watersheds. The overall vision also includes visions for ecological processes, habitats, species, stressors, and the Ecological Management Units.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

CACHE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Cache Creek Ecological Management Unit is that native resident fish will be sustained by improving streamflows, fish passage, riparian habitat, and spawning gravel recruitment and by screening unscreened diversions.

PUTAH CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Putah Creek Ecological Management Unit is that native resident fish will be protected and enhanced by improving stream channel characteristics, instream habitat, streamflows, fish passage, riparian habitat, and spawning gravel recruitment and by screening unscreened diversions. Opportunities to promote use by chinook salmon and steelhead trout will be further evaluated.

SOLANO ECOLOGICAL MANAGEMENT UNIT

The vision for the Solano Ecological Management Unit is that creeks and sloughs and the associated riparian, wetland, and upland habitats in the unit will provide connections to the North Delta. Populations of native resident fish, including Sacramento splittail and delta smelt, may be enhanced by improving conditions in these habitats.

WILLOW SLOUGH ECOLOGICAL MANAGEMENT UNIT

The vision for the Willow Slough Ecological Management Unit is to integrate agriculture, natural habitats, and urban development in a manner to support ecological health.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Streamflows shape channels, support riparian vegetation, and provide habitat for fish and other aquatic species. Streamflows also transport sediments, nutrients, and juvenile fish. The vision is that streamflows in Cache and Putah Creeks will support stream channel maintenance processes, such as sediment transport and meander (consistent with flood protection and adjoining land uses), a healthy riparian zone, and sustainable native resident fish populations.

COARSE SEDIMENT SUPPLY: The availability and quality of sediments within the active stream channel are important for supporting natural stream channel dynamics, channel maintenance, soil medium for vegetation, and stream substrate. Sediments also include gravel, which provides for fish spawning and invertebrate production. The vision for coarse sediment supply is that a sediment equilibrium will be achieved that balances sediment transport with sediment input to make suitably sized gravels available for fish spawning and enhances riparian plant life.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Stream-floodplain interactions are an important ecological process. Streams need the opportunity to inundate their floodplains on a regular cycle to support riparian regeneration, nutrient input to the system, and to erode and deposit sediments. The vision for floodplains in the Yolo Basin Ecological Management Zone is that Cache and Putah Creek will seasonally flood their active floodplains. The vision also anticipates that the flood capacity and biological productivity of the flood bypass system will be increased by improving conditions that support habitat and juvenile and adult fish survival.

VISION FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: A healthy riparian corridor provides a migratory pathway linking lower and higher elevation habitats for terrestrial species, such as mammals and birds. Health riparian systems also produce and contribute to shaded riverine aquatic (SRA) habitat, which can provide cover in the form of shade or woody debris. The vision for riparian and SRA habitats is that they will provide a migration corridor between the Delta and upstream habitats that support terrestrial and aquatic species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The streams in the Yolo Basin Ecological Management Zone are a combination of fall-run chinook salmon spawning streams in some years of early rainfall but more typically hitch streams during most years (Moyle and Ellison 1991). The quality of freshwater fish habitat in Cache Creek, Putah Creek, and Willow Slough will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Both Cache Creek and Putah Creek are identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creek include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Diversion can dewater stream reaches and cause direct mortality to juvenile fish by entrainment. The vision is that additional water supplies will be developed to ensure that diversions will not impair efforts to establish sustainable populations of native resident fish species.

GRAVEL MINING: Gravel mining can remove significant quantities of sediments from the active stream channel. This loss of sediments, often in the form of gravel and sand, can have significant adverse affects on stream channel dynamics and riparian succession. The vision is that intensive gravel mining activities will be relocated to sites outside the active stream channels while allowing for continued stream restoration, flood maintenance, and erosion control.

INVASIVE RIPARIAN AND MARSH PLANTS: Invasive plant species can outcompete and displace valuable native species. Invasive plants often have little or no value to native wildlife and are de-stabilizing natural ecosystem functions and processes. The vision is that invasive plants will be controlled to allow native riparian plant species to naturally propagate.

PREDATION AND COMPETITION: The presence of non-native fish populations in the streams of the Yolo Basin Ecological Management Zone has adversely affected native fish assemblages. This is largely a result of competition for food and space, though some of the non-native fish prey on native species. Improving habitat for native species will contribute to reducing, but not eliminating, predation and competition.

CONTAMINANTS: Reducing toxin inputs in discharges and from contaminated sediments is essential to maintain water quality. Reduced concentrations in waters entering the Delta should lead to lower concentrations in Delta water and in fish and invertebrate tissues. Fewer health warnings for human consumption of Delta fish and improved foodweb productivity would also be expected.

VISIONS FOR SPECIES

CHINOOK SALMON AND STEELHEAD: The vision is that the Yolo Ecological Management Zone will contribute to the recovery of fall-run chinook salmon and steelhead populations.

NATIVE RESIDENT FISH SPECIES: Many native fish species will benefit from improved aquatic habitats and stream channel/floodplain processes. Population abundance indices should remain stable or increase and population sizes should be large enough to fully recover from natural and human-induced disasters. The distribution of native resident fishes should increase with widespread habitat restoration.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

All efforts proposed in the Ecosystem Restoration Program Plan (ERPP) to improve habitat and reduce stressors will be coordinated with existing State and federal programs and with local stakeholder organizations. The ERPP also supports and complements restoration efforts already underway in the Yolo Basin, including the following.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The Central Valley Project Improvement Act (CVPIA) which calls for efforts to double the salmon and steelhead populations in the Central Valley by 2002 through changes in flows and project facilities and operations.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

DFG is required under the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988 to restore salmon and steelhead runs in the Central Valley.

THE DELTA NATIVE FISHES RECOVERY PLAN

This plan prescribes efforts to assist the recovery of many fish species native to the Central Valley, including delta smelt, splittail, and other native fish species.

ENDANGERED SPECIES ACT

The National Marine Fisheries Service (NMFS) is reviewing the status of steelhead trout in the Central Valley. Any restoration program developed under the federal Endangered Species Act (ESA) will be compatible with recommendations in the ERPP.

The health of the Ecological Management Units of the Yolo Basin Ecological Management Zone can be maintained and restored only with the active participation of local watershed groups, which include local landowners and concerned individuals.

NATIVE SPECIES RECOVERY PLAN FOR LOWER PUTAH CREEK

A recovery plan for Lower Putah Creek native fish species was prepared in 1996. This plan is intended to re-establish and maintain: (10 a resident native cool water fish assemblage, (2) a mixed native warm-water fish assemblage, (3) a warm-water game fish assemblage, and (4) a native anadromous fish assemblage. Many of the ERPP targets and programmatic actions for Putah Creek are consistent with the recommendation in this plan

WATERSHED ORGANIZATIONS

Some watershed groups that already have been established in the Ecological Management Zone are:

- Cache Creek Conservancy,
- Cache Creek Stakeholders Group,
- UC Davis Putah-Cache Bioregional Project,
- Solano County Water Agency,
- Water Resources Association of Yolo County,
- Farm Bureau
- Putah Creek Landowners Association,
- Putah Creek Council,
- Yolo County Resource Conservation District,
- Yolo Basin Foundation,
- Flood Plain Management Group,
- Blue Ridge Ranchers, and
- Quail Ridge Conservancy.

Efforts in the Yolo Basin will be linked to similar work by the California Waterfowl Association, Ducks Unlimited, The Nature Conservancy (TNC), and the California Rice Industry. The overall success of these efforts will require cooperation from resource agencies, such as the California Department of Fish and Game (DFG), California Department of Water Resources (DWR), and USFWS, as well as participation and support from the U.S. Bureau of Reclamation (Reclamation), Natural Resources Conservation Service (NRCS), private organizations, water districts, county and city governments, and individual landowners. These groups will work together to maintain and restore streamflows and fish and wildlife habitat, develop additional water supplies to reduce impacts of diversions, and minimize poaching and degradation of habitat and water quality in basin streams. To support this effort, funding may be provided to enhance streamflows, reduce problems related to fish passage, install screens at diversions, restore habitats, and increase enforcement of the California Fish and Game Code to protect recovering populations of salmon and steelhead.

WILLOW SLOUGH INTEGRATED RESOURCE MANAGEMENT PLAN

To implement a set of resource management practices, the Yolo County Resource Conservation District (RCD) is working with local landowners, and local, state, and federal agencies under the Willow Slough Integrated Resource Management Plan. The goal of this plan is to enhance the natural resources of the watershed using voluntary, small-scale, on-farm, and reproducible management practices. The resources and problems that could be jointly managed include stormwater runoff, erosion, sedimentation, chemical use, wildlife habitat, and groundwater recharge.

A resource inventory completed during the plan development process found multiple benefits could be achieved. The analysis focused on opportunities for creating or enhancing wetland and riparian habitats, augmenting groundwater recharge, and decreasing flooding problems.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Many of the resource elements in the Yolo Basin Ecological Management Zone depend on conditions or elements in other zones, including the Sacramento River and Delta. The Yolo Basin

Ecological Management Zone has important connection with the North Delta Ecological Management Zone. The major area that connects the two in the Yolo Bypass. The upper section of the bypass (above the Interstate 80 causeway) is in the Yolo Basin Ecological Management Zone and the section below the causeway is in the North Delta Ecological Management Unit.

The connections between these areas also include other ecosystem elements. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem Sacramento River, the Delta, the San Francisco Bay, and the nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, water quality deterioration, and harvest, restoring salmon and steelhead populations in the Yolo Bypass will require efforts in other zones.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW

TARGET 1: More closely emulate natural seasonal patterns in Cache and Putah Creeks by providing additional flows, when available from existing water supplies. Flows in the Yolo Bypass would be supplemented, as needed, by the Colusa basin drain through the Knights Landing Ridge Cut Canal, extending the Tehama-Colusa Canal, and the Sacramento River through the Fremont weir. Supplemental flows may be needed in fall if water temperature and flow in the lower Yolo Bypass are insufficient for passage from Cache Slough to upstream areas in the Sacramento River. Supplemental flows may be needed in winter and spring to sustain downstream migrating juvenile salmon and steelhead on their journey through the Yolo Bypass to the Delta. Supplemental flows would be needed along with irrigation water from spring to fall to sustain native fish, wetlands, and riparian habitats in channel sloughs of the Yolo Bypass (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to provide water for summer flows in Cache Creek to maintain riparian vegetation by developing new conjunctive supplies, including groundwater.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to provide water for the target flows in Putah Creek from additional Lake Berryessa releases or reductions in water diversions at Solano Diversion Dam and in the creek downstream of the dam. Water would be obtained from willing sellers, water transfers, and by developing new supplies, including groundwater.

PROGRAMMATIC ACTION 1C: Cooperatively evaluate the feasibility of providing water for the upper Yolo Bypass portion of the Cache Creek Unit by redirecting water from Colusa basin drain through the Knights Landing Ridge Cut Canal, an extension of the Tehama-Colusa Canal, and the Sacramento River through the Grays Bend-Old River-Fremont weir complex.

RATIONALE: *Supplemental summer flows proposed in Cache Creek would sustain newly established riparian vegetation and provide refuge for native resident fish. Flows from the Colusa basin drain, Tehama Colusa Canal extension, and the Sacramento River are necessary to provide sufficient flow in the Yolo Bypass during the spring through fall irrigation season to sustain native fish, wetlands, and riparian habitat; additional supplemental flow may be needed during the late-fall through early spring salmon and steelhead migration season. These flows will sustain native resident fish species and salmon and steelhead using the Yolo Bypass route to and from the upper Sacramento River watersheds.*

Flow in this area would pass south along both sides of the Yolo Bypass, merging with any supplemental Cache and Putah Creek flows along the west side of the Yolo Bypass. A weir or screen will be placed at the Knights Landing Ridge Cut Canal outlet to keep salmon and steelhead from migrating upstream into the Colusa basin drain. Fish passage facilities will be constructed at the Grays Bend-Old River-Fremont weir complex to allow migrating adult salmon and steelhead moving upstream through the Yolo Bypass toward upper Sacramento River basins to enter the Sacramento River. Downstream migrating juvenile salmon and steelhead will not be discouraged from moving from the Sacramento River into the Yolo Bypass, because conditions should be optimal for rearing and migrating on their way to the Delta.

Improved streamflows are one of the most critical ecosystem elements required to promote healthy native fish populations in Putah Creek. Opportunities to provide the needed flows are presently limited, but that does not lessen the need to continue efforts to find a collaborative means by which to meet the needs for all the beneficial uses of Putah Creek water. There are four general classes of streamflow needs for Putah Creek native fishes: (1) flows for native fish rearing, (2) flows for native fish spawning, (3) flushing flows to push non-native pond fish downstream, and (4) anadromous fish flows. The first two streamflow needs are of higher priority at this time and alternatives to using streamflows to control non-native fish species need to be further examined. Restoring more natural channel characteristics, providing instream habitats such as woody debris, pools, overhanging vegetation, may provide native species with the advantage required to naturally displace or successfully compete non-native species such as the red shiner.

COARSE SEDIMENT SUPPLY

TARGET 1: Restore gravel recruitment in Cache and Putah Creeks to meet the needs of spawning fish, maintain natural stream channel meanders and bar formation where consistent with flood protection and adjoining land uses, and match existing rates of downstream displacement (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to supplement gravel recruitment below Solano Diversion Dam as needed to replace natural gravel recruitment interrupted by the diversion dam.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to supplement gravel in areas downstream of the diversion dams where other structures or gravel mining has interrupted the gravel recruitment process.

RATIONALE: *Gravel recruitment has been severely interrupted in Putah Creek from dam construction. Replacement is necessary below the dam to sustain fish rearing habitat, feasible stream meander, and riparian corridors. Consistent with this is the need to improve the stream channel characteristic of Putah Creek downstream of Solano Diversion Dam. Of concern is the existing channel geometry including width and depth.*

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: More closely emulate natural stream channel configurations in Cache Creek and Putah Creek, as well as in channels and sloughs of the upper Yolo Bypass, consistent with flood control requirements (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate the feasibility of modifying the cross sections and channel configurations in Cache and Putah Creeks to provide a more natural configuration, while maintaining consistency with flood control requirements and minimizing impacts to adjoining established land uses.

TARGET 2: Increase overbank flooding potential to floodplains, where feasible and consistent with flood protection, to support a desirable vegetation succession process (◆).

PROGRAMMATIC ACTION 2A: Evaluate oppor-tunities to provide flow to Yolo Bypass from Colusa basin drain, extending the Tehama-Colusa Canal, and Sacramento River (through Fremont weir) in dry and normal water years, as well as normally occurring overflow in wetter years.

TARGET 3: Increase the area of flooding to the active Cache and Putah Creek floodplains during the wet season, where feasible and consistent with flood protection (◆◆).

PROGRAMMATIC ACTION 3A: Evaluate the feasibility of expanding floodplain overflow areas in the lower Cache and Putah Creek floodplains. Such areas would include sloughs and creek channels, setback levees, and wetlands, where feasible and consistent with flood protection.

TARGET 4: Establish a desirable level of floodwater retention potential by expanding, where feasible and consistent with flood protection, the floodplain area of the Yolo Bypass, lower Cache Creek, and lower Putah Creek, and by developing off-channel water storage facilities (◆◆).

PROGRAMMATIC ACTION 4A: Cooperatively evaluate the feasibility of reoperating and modifying the Yolo Basin to increase its capacity for floodwater detention and sediment retention by reconfiguring levees, channels, and other physical constraints to large-volume flow events.

RATIONALE: *Overbank flooding is a regular occurrence in the Yolo Bypass in flood years. Proposed actions will provide this valuable process in dry and normal water years when no flooding of the Bypass would normally occur. Flooding in the Bypass sustains wetlands and provides for the transfer of considerable amounts of nutrients and organic materials to the Delta and Bay, where it serves the valuable purpose of contributing to the estuarine foodweb. Developing floodplain overflow areas and off-channel water storage facilities along lower Cache and Putah Creeks will help reduce flood damage, provide supplemental flows during the summer, and improve fish, riparian, and wetland habitats, and further contribute nutrients and organic materials to the Bay-Delta foodweb.*

Natural floodplain overflow basins and off-channel water storage facilities serve to store sediment, nutrients, and water, making them available for other uses and to the rivers at other times. The subsurface water and sediment flow and nutrient retention also help form and maintain riparian habitats, which provide spawning and rearing habitat for native resident fish during higher water periods.

Successful restoration of the Yolo Basin streams will minimally require considerable stream channel reconfiguration. The intent is to restore channels to configurations that can be retained in a natural state by the proposed flows, natural erosion and sedimentation processes, riparian vegetation succession, and gravel-sediment regimes (patterns), where feasible with flood protection and adjoining land uses.

Increasing the flood capacity of the bypass may be necessary to develop and implement future riparian habitat restoration programs. Riparian vegetation reduces flood capacity, so an effective riparian restoration program in the Yolo Basin would need to be integrated with a program to offset any potential loss by increasing capacity.

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITAT

TARGET 1: Restore riparian vegetation along Cache Creek, Putah Creek, and Yolo Bypass and Solano Ecological Management Unit channels and sloughs, where possible, to provide cover and other essential habitat requirements for native resident fish species and wildlife (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore riparian vegetation, where possible and fill gaps in forest continuity.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to protect existing riparian corridors along creeks, streams, sloughs, and channels connecting to the Delta.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to plant riparian vegetation and provide for early development until it becomes naturally self-sustaining.

PROGRAMMATIC ACTION 1D: Develop a cooperative control program for non-native riparian plants, where necessary, to promote development of healthy natural riparian corridors.

RATIONALE: *Healthy riparian corridors along creeks, sloughs, and channels, including those in the Yolo Bypass, provide essential cover, shade, and food for spawning, rearing, and migrating native resident fishes and other wildlife.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for American River Basin Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of streams in this zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Screen all diversions in the Yolo Bypass channels and sloughs (◆◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of screening diversions in the Yolo Bypass with positive-barrier fish screens.

RATIONALE: *Reducing loss of juvenile salmon, steelhead, native resident fishes, nutrients, organic debris, and aquatic invertebrates is essential to restoring salmon, steelhead and native resident fish populations to the Yolo Bypass. Unscreened diversions are a significant threat to downstream migrating juvenile salmon and steelhead in late winter and early spring, and to oversummer rearing steelhead in upstream rearing areas. Salmon and steelhead populations from the upper Sacramento River watersheds will benefit from reduced stranding losses in the Yolo Bypass.*

DAMS AND OTHER STRUCTURES

TARGET 1: Improve fish passage between the Delta and spawning grounds in the upper watersheds (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of constructing fish passage facilities at the Grays Bend-Old River-Fremont weir complex at the upper end of the Yolo Bypass.

PROGRAMMATIC ACTION 1B: Evaluate the feasibility of providing fish passage at the Solano Diversion Dam.

RATIONALE: *During floods, large numbers of adult late-fall-, winter-, and spring-run chinook salmon, as well as winter- and spring-run steelhead from the upper Sacramento River watersheds, migrate upstream through the Yolo Bypass. As floodwaters recede, some of these fish are delayed or stranded behind the Fremont weir. Additional releases from the Colusa basin drain and Fremont weir will further aggravate this existing problem. Ensuring fish passage into upper Sacramento River watersheds from the Yolo Bypass is essential to restoring these wild salmon and steelhead runs to the Sacramento River basin.*

Providing fish passage at Solano Diversion Dam would allow salmon and steelhead passage into the cold tailwaters of Monticello Dam. The interdam reach - several miles of high quality riparian and shaded riverine aquatic habitat - currently supports wild trout and stocked trout fisheries. With appropriate spawning gravels, the 12-mile reach between Solano Diversion Dam and Monticello Dam could provide good spawning and rearing habitat for salmon and steelhead. This reach offers excellent habitat for oversummer rearing of juvenile steelhead.

GRAVEL MINING

TARGET 1: Protect, enhance, and restore natural gravel recruitment within the active floodplain and remnant gravel pits (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to incorporate remnant gravel pits into active creek floodplains to increase the channel area and restore natural channel configurations, while providing for the maintenance of flood capacity and protection of adjoining land uses.

RATIONALE: *There are remnant gravel mining effects in lower Cache and Putah Creeks. Restoring the natural channels by integrating remnant pits with the active floodplain will ensure that juvenile native resident fish are not stranded in ponds and exposed to the unnatural levels of predatory fish that reside in these ponds. Increasing the width and variation of the channel in those areas altered by former gravel mining operations will restore gravel recruitment to the river and allow for the development of more natural and stable stream channels and riparian habitat.*

INVASIVE RIPARIAN AND MARSH PLANT SPECIES

TARGET 1: Reduce populations of invasive non-native plant species that compete with the establishment and succession of native riparian vegetation along Cache Creek and Putah Creek. This will help to reestablish native riparian vegetation in floodplains, increase SRA cover for fish, and increase habitat values for riparian-associated wildlife (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to monitor the distribution and abundance of non-native plants and develop cooperative control programs as needed.

RATIONALE: *Non-native plant species, such as false bamboo, salt cedar, eucalyptus, water hyacinth, and pepperweed, can undermine riparian habitat value to fish and wildlife, as well as the natural plant succession that contributes to the physical character of the riparian corridors.*

PREDATION AND COMPETITION

TARGET 1: Reduce predation and competition on native fish species (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to modify the stream channel and improve aquatic habitats. (*Refer to recommendations for streamflow, sediment supply, floodplain, and contaminants.)*

RATIONALE: *Habitat alteration often provides a competitive advantage to non-native fish species and native fish species decline as a result of poor habitat, predation, and competition for limited nutrients and habitat. Reducing the adverse effects of non-native species can be achieved by a program to restore ecological processes, habitats, and reducing other stressors to the extent possible.*

CONTAMINANTS

TARGET 1: Restore and maintain water quality in the Cache Creek watershed(◆◆).

PROGRAMMATIC ACTION 1A: Identify the sources and reduce the amounts of mercury and other contaminants coming into the watershed from upstream sources.

TARGET 2: Restore and maintain water quality in the Putah Creek Watershed (◆◆).

PROGRAMMATIC ACTION 2A: Develop and implement a Streamkeeper program on Putah Creek.

RATIONALE: *Implementing a "Streamkeeper Program" on Putah Creek would provide an effective means by which to monitor a variety of environmental factors that influence the watershed health below Monticello Dam. In addition to collecting water samples for chemical analysis a streamkeeper could (1) monitor telemetered stream gauges, (2) conduct frequent site visits, (3) identify and plan restoration projects, (4) provide local public outreach with private landowners, (5) monitor the native resident fishery, (6) act as a watchdog for the creek, and (7) provide useful information local government, and state and federal agencies regarding the health of Putah Creek.*

STRANDING

TARGET 1: Prevent adult salmon and steelhead stranding in the Yolo Bypass during their upstream migrations (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of constructing fish passage facilities at the Grays Bend-Old River-Fremont weir complex at the upper end of the Yolo Bypass.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to construct a weir or screen at the lower end of the Knights Landing Ridge Cut Canal to keep adult salmon and steelhead from migrating upstream into the Colusa basin drain.

RATIONALE: *The stranding and subsequent losses of juvenile and adult fish in the Yolo Basin Ecological Management Zone have been observed in past years. Additional information is required to identify effective measures to reduce or eliminate these losses. Potential measures need to be consistent with the overall goal of restoring processes, habitats and species while maintaining or improving flood control capacity of the system.*

REFERENCES USED TO DEVELOP THE VISION FOR THE YOLO BASIN ECOLOGICAL MANAGEMENT ZONE

California Department of Fish and Game. 1955. Letter from L. Shapovalov, Senior Fisheries Biologist, to R.E. Dedrick, dated March 2, 1955.

California Department of Fish and Game. 1993. Restoring Central Valley Streams: a plan for action. November 1993.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead:

Status of Knowledge, Review of Existing Programs, and Assessment of Needs. *in* Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. App. VII-A-11.

Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

Trihey & Associates. 1996. Native species recovery plan for lower Putah Creek, California. Trihey & Associates, Concord, California. January 29, 1996.

U.S. Fish and Wildlife Service. 1996. Recovery plan for the Sacramento/San Joaquin Delta native fishes. U.S. Fish and Wildlife Service November 1996.

U.S. Fish and Wildlife Service. 1997. Revised draft anadromous fish restoration plan: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

Yolo County. 1996. Cache Creek Resources Management Plan and Cache Creek Improvement Program. August 1996.

Yolo County Resource Conservation District. 1995. The Willow Slough Watershed Integrated Resource Management Plan.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: Final report to Congress, vol.III. Centers for Water and Wildland Resources, Univ. Cal. Davis. pg. 309-361.

◆ Eastside Delta Tributaries Ecological Management Zone

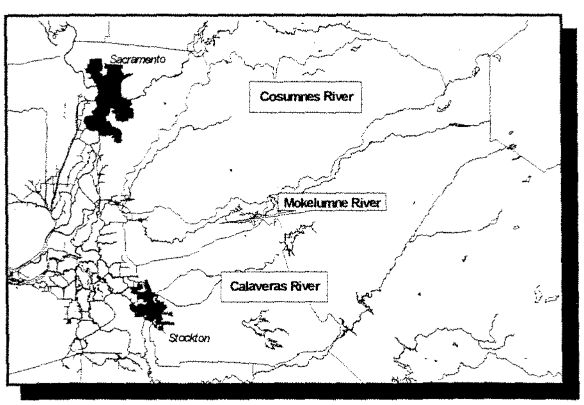
Introduction

The health of the Delta is closely linked to the health of its component watersheds. The major watersheds contributing streamflow to the Delta include the Sacramento River, San Joaquin River, and the eastside Delta tributary streams. Cumulatively, these provide over 95% of the annual freshwater inflow to the Delta and provide migration, spawning, and rearing habitat for resident, anadromous, and some estuarine fish that depend on a healthy Delta ecosystem. The eastside Delta tributary streams can support increased abundances of resident, anadromous, and estuarine fish, such as steelhead, chinook salmon, and splittail, which will, in turn, contribute to the overall Delta health.

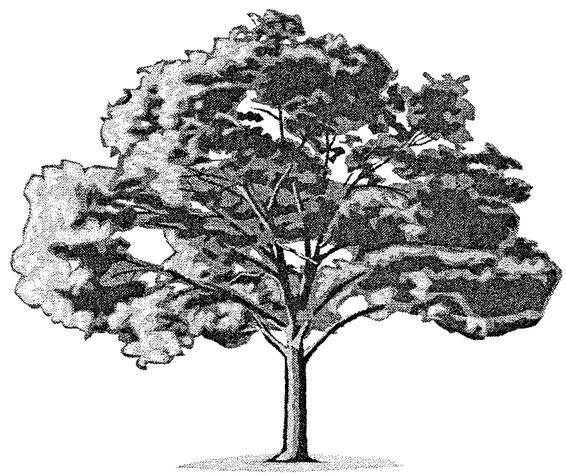
Description of the Management Zone

The Eastside Delta Tributaries Ecological Management Zone includes the three major tributaries entering the Sacramento-San Joaquin Delta on its east side:

- Cosumnes River Ecological Unit,
- Mokelumne River Ecological Unit, and
- Calaveras River Ecological Unit.



Location Map of the Eastside Tributaries Ecological Management Zone and Units.



Important ecological processes within the Eastside Delta Tributaries Ecological Management Zone include streamflow, stream meander, gravel recruitment and cleansing, sediment transport, flood and floodplain processes, and water temperature. Important habitats include seasonal wetlands 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 zone and on complementary restoration actions in the Sacramento-San Joaquin Delta Ecological Management Zone. The confluences 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.

Notable stressors to ecological functions, processes, habitats, and resources within the zone include:

- altered instream flows,
- altered water temperature regimes,
- separation of rivers from their floodplains,
- interruption of gravel recruitment and cleansing processes,
- reduced sediment transport,
- poor land use and livestock grazing practices,
- high levels of predation on juvenile salmonids,
- entrainment of aquatic organisms in water diversions,
- restriction of fish passage at dams and diversion structures,
- input of contaminants,
- illegal salmon and steelhead harvest, and
- riparian vegetation removal.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE EASTSIDE DELTA TRIBUTARIES ECOLOGICAL MANAGEMENT ZONE

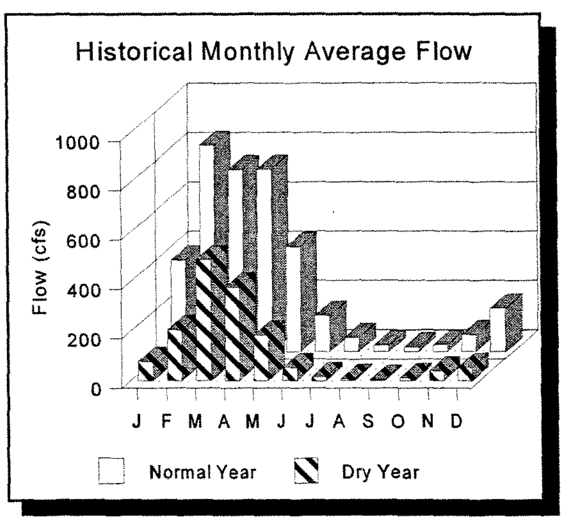
- splittail
- chinook salmon
- steelhead trout
- native resident fishes
- giant garter snake
- western pond turtle
- Swainson's hawk
- greater sandhill crane
- waterfowl
- plants and plant communities.

DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

COSUMNES RIVER ECOLOGICAL MANAGEMENT UNIT

The Cosumnes River, with a watershed of approximately 1,265 square miles, drains the Sierra Nevada foothills and joins the Mokelumne River north of Thornton in the Delta. Flow records are available for Michigan Bar (535-square mile watershed), located near the base of the foothills as the river flows onto the valley floor. The Sly Park Dam (Jenkinson Lake) has a capacity of 40,000 acre-feet on the North Fork Cosumnes, with a watershed of 60 square miles. Releases are primarily into the Camino conduit for irrigation in Cosumnes and South Fork American River basins (average of about 25 cubic feet per second [cfs]). There are no other major impoundments in the Cosumnes River watershed, although several agricultural diversions are located between Michigan Bar and Thornton. Due to the low elevation of its headwaters, the river receives most of its water from rainfall rather than snowmelt. The entire Cosumnes River watershed is included in this Ecological Management Zone from its headwaters to the confluence with the Mokelumne River. The Cosumnes River floodplain lies primarily within the legally defined Delta boundary.

The Cosumnes River natural streamflow pattern is typical of Sierra foothill streams, with high late winter and early spring flows, moderate late spring flows, and very low summer and fall flows. Annual flows also vary greatly. Peak flows occur

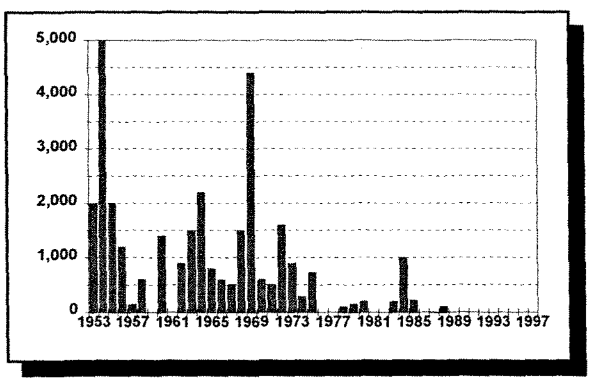


Cosumnes River Streamflow, 1962-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

from February through April. In years with the highest rainfall, average monthly winter and early spring flows range from 4,000 to 6,000 cfs, but only from 80 to 120 cfs in August and September. In driest years, flows peak at only 30 to 50 cfs from February to May, while flows the remainder of the year are 0 to 20 cfs. Average monthly late winter and early spring flows in dry and normal years range from 400 to 800 cfs.

The historic flows at Michigan Bar are very similar to unimpaired flows, because there are limited diversions from the upper watershed, and Jenkinson Lake does not provide substantial regulation of winter and spring runoff.

During the 1950s, the Cosumnes River supported an average annual run of approximately 5,000 fall-run chinook salmon. During recent years, it has been estimated that the average annual run consists of 100 fish or less. The river has extensive gravel areas suitable for chinook salmon spawning and provides good rearing conditions for juvenile salmon. Spawning areas are located between Michigan Bar and Sloughhouse. Chinook salmon have been observed in the 40 miles of stream from the mouth to Michigan Bar. A natural migration barrier is located upstream from Michigan Bar.



Fall-run Chinook Salmon Returns to the Cosumnes River, 1953-1997.

Low natural streamflow in summer and fall, particularly in low rainfall years, is the primary factor limiting the salmon run size in the Cosumnes River. In many years, the early portion of the run experiences difficulty negotiating the shallow bar and shoal areas, as well as high water temperatures. Only during normal and wet water years are winter and spring flows usually adequate for juvenile salmon emigration. Typically, 35 miles of the river between Twin Cities Road and Highway 16 are dry during the summer to early fall months.

Historically, the Cosumnes River overflowed its banks and deposited sediments, primarily sand, which formed natural levees. The area downstream of Wilton Road also had a mosaic of riparian (waterside) forest and freshwater emergent wetlands, whereas today, only remnant stands of valley oak woodlands remain.

Presently, the lower Cosumnes River between Dillard Road and Twin Cities Road is extensively leveed. Levees extend 15.8 miles along the right bank (facing downstream) and 3.6 miles along the left bank.

There are no water storage reservoirs on the mainstem Cosumnes River, and streamflows are altered primarily due to numerous small water diversions. There is one diversion dam (Granlees Diversion Dam) on the river, located approximately 1 mile upstream from the Highway 16 crossing. This dam has two functional fishways. In addition, there are 157 registered appropriative water rights on the river. Most water is diverted out of the river from the first rains in the fall through early summer. This is the period when fall-run chinook salmon most need high flows.

Groundwater pumping is apparently the cause of a significant decline in the local groundwater table. This decline is responsible for the number of days of very little to no flow in the Cosumnes River, increasing from 82 days for water years 1942 through 1961 to 104 days for 1942 through 1982. Daily average flow data for the lower Cosumnes River have not been available since 1982, and the present number of very low to no flow days is probably greater. The decline in the groundwater table in the vicinity of the Cosumnes

River and the increased days of very little to no flow limit access to the river by fall-run chinook salmon as they enter, or try to enter, the river in October and November.

Other factors limiting anadromous fish production in this ecological management zone include streambed incision and loss of spawning gravel due to the effects of levees, blocked upstream fish passage at small dams, entrainment of young salmon at water diversions, general climatic variations, oceanic conditions, and commercial and recreational fish harvest.

Opportunities to restore fall-run chinook salmon in the Cosumnes River are limited. The major limiting factor is low or no flows in the lower river during the early upstream migration period (late September and October). In years when winter rains are late or lacking, salmon are not able to swim up the river and spawn.

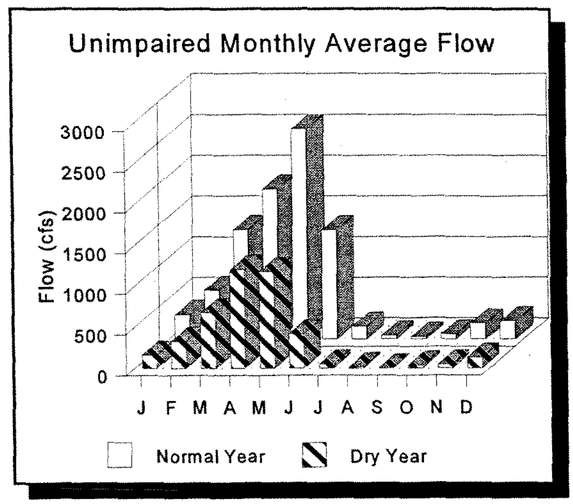
The lower Cosumnes River area also provides wintering habitat for greater sandhill cranes, roosting and foraging habitat for Swainson's hawk, and terrestrial and aquatic habitat for giant garter snake and western pond turtle.

Riparian habitat and channel conditions are affected by an extensive system of private levees along the lower Cosumnes River that are set close to the active channel. These levees are substandard and were breached in 14 locations during the January 1997 flood. Levee and channel maintenance often requires riparian vegetation removal.

MOKELUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

The Mokelumne River, the largest eastside Delta tributary, drains approximately 661 square miles, with its headwaters at 10,000 elevation feet on the Sierra Nevada crest. Downstream of the town of Thornton, the river splits into the North and South Fork channels. The Delta Cross Channel and Georgiana Slough divert water from the Sacramento River into the North Fork Mokelumne River channel. The river enters the lower San Joaquin River northwest of Stockton. The median historical unimpaired runoff is 696,000 acre-feet (af), with a range of 129,000 to 1.8 million af.

The Mokelumne River has had a long history of water development. Three major impoundments in the watershed, with a combined storage capacity of more than 750,000 af (Camanche, Pardee, and Salt Springs Reservoirs), now control releases to the lower Mokelumne River. In 1929, East Bay Municipal Utility District (EBMUD) constructed Pardee Reservoir and the Mokelumne Aqueduct to supply water to 1.2 million people living in 20 cities and 10 unincorporated areas in Contra Costa and Alameda counties. The reservoir has a capacity of 197,590 af and the aqueduct can carry about 500 cfs from Pardee Reservoir. Camanche Dam, constructed in 1964 by EBMUD, is now the upstream boundary for anadromous fish migration.

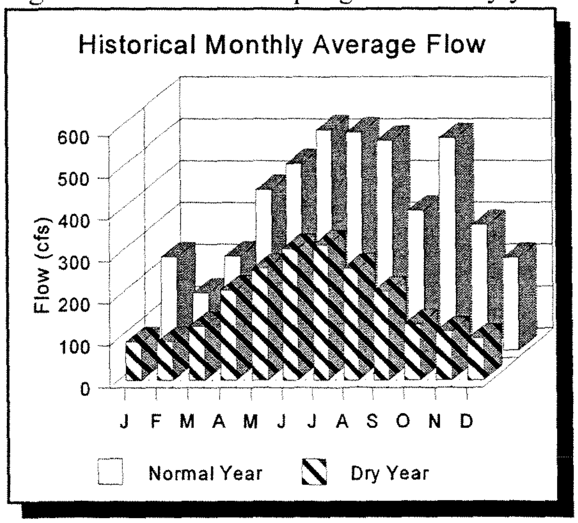


Mokelumne River Unimpaired Streamflow at Pardee, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Camanche Reservoir, with a capacity of approximately 417,120 af, provides seasonal storage for downstream diversions and instream flows. Downstream of Camanche Reservoir, developments include both hydroelectric and irrigation facilities. At Lodi, the Woodbridge Diversion Dam supplies water to the eastern Delta agricultural area.

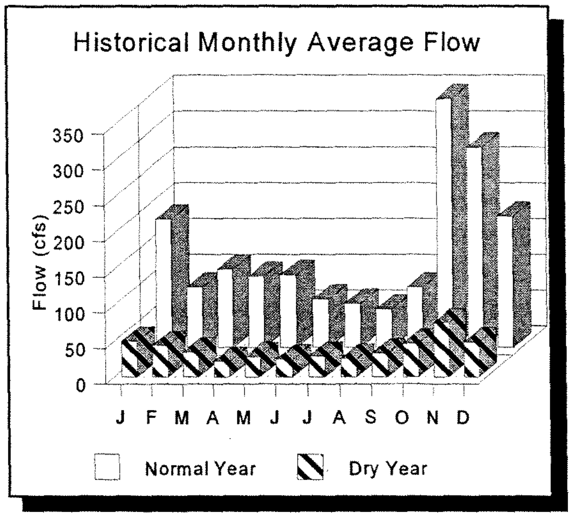
The natural Mokelumne River streamflow pattern is typical of streams in the central Sierra, with high spring flows, very low summer and fall flows, and moderate winter flows. Total annual inflow also varies greatly. Peak inflows occur in April and May. In years with the highest rainfall, average monthly inflows range from 4,000 to 6,000 cfs from January through June, but from only 200 to 500 cfs in August and September. In driest years, inflows peak at only 600 to 1,000 cfs in April and May, while summer and fall inflows are 0 cfs, and winter inflows are only 30 to 150 cfs. Typical average monthly spring inflows in dry and normal years range from 500 to 2,500 cfs.

Pardee and Camanche Dams have markedly changed streamflow in the lower Mokelumne River below Camanche Dam. Winter and spring flows have been greatly reduced in all but high rainfall years, while summer and fall flows have increased. Flows in years with the highest rainfall range from 1,400 to 2,800 cfs in summer and fall, and from 2,700 to 5,100 cfs in winter and spring. In driest years, spring and summer flows range from 120 to 250 cfs, while fall and winter flows range from 30 to 90 cfs. Spring flows in dry years



Mokelumne River Flow below Camanche Dam, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

have declined from the 400 to 1200 cfs range to the 100-300 cfs range. Normal rainfall year spring flows have declined from the 1,400 to 2,600 cfs range to the 200-500 cfs range.

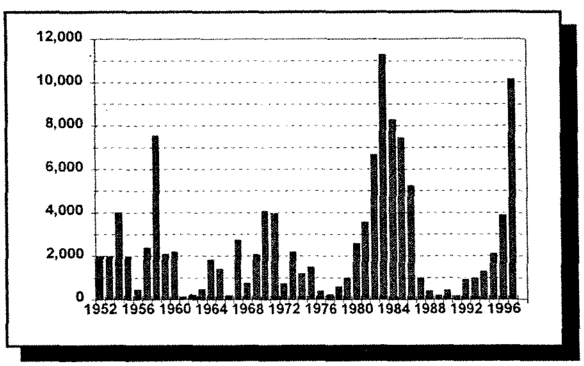


Lower Mokelumne River Flow at Woodbridge, 1972-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Irrigation diversions along the Mokelumne River below Camanche Dam reduce the flow in the river during the irrigation season, typically late March through October. The largest diversion is at Woodbridge Diversion Dam near Lodi, approximately 15 miles upstream from the Delta. Streamflow below Woodbridge Diversion Dam is low in all but wet years, which is similar to the historic flow pattern in the lower Mokelumne River in late summer and fall. In driest years, monthly average flows range from 5 to 40 cfs. Average monthly flows in dry years range from 20 to 80 cfs. In normal flow years, spring and summer flows range from 50 to 100 cfs. Fall flows in normal to wet years range from approximately 200 to 800 cfs.

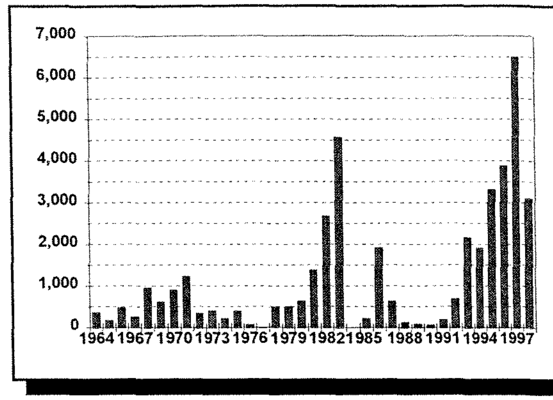
Fall-run chinook salmon and steelhead occur in the Mokelumne River below Camanche Dam. American shad and striped bass also occur in the river below Woodbridge Irrigation Dam. Highly variable flow and habitat conditions in the lower river have resulted in widely varying population levels of all these species. Before the completion of Camanche Dam in 1964, chinook salmon spawned primarily between the town of Clements and the canyon about 3 miles below Pardee Dam, with a few fish spawning upstream in the canyon below Pardee Dam and downstream between Clements and Lockeford.

Mokelumne River chinook salmon and steelhead populations have failed to consistently achieve population levels believed possible following the completion of Camanche Dam. The fall-run chinook salmon population reached a peak of slightly more than 11,000 in 1983, but declined to less 410 spawners in 1991. (Note: The 11,000 spawner estimate is not considered a reliable estimate as it was the result of an extrapolation of a hatchery vs naturally spawning chinook escapement regression line.) Since the 1987 through 1992 drought, the population rebounded to about 7,775 spawners in 1996.



Naturally Spawning Fall-run Chinook Salmon Returns to the Mokelumne River, 1952-1997.

Presently, the majority of salmon spawning takes place in the 5 miles between Camanche Dam and Mackville Road, with 95% of the suitable spawning habitat within 3.5 miles of the dam. Instream flow releases following the completion of Camanche Dam provided insufficient habitat for anadromous fish spawning, rearing, and outmigration. Water temperature in the Mokelumne River below Camanche Dam, which is important for steelhead rearing, changes downstream because of flow releases from the dam.



Fall-run Chinook Salmon Returns to Mokelumne River Fish Installation, 1964-1998.

he California Department of Fish and Game (DFG) (1993) recommended substantial increases in flow releases, with specific monthly flows in wet, normal, and dry years ranging from approximately 100 cfs to 450 cfs, along with temperature objectives during the summer steelhead rearing period. The U.S. Fish and Wildlife Service (USFWS 1997) recommended evaluation of spring flows to assist the outmigration of juveniles. USFWS (1997) also recommended improving fish passage at Woodbridge Dam and replenishing spawning gravels. However, neither flow recommendation was based on modeling results that considered water supply, water quality, and water temperatures.

EBMUD prepared a comprehensive management plan for the lower Mokelumne River in 1992 that includes additional instream flows and non-flow enhancement components. The Plan was implemented voluntarily by EBMUD in 1993 and the Plan was further improved by implementing components of the FERC Settlement Agreement in 1996.

Unscreened or poorly screened diversions along the lower Mokelumne River contribute to the poor salmon and steelhead production on the river. Juvenile salmon and steelhead losses occur at the Woodbridge Irrigation District water diversion at Woodbridge Canal due to inadequate screening. The North San Joaquin Water Conservation District diversion, the second largest single diversion below Camanche Dam, is unscreened. There are also numerous unscreened small irrigation diversions on the lower Mokelumne River.

Woodbridge Dam also provides conditions for predators, such as birds, squawfish, and striped bass, to prey on juvenile salmonids that pass downstream over the dam or through the fish ladder. The dam also impedes upstream adult salmon and steelhead passage.

The amount and condition of spawning and rearing habitat below Camanche Dam may limit the chinook salmon and steelhead populations, although based upon the results of fisheries monitoring studies conducted since 1991, EBMUD has seen no evidence that rearing habitat is limiting in the lower Mokelumne River. Spawning habitat for chinook salmon and steelhead is limited below Camanche Dam, because gravel transport down the river has been disrupted by Camanche and Pardee Dams. Also, the stream channel has become armored in many places from lack of new gravels, low streamflows, and levees constructed for flood control. The river supported 3,892 chinook salmon spawners in 1996 and gravel restoration since 1990 has increased the carrying capacity by 300 spawning female salmon (Setka 1997). Rearing habitat suffers from a lack of riparian shade vegetation and cover. There has also been a significant loss of riparian and riverine aquatic vegetation along the lower river. In many years, including dry years, water temperatures are purposely increased by drawing water off the epilimnion to provide optimum salmonid rearing temperatures downstream of Camanche Dam. This is done to increase growth rates and speed smoltification so chinook salmon will move through the Delta before being affected by high late spring water temperatures in the Delta.

As mitigation for the loss of spawning habitat between Camanche and Pardee Dams, EBMUD constructed a hatchery below Camanche Dam. The river below the hatchery was expected to provide habitat for 5,000 chinook salmon and the hatchery would produce 100,000 steelhead. From 1964 through 1988, the hatchery received an average annual return of 490 adult salmon and 28 adult steelhead. This has improved in recent years with an average annual hatchery return of 1,528 chinook salmon during 1989-1996.

CALAVERAS RIVER ECOLOGICAL MANAGEMENT UNIT

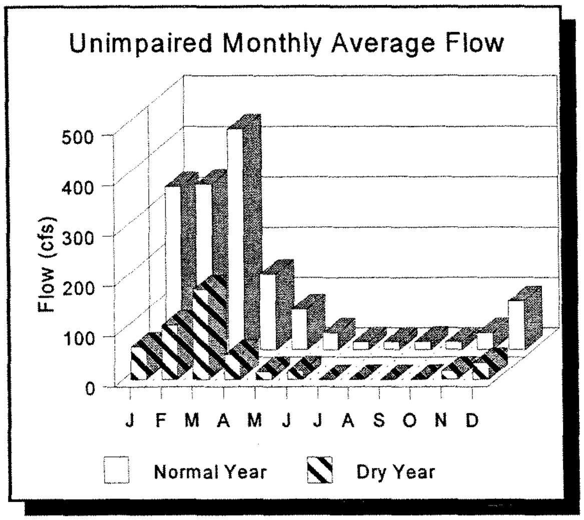
The Calaveras River enters the San Joaquin River at Stockton, draining approximately 362 square miles in the foothills south of the Mokelumne River with an average annual runoff of 166,000 af. The river flows through Stockton and enters the San Joaquin River channel in the Delta. The ecological unit includes the lower Calaveras River from New Hogan Dam to the confluence with the lower San Joaquin River.

Flows on the Calaveras River are controlled by New Hogan Dam, constructed in 1964 by the U.S. Army Corps of Engineers (Corps) and operated by the U.S. Bureau of Reclamation (Reclamation). The conservation yield from the reservoir, with a gross pool capacity of approximately 325,000 af, is contracted for municipal and agricultural use to Calaveras County Water District and Stockton East Water District. The dam and reservoir are located in western Calaveras County near the town of Valley Springs.

The Calaveras River drainage is almost entirely below the effective average snow level; therefore, the area receives runoff primarily as rainfall. About 93% of the runoff occurs from November to April. The valley portion of the river historically experienced frequent periods of low or no flow in late summer and early fall. However, deep pools in the approximately 6-mile reach from the dam to the town of Jenny Lind now provide suitable summer holding areas for salmon and resident trout in all but the driest years.

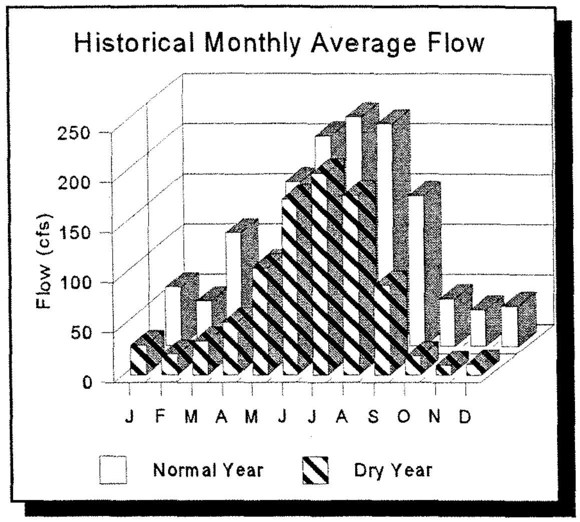
The monthly unimpaired flow pattern for the river is typical of Sierra foothill streams, with most rainfall coming in winter. Streamflow varies considerably from year to year with rainfall variations. The average annual streamflow is 240 cfs with the peak average monthly flows of 3,000 cfs in winter of wettest years. Summer and early fall flows are very low, and the channel is dry from July through October in low rainfall years.

Historical flow data below New Hogan Dam indicate a shift of the natural runoff pattern to



Calaveras River Unimpaired Streamflow at Jenny Lind, 1970-1990 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

irrigation season releases from May through September, with a slight decrease in the average flow (220 cfs) caused by evaporation and upstream diversions. Because of the relatively large capacity of New Hogan reservoir, non-irrigation releases (spills) are confined to wet years. In the highest rainfall years, average monthly flows range from 1,400 to 2,800 cfs from November through April. Irrigation season releases generally range from 150 to 250 cfs, except in the driest years, when releases only average 60 to 80 cfs from May through August. Non-irrigation season minimum flows are generally 30 to 90 cfs, except in drier years, when they average only 30 cfs or less.



Lower Calaveras River Streamflow below New Hogan Dam, 1970-1990 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Although winter-run chinook salmon were known to occur irregularly in the Calaveras River, this stock is not a focus of restoration in this ecological management zone. The Ecosystem Restoration Program Plan (ERPP) focuses on restoring or re-creating ecological processes that support sediment supply, stream channel meander, and riparian and riverine aquatic habitat and eliminating or reducing stressors. Together, the actions proposed for the Calaveras River Ecological Unit will benefit fall-run chinook salmon and other fish, wildlife, and plant resources. New Hogan Dam operations may have increased the frequency of salmon runs into the Calaveras River, despite no requirements for minimum flow releases. Since the completion of the New Hogan project, returns of winter-run chinook salmon to the river were documented in 1972, 1975, 1976 (tidewater only), 1978, 1982 (tidewater only), and 1984. Physical habitat conditions are adequate for salmon spawning and rearing, which includes abundant spawning gravel and a dense riparian canopy. Streamflow is the principal limiting factor.

Another limiting factor is loss of juvenile salmon into water diversions downstream of New Hogan

Dam. Stockton East Water District's diversion is presently unscreened. There are several other unscreened diversions along the river.

Diversion channels that carry Calaveras River water and act as migratory routes for salmon below Bellota Dam include the original Calaveras River channel, Mormon Slough, and the Stockton Diverting Canal. In some years, typically in March, partial or complete blockage of adult salmon migration coincides with placing approximately 30 temporary irrigation dams in these channels. Adult salmon are prevented from reaching deep pools and spawning gravel above Bellota Dam and are subject to poaching below the flashboard dams. Two of the diversion structures, Clements Dam and Cherryland Dam, have been identified as barriers to salmon movement. The Bellota Dam (weir) blocks upstream salmon migrants at flows below approximately 200 cfs.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Eastside Delta Tributaries Ecological Management Zone is to improve the values of the rivers and riparian zones as fish and wildlife corridors from the delta to the upland and upstream habitats; restore tidal wetlands; create and maintain permanent freshwater marshes, seasonal wetlands, floodplain habitat, spawning areas for splittail, and rearing, spawning, and foraging habitat for fall-run chinook salmon and steelhead. Elements to reach this vision include improved streamflow patterns and water temperatures, reconnecting the river with its floodplain, restoring riparian and riverine aquatic habitat, reducing loss of salmon and steelhead and other young fish at unscreened diversions, and reducing fish passage problems at diversion dams. Ecological health will be attained when levees are modified to allow seasonal floodplain inundation; chinook salmon and steelhead populations reach target levels; habitat is improved for resident native fishes, sandhill cranes, and migratory waterfowl; migration corridors are improved for aquatic and terrestrial species; and riparian and stream channel habitats are restored.

The vision focuses on improving streamflows and stream channel and gravel recruitment processes needed to support habitat for anadromous salmonids and other fish species. It also focuses on restoring tidal wetlands, floodplains, seasonal floodplain inundation, and natural flood regimes. On the lower Mokelumne River, restoration will focus on habitat for fall-run chinook salmon and steelhead. On the Calaveras River, the emphasis will be on providing the opportunity for fall-run chinook salmon to successfully spawn and providing juveniles the opportunity to successfully emigrate from the system. On the Cosumnes River, the focus will be on restoring floodplain processes, seasonally flooded habitat, tidal wetlands, splittail and chinook salmon rearing habitat, sandhill crane habitat, and establishing an extensive riparian and riverine aquatic corridor. Throughout the basin, restoring and protecting a self-sustaining, diverse riparian community will be emphasized to maintain nutrient and woody debris input to the aquatic system, enhance bank stability and stream shading, and provide valuable habitat for a variety of wildlife species.

The ERPP envisions that the fish, wildlife, and riparian needs of the East Delta Tributaries Ecological Management Zone will be met and an acceptable level of ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

COSUMNES RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Cosumnes River Ecological Unit is to restore floodplains, seasonally flooded habitat, tidal wetlands, splittail and chinook salmon rearing habitat, sandhill crane habitat, and a riparian plant community. The fall-run chinook salmon population can be sustained through improvements in streamflow, channel and floodplain morphology, spawning and rearing habitat, fish passage at diversion dams, and reducing losses to unscreened diversions and illegal harvest.

The vision for the Cosumnes River includes improved streamflow and riparian habitat, modified floodplain and channel conditions, reduced fish passage problems and unscreened diversions. These actions will improve habitat conditions for fall-run chinook salmon and other wildlife species. The flow regime is the primary factor affecting the size of the Cosumnes River salmon run. In drier years, the early portion of the run experiences difficulty negotiating the shallow bar and shoal areas.

Although there are only minor water storage reservoirs on the Cosumnes River, streamflows are reduced by numerous small water diversions and the lowering groundwater table. Most water is diverted from the first rains in the fall through early summer, coinciding with instream flow needs for fall-run chinook salmon. Minimum instream flow during the salmon spawning and rearing season may be needed. Additional streamflow is needed in dry and normal years to ensure survival of downstream migrating juvenile salmon.

Also important to restoration will be removing existing levees and constructing set back levees, implementing improved land management and livestock grazing practices along stream/riparian zones, fish passage improvements at small dams, screening water diversions, and improving gravel recruitment and riparian habitats.

Riparian and aquatic habitat quality and distribution will be improved by expanding the width of the river floodplain through a program of levee setbacks. In combination with other efforts to improve floodplain safety and levee management on the lower Cosumnes River, levee setbacks will allow natural river meanders to form and associated habitats to thrive. Greater floodplain width between levees reduces the need for channel straightening and bank armoring at the expense of aquatic and riparian habitat. Floodplain land could continue to be farmed within the levees, or conservation easements could be acquired to expand riparian forest and seasonal wetland habitats along the river.

Sandhill crane roosting and foraging habitat in the lower Cosumnes River will be protected by land acquisition through in-fee purchase or easement.

MOKELUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Mokelumne River Ecological Unit is to support self-sustaining fall-run chinook salmon and steelhead populations by improving streamflows, riparian and SRA habitat, natural sediment supply and gravel recruitment, and fish passage; reducing predation and illegal harvest; eliminating unscreened and poorly screened diversions; and improving and upgrading hatchery facilities and management strategies.

The vision for the Mokelumne River includes improved streamflow, gravel recruitment, floodplain configuration, fish passage, salmon spawning and rearing habitat, riparian habitat, screening of diversions, and enforcement of fishing regulations. Under this vision, the Mokelumne River would better support naturally spawning steelhead trout, fall-run chinook salmon, American shad, and resident native fishes. For the Mokelumne River, this means improving flows from spring through fall below Camanche and Woodbridge dams. Higher and more natural flows will help steelhead move upstream during their traditional migrations in late winter and spring. Higher flows will benefit downstream migrating juvenile fall-run chinook salmon and steelhead, as well as juvenile salmon and steelhead migrating out of the Sacramento and San Joaquin Rivers and their tributaries through the Delta. These flows will also benefit stream channel and riparian vegetation processes in the lower river, which in turn will benefit the fish.

Habitat improvements in the lower Mokelumne River will improve natural production of these same anadromous fish. Improved spawning habitat will increase young salmon and steelhead production. Improved stream channel and riparian vegetation will increase juvenile salmon and steelhead survival. Floodplain stream channel and habitat improvements will also benefit salmon and steelhead by providing valuable seasonal rearing habitat.

Calaveras River Ecological Management Unit

The vision for the Calaveras River Ecological Unit is to restore and maintain important ecological processes that support a sustainable migration corridor for fall-run chinook salmon and other terrestrial and aquatic species and their upstream habitat.

The vision for the Calaveras River includes improved streamflow, gravel recruitment, floodplain configuration, fish passage, riparian and stream channel habitat, screening of diversions, and enforcement of fishing regulations. Proper conditions will maintain more consistent fall-run chinook runs.

Restoring instream flows adequate to maintain anadromous fish habitat will be the focus element. Maintaining an adequate water temperature regime, improving fish passage at irrigation dams, and reducing entrainment at water diversions will also be important.

Physical habitat conditions are adequate for salmon spawning and rearing, including abundant spawning gravel and a dense riparian canopy. With appropriately timed flows and other improvements, fall-run chinook salmon could be maintained more consistently.

Visions for Ecological Processes

Central Valley Streamflows: Instream flows are inadequate and need to be supplemented where possible, consistent with existing agreements. Increased flows would help restore ecological processes and functions that maintain habitats for important aquatic and terrestrial species. The vision is that instream flows will be at levels that support restored ecological processes and functions that maintain important fish, wildlife, and plant communities and their habitats.

Coarse Sediment Supply: The input of sediments into the riverine systems below major dams is inadequate to maintain ecological health. The vision is that gravel recruitment, transport, and cleansing processes will be restored, reactivated, or supplemented to a level that supports habitat for anadromous and other native fish populations and sustains self-regenerating riparian and riverine plant communities.

Natural Floodplain and Flood Processes: Natural river-floodplain interaction has been impaired by the construction of dams and levees. This seasonal inundation is needed to promote ecological health and restoration of important species. The vision is that floodplains along the Cosumnes, Mokelumne, and Calaveras Rivers will be expanded, reconnected to their channels, and seasonally inundated by increased stream flows. These actions will support natural riparian regeneration and nutrient input to the Delta and help create seasonal habitat for splittail spawning and the rearing and emigration of juvenile fish.

Central Valley Stream Temperatures: High stream temperatures limit or interrupt the natural life cycle of aquatic organisms. The vision is that water temperatures below major dams will be suitable for maintaining important aquatic organisms and biological functions, such as chinook salmon and steelhead spawning, egg development, and fry and juvenile rearing and emigration.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding of leveed lands, use of the Butte Sinks's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian plant communities are important to a healthy ecosystem and contribute in many ways to sustaining fish and wildlife populations. The vision is to restore diverse, self-sustaining riparian and shaded riverine aquatic habitat along the lower reaches of the Cosumnes, Mokelumne, and Calaveras Rivers.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The streams of the Eastside Delta Tributaries Ecological Management Zone are typical of a fall chinook salmon spawning stream (Moyle and Ellison 1991). The quality of freshwater fish habitat in these streams will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Mokelumne, Cosumnes, and Calaveras rivers have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these streams include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: The vision is to contribute to adult fish survival and return by reducing the loss of juvenile aquatic organisms into water diversions.

DAMS AND OTHER STRUCTURES: The vision is to contribute to restoring chinook salmon and steelhead by improving up- and downstream fish passage at diversion structures.

INVASIVE RIPARIAN AND MARSH PLANTS: The vision is to support riparian regeneration by controlling invasive (non-native) plants so that they do not impair efforts to restore natural riparian and riverine plant communities.

PREDATION AND COMPETITION: The vision is to contribute to restoring naturally spawning chinook salmon and steelhead populations by modifying hatchery practices and instream structures to reduce rates at which juvenile salmonids fall prey to predators.

CONTAMINANTS: The vision is to reduce fish and wildlife losses due to pesticides, hydrocarbons, heavy metals, and other toxins and contaminants.

HARVEST OF FISH AND WILDLIFE: The vision is to contribute to restoring important resident, estuarine, and anadromous fish species by managing legal and illegal harvest to protect naturally spawning fish.

ARTIFICIAL PROPAGATION OF FISH: The vision is to improve and balance natural chinook salmon and steelhead production in the Mokelumne River with hatchery produced populations.

VISIONS FOR SPECIES

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species. The vision is to contribute to splittail restoration by improving the riparian and stream meander corridors and natural floodplains along the Cosumnes and Mokelumne Rivers. The value of the seasonal habitat will be improved by late-winter and early-spring streamflows to provide attraction flows for spawning adults and increased spawning habitat.

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA or CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. The vision is to assist in fall-run chinook salmon restoration by:

- improving streamflows for passage, spawning, rearing, and emigration
- improving gravel recruitment,
- providing water temperatures needed for successful egg incubation and rearing,
- increasing riparian and riverine aquatic habitat,
- reducing or eliminating unscreened diversions and sources of contaminants, and
- operating Mokelumne River Fish Facility to improve and protect naturally spawning fish.

STEELHEAD TROUT: The vision for steelhead trout is to recover this species listed as threatened under ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats. The vision is to assist in of steelhead trout restoration by:

- improving streamflows for passage, spawning, rearing and emigration,
- improving gravel recruitment,
- providing water temperatures needed for successful egg incubation and rearing,
- increasing riparian and riverine aquatic habitat,
- reducing or eliminating unscreened diversions, sources of contaminants, and
- operating Mokelumne River Fish Facility to improve and protect naturally spawning fish.

NATIVE RESIDENT FISH SPECIES: The vision for resident fish species is to increase their abundance and distribution by implementing actions to improve stream channel, floodplain, and riparian processes.

GIANT GARTER SNAKE: The vision for giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. The vision for giant garter snake is to maintain or expand existing populations by improving stream channel, floodplain, and riparian processes.

WESTERN POND TURTLE: The vision for the western pond turtle is to maintain and restore their abundance and distribution by maintaining or expanding existing populations by improving stream channel, floodplain, and riparian processes.

SWAINSON'S HAWK: The vision for Swainson's hawk is to contribute to the recovery of this State-listed threatened species. The vision for Swainson's hawk is that actions in the Eastside Delta Tributaries Ecological Management Zone to improve nesting and foraging habitat will contribute to overall species recovery.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this California species of special concern. The vision includes contributing to their recovery by improving foraging and resting habitat.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Eastside Tributaries Ecological Management Zone. Improved seasonal wetlands and floodplain/stream interactions will be beneficial not only to waterfowl but other fish and wildlife resources.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Eastside Delta Tributaries Ecological Management Zone includes near-term funding and implementing actions to achieve the targets. This includes managing water project operations, purchasing in-title or land easements from willing sellers, cooperatively developing and implementing a phased fish screening program, acquiring and placing gravel in the stream channel, and the performing engineering feasibility and design studies to improve fish passage at diversion structures.

Along with the near-term actions, the vision includes cooperation and support of existing ecosystem and species restoration efforts and programs. Parallel efforts include developing and integrating local land use plans that embrace and foster the objectives of ERPP.

Long-term efforts that will enhance the vision for the Eastside Delta Tributaries Ecological Management Zone and provide durable ecosystem restoration involve developing and implementing watershed management plans by land use agencies and evaluating flood management options.

COSUMNES RIVER PROJECT

The Cosumnes River Project is a multi-agency effort to restore and protect the Cosumnes River ecosystem. The Cosumnes River Project encompasses a 10,695-acre project area. Partners in this effort include The Nature Conservancy, Bureau of Land Management, County of Sacramento, Department of Water Resources, Department of Fish and Game, Ducks Unlimited, Environmental Protection Agency, Wildlife Conservation Board, and the American Farmland Trust. Actions sponsored by the Cosumnes River Project will complement efforts undertaken by the ERPP to restore ecological health of the Cosumnes River Ecological Unit.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the Eastside Delta Tributaries Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. The program proposed by the CVPIA will complement efforts of the USFWS' Anadromous Fish Restoration Program. The goal of the program is to double the average number of anadromous fish that was produced naturally in the system from 1967 through 1991.

CALFED BAY-DELTA PROGRAM

CALFED has funded eight ecosystem restoration projects in the Eastside Delta Tributaries Ecological Management Zone. One of the more significant projects is the design and construction of fish screens and ladders at the Woodbridge Irrigation District diversion on the Mokelumne River.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT (SB 2261)

The vision will also help the DFG reach its goal of doubling the number of anadromous fish that were produced in 1988.

JOINT SETTLEMENT AGREEMENT BETWEEN EAST BAY MUNICIPAL UTILITY DISTRICT, U.S. FISH AND WILDLIFE SERVICE, AND CALIFORNIA DEPARTMENT OF FISH AND GAME

This agreement protects and maintains the purpose of the EBMUD's Mokelumne River Project, protects the anadromous fishery and lower Mokelumne River ecosystem, and encourages cooperative action to achieve and maintain the objectives. The agreement contributes to the overall effort to improve the ecological health of the Mokelumne River Ecological Unit by establishing a $2 million partnership fund, encouraging voluntary participation of local interests, establishing a lower Mokelumne River stakeholders group, and recommending ecosystem protection and improvement priorities.

Efforts in the Eastside Delta Tributaries Ecological Management Zone will require cooperation from resource agencies, such as DFG, the California Department of Water Resources (DWR), California Department of Forestry and Fire Protection, State Water Resources Control Board, USFWS, USFS, U.S. Bureau of Land Management and the National Marine Fisheries Service (NMFS), as well as participation and support from the Corps, Reclamation, Natural Resource Conservation Service, other private organizations, water districts, and individual land owners. These groups are expected to work together to restore and maintain ecosystem health in this zone. This program may provide funding for the restoration measures included in the visions.

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 Eastside Delta Tributaries Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this ecological management zone.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

The ecosystem health of the Eastside Delta Tributaries Ecological Management Zone depends on conditions in the Sacramento-San Joaquin Delta Ecological Management Zone. Because these tributaries are directly linked to the Delta, stressors there (entrainment, water quality) have a significant effect on resources, such as anadromous fish, in this zone. Conditions in San Francisco Bay and the Pacific Ocean can also have a significant effect on anadromous fish.

Reducing or eliminating stressors in the downstream ecological management zones will be important in restoring healthy fish and wildlife communities in the Eastside Delta Tributaries Ecological Management Zone.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: For the Cosumnes River, where a natural streamflow pattern presently exists with natural winter and spring streamflows, the target is to maintain or restore natural summer and fall base flows (◆◆).

Programmatic Action 1a: Improve summer and fall base flows on the Cosumnes River by developing new water supplies along the river and by purchases from willing sellers.

Programmatic Action 1b: Cooperatively develop a program to minimize or eliminate unpermitted water diversions on the Cosumnes River, and review water allocation for the entire basin.

Programmatic Action 1c: Cooperatively develop a groundwater replenishment program to raise the water table in the Cosumnes River floodplain.

Target 2: The target for the Mokelumne River is to provide conditions to maintain the fishery and riparian resources in good condition by implementing and evaluating the flow regime in the Joint Settlement Agreement (JSA) for Mokelumne River. The JSA provides increased flows below Camanche Dam beyond present requirements, which will benefit the fishery and riparian resources of the lower Mokelumne River (◆◆◆).

Programmatic Action 2a: Provide target flows for Mokelumne River storage releases, but only if there are sufficient inflows into storage reservoirs and carryover storage to meet target levels. The additional water would be obtained by developing new water supplies within the Central Valley basin, water transfers, and from willing sellers.

Programmatic Action 2b: Maintain or enhance summer and fall base flows on the Mokelumne River by developing new water supplies and by purchases from willing sellers.

Target 3: The target also is to provide enhanced streamflows below Woodbridge Dam by providing minimum flows recommended by DFG in dry years: 200 cfs from November 1 through April 14; 250 cfs from April 15 through April 30; 300 cfs in May; and 20 cfs from June 1 through October 31. In normal years, minimum flows should be 250 cfs from October 1 through October 14; 300 cfs from October 15 through February 29; 350 cfs during March; 400 cfs during April; 450 cfs during May; 400 cfs during June; 150 cfs during July; and 100 cfs during August and September. In wet years, minimum flows should be 300 cfs from June 1 through October 14; 350 cfs from October 15 through February 29; 400 cfs in March; and 450 cfs during April and May (◆).

Programmatic Action 3a: Cooperatively evaluate the potential for minimizing water supply impacts by replacing the diversions at Woodbridge with other Delta diversions.

Programmatic Action 3b: Cooperatively develop a program to minimize or eliminate unpermitted water diversions on the Mokelumne River.

Target 4: A flow event should be provided in late April or early May, averaging 500 to 1,000 cfs in dry years, 1,000 to 2,000 cfs in normal years, and 2,000 to 2,500 cfs in wet years (◆).

Programmatic Action 4a: Develop a cooperative feasibility study of opportunities to provide spring flow events.

Target 5: For the Calaveras River, where the natural streamflow has been greatly altered, streamflows should be enhanced below New Hogan Dam by the minimum flows recommended by DFG (◆).

PROGRAMMATIC ACTION 5A: Provide target flows for the Calaveras River from storage releases, but only if there are sufficient inflows into storage reservoirs and carryover storage to meet target levels. The additional water would be obtained by developing new water supplies within the Central Valley basin, water transfers, and from willing sellers.

PROGRAMMATIC ACTION 5B: Cooperatively develop a program to minimize or eliminate unpermitted water diversions on the Calaveras River.

PROGRAMMATIC ACTION 5C: Cooperatively evaluate the potential for resizing criteria at New Hogan Reservoir on the Calaveras River to yield additional water for instream flow needs while maintaining or improving flood control requirements.

PROGRAMMATIC ACTION 5D: A flow event should be provided in late February or early March, averaging 100 to 200 cfs in dry years, 300 to 400 cfs in normal years, and 600 to 800 cfs in wet years. Such flows would be provided only when inflows to New Hogan Reservoir are at these levels

RATIONALE: *Inadequate instream flows have been identified as a limiting factor for anadromous fish and other aquatic resources in the eastside Delta tributary streams. For example, the Cosumnes River receives most of its water from rainfall due to the low elevation of its headwaters and the lower reaches of the river are often dry until the fall rains occur. As a result, adult fish must await the runoff following rains in late October and November before ascending to the spawning areas between Michigan Bar and Sloughhouse. Although there are no water storage reservoirs on the Cosumnes River, there are 157 registered appropriative water rights (U.S. Fish and Wildlife Service 1995). Most water is diverted from the first rains in the fall through early summer, coinciding with instream flow needs for fall-run chinook salmon. USFWS recommended an evaluation of instream flow requirement to ensure adequate flows for all life stages of all salmonids.*

DFG (1993) recommended revised minimum flow schedules for the lower Mokelumne River. In 1996, the Principles of Agreement was signed between EBMUD and the resource agencies. The POA provides significantly improved fish flows for the Mokelumne River (including higher minimum flows below Camanche Dam) and gainsharing for additional flows between EBMUD and the environment. It incorporates a broader ecosystem approach for managing the Mokelumne River resources.

The JSA flows for the Mokelumne River follow.

- *In normal and above normal water years, the agreed upon flows at Camanche Dam are 325 cfs from October 1 to June 30, 100 cfs in July, August, and September.*
- *In below normal years, the agreed upon flows at Camanche Dam are 250 cfs from October 1 through June 30, and 100 cfs in July, august and September.*
- *In dry years the agreed upon flows at Camanche Dam are 220 cfs from October 1 through May 31, and 100 cfs in June, July, August, and September.*
- *In critically dry years the recommended flows at Camanche Dam are 100 cfs from October 1 through 15, 130 cfs from October 16 through April 30, and 100 cfs in May, June, July, August, and September.*

Although the 1993 DFG flows for the Mokelumne River are presented as enhancement targets to be achieved when possible, these target levels need further review and should be a subject of adaptive *management and focused research. The DFG flows were not developed with full consideration of upstream water quality, reservoir storage, and water temperatures, which need to be addressed for a finer assessment of water availability. The target flows, however, provide a possible target for further enhancement of the Mokelumne resource.*

The Calaveras River drainage is almost entirely below the effective average snow level and thus receives runoff primarily as rainfall. Historically, the valley portion of the river commonly experienced periods of low or even no flow for many days or weeks in the late summer and early fall (California Department of Fish and Game 1993). Chinook salmon runs into the river were known to occur irregularly. There are currently no requirements to maintain flow releases for fishery purposes.

A preliminary instream flow study (U.S. Fish and Wildlife Service 1993) indicated that between 50 and 225 cfs, depending on time of year and water year type, is needed to provide spawning and rearing habitat for chinook salmon. A complete instream flow incremental methodology study is needed, however, to further define flow needs. Since the Calaveras River water supply is already over-allocated, the means of providing additional instream flows also need to be considered. The resizing of flood control criteria at New Hogan Reservoir has the potential to yield additional water to meet instream flow needs.

COARSE SEDIMENT SUPPLY

TARGET 1: On the Mokelumne River below Camanche Dam, provide annual supplementation of 1,200 to 2,500 cubic yards of gravel into the active stream channel to maintain quality spawning areas and to replace gravel that is transported downstream (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate, implement, and monitor sediment supplementation on the Mokelumne River, consistent with adaptive management.

TARGET 2: On the Calaveras River, provide for the annual recruitment of 500 to 1,000 cubic yards of gravel into the active stream channel (◆◆).

PROGRAMMATIC ACTION 2A: Cooperatively develop a program to protect all existing gravel recruitment sources to the rivers.

PROGRAMMATIC ACTION 2B: Develop a cooperative program to supplement gravel with artificial introductions.

PROGRAMMATIC ACTION 2C: Develop a cooperative program with the aggregate (sand and gravel) resource industry to improve extraction activities within the Mokelumne River floodplain.

TARGET 3: Restore gravel transport and cleaning processes to attain sufficient high quality salmon spawning habitat in each of the three streams for target population levels (◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to provide late winter or early spring flow events, as needed, to establish appropriate flushing/channel maintenance flows.

PROGRAMMATIC ACTION 3B: Facilitate fine sediment transport by restoring, as necessary, the river channel configuration so that it is consistent with planned flow regime and available sediment supply.

PROGRAMMATIC ACTION 3C: Develop a cooperative program to improve the flexibility of upstream reservoir management to minimize fine sediment inputs to the lower Mokelumne and Calaveras Rivers.

PROGRAMMATIC ACTION 3D: Develop a cooperative evaluation of mechanically cleaning spawning gravel at selected sites in lower Mokelumne and Calaveras Rivers.

PROGRAMMATIC ACTION 3E: Develop a cooperative program on the Cosumnes River to relocate sand and gravel extraction activities to areas beyond the natural stream meander corridor.

TARGET 4: Restore channel gradient and stream profile in the Cosumnes River between Twin Cities Road and Highway 16 (◆◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative program to assess the feasibility of reversing head cutting and stream channel incision in the Cosumnes River.

RATIONALE: *Recruitment of suitable salmonid spawning gravel below Camanche Dam on the Mokelumne River is minimal. Most gravel present is in the small range of the preferred sizes used by spawning chinook salmon. Targeted levels are to maintain processes linked to sediment supply, stream channel meander, and riparian and riverine aquatic habitat. This program will be subject to adaptive management, focused research, and monitoring, and thus is considered short-term until a more detailed evaluation is completed.*

Flood stage for the lower Mokelumne River is 5,000 cfs. Preliminary data suggest that spawning-sized gravel for adult salmonids (DFG 1991, Bjorn and Reiser 1991) do not begin moving in the lower Mokelumne River until flows of 3,000 cfs or more are reached (Envirosphere 1988). Even at 5,000 cfs (flood stage), the larger gravel does not move. Significant impacts occur to property along the lower Mokelumne River at flows above 2,500 cfs. It would not be practical to place supplemental gravel along the entire reach of the lower Mokelumne River because numerous roads would have to be constructed for access. The environmental impact of these roads would negate any benefit from the addition of spawning gravel. Therefore, a gravel supplementation program on the Mokelumne River would have to be long-term and gravel injected at the upper end. The development of an addition gravel injection site lower in the river might be beneficial.

Flow regulation has reduced the frequency and magnitude of high flow events in the lower Mokelumne River. Due to the reduction in high flows and excessive input of fine sediments, sediments accumulate in salmonid spawning gravel and degrade habitat. BioSystems (1992) reported that over 70% of the substrate samples taken in 1991 and 1992 from chinook salmon redds contained amounts of fine sediment less than 0.48 mm in diameter, which is detrimental to egg survival (Chapman 1988). The need for salmonid spawning gravel restoration is also identified by DFG (1993) and USFWS (1997).

Gravel supplementation programs should be subject to adaptive management, monitoring, and focused research. The frequency and amount of supplemental gravel will vary greatly from year to year. Physical monitoring can record observable changes in the size and distribution of gravel, while biological monitoring can record use of new gravel by anadromous fish and invertebrates. Focused research is needed to calculate annual bedload movement, gravel quality, infiltration, and intragravel water quality.

Mechanical means to clean gravel should be evaluated. This could be a focused research project. Due to water quality constraints and the presence of juvenile anadromous and other fish species, the window for gravel cleansing may be short. This concern should be included in the feasibility analysis.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore and improve opportunities for rivers to seasonally inundate their floodplain (◆◆◆).

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to construct setback levees in the Mokelumne River floodplain in the area from Elliot Road to Woodbridge and from Woodbridge to the mouth, including the Mokelumne forks below the river's mouth.

Programmatic Action 1B: Restore, as needed, stream channel and overflow basin configurations within the floodplain.

Programmatic Action 1C: Minimize effects of permanent structures, such as bridges and diversion dams, on floodplain processes.

Programmatic Action 1D: Develop a floodplain management plan for the Mokelumne River.

Programmatic Action 1E: Develop a floodplain management plan for the Calaveras River.

Programmatic Action 1F: Develop and implement a cooperative program to evaluate the feasibility of reconnecting the Cosumnes River to its historical floodplain in areas where the river has become entrenched.

Programmatic Action 1G: Cooperatively develop and implement a feasibility study on the Cosumnes River to identify opportunities to improve sediment transport, stream meander, and maintain the natural flow pattern.

Rationale: *Setback levees will provide greater floodplain inundation, room for stream meander, and greater amounts of riparian forest and seasonal wetland habitats along the lower rivers. Channel configuration adjustments may be necessary to accelerate restoration of natural floodplain habitats and to restore and maintain configurations that may not occur naturally due to remaining constraints from new setback levees. Permanent structures, such as bridges and diversions dams, can interrupt and impair natural floodplain processes and habitat development and succession, thus requiring removal of the structures, rebuilding, or some continuing maintenance or mitigative efforts to minimize their effects. Some reaches of the Cosumnes River upstream of Twin Cities Road have become entrenched and even setback levees will not raise the level of the river bed to the point where the historical floodplain is again functional. This requires a feasibility analysis to identify causes of the stream channel degradation and identification of potential remedial measures.*

Central Valley Stream Temperatures

Target 1: Maintain mean daily water temperatures at or below levels suitable for all life stages of fall-run chinook salmon and steelhead (◆◆).

Programmatic Action 1A: Cooperatively evaluate the feasibility of releasing sufficient instream flows to improve temperature conditions for key resources in the Mokelumne and Calaveras Rivers.

Programmatic Action 1B: Establish minimum pool size at New Hogan Reservoir to ensure cold-water releases into the Calaveras River.

Programmatic Action 1C: Cooperatively develop reservoir and stream temperature models for the Calaveras River to identify potential for water temperature improvement.

Programmatic Action 1D: Manage Pardee and Camanche Reservoirs through October to maintain a cold water volume of 28,000 af when Pardee Reservoir volume exceeds 100,000 af.

Rationale: *Water temperatures in the lower Mokelumne, Calaveras, and Cosumnes Rivers are often at stressfully high levels for fall-run chinook salmon early in the spawning run, and again in the spring when young salmon are migrating downstream to the Delta. The problem is especially acute downstream of Camanche Dam, where water temperature depends on release temperature, prevailing weather conditions, and flow rate. From April to mid-October, the closure of Woodbridge Dam and subsequent filling of Lake Lodi results in the slowing of flow, allowing* *the water to warm. Differences in water temperature between Camanche and Woodbridge Dams have been measured up to 16.2 °F during dry years (Walsh et al. 1992). Higher flow, colder water, and riparian woodlands may reduce this water heating during the fall upstream spawning run and spring downstream migration of young to the Delta.*

Releases of Pardee Reservoir water into Camanche Reservoir should coordinated to maximize the effectiveness of the Camanche coldwater pool. Timely releases of cold water from Pardee Reservoir can extend the period and increase the value of coldwater releases from Camanche Reservoir.

Water temperatures in the Calaveras River are closely associated with instream flows, reservoir release schedules, and pool size at New Hogan Reservoir (U.S. Fish and Wildlife Service 1993). Temperatures often exceed stressful or lethal levels for chinook salmon migration, spawning, egg incubation, and rearing. An improved temperature regime could be achieved by maintaining a minimum pool at New Hogan Reservoir and adequate instream flow releases (U.S. Fish and Wildlife Service 1993). The appropriate minimum pool size needs to be determined. Reservoir and stream temperature computer models are also needed to identify the potential for maintaining suitable water temperatures for chinook salmon and to weigh the conflict between coldwater releases and loss of carryover storage necessary to provide coldwater releases later in the season or the following year(s).

Riparian woodlands along all three rivers are essential for shade to minimize heating of the rivers. This is especially important along the Cosumnes River, because there is no source of cold reservoir bottom water as there is below Camanche and New Hogan Reservoirs.

HABITATS

GENERAL HABITAT RATIONALE

Restoring seasonal wetland habitats along with other aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Eastside Tributaries Ecological Management Zone. The ecological units in this zone are closely linked to the Sacramento/San Joaquin Delta Ecological Management Zone, particularly the East Delta Ecological Unit. The lower sections of the Eastside ecological units overlap the East Delta Ecological Unit so it is important to consider habitat restoration recommendations in the Delta when evaluating needs in the Eastside Tributaries. For example, the following programmatic actions apply to the East Delta Ecological Unit:

- *restore 1,000 acres of shallow-water habitat (tidal perennial aquatic habitat) at the eastern edge of the East Delta Ecological Unit,*
- *develop 200 acres of open-water areas (nontidal perennial aquatic habitat) in the East Delta Ecological Unit,*
- *develop 300 acres of shallow, open-water areas (nontidal perennial aquatic habitat) within restored fresh emergent wetland habitat in the East Delta Ecological Unit,*
- *in the short-term, restore 10 miles of slough habitat and 30 miles in the long-term in the East Delta Ecological Unit,*
- *restore tidal action to portions of islands and tracts in the East Delta Ecological Unit with appropriate elevations, topography, and water-landform conditions,*
- *develop tidal freshwater marshes (fresh emergent wetland habitat) along the upper ends of dead-end slough in the East Delta Ecological Unit,*

- *restore 1,000 acres of nontidal freshwater marshes (fresh emergent wetland habitat) in leveed lands designated for floodplain overflow adjacent to the dead-end sloughs in the East Delta Ecological Unit,*
- *restore and manage at least 6,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the East Delta Ecological Unit,*
- *restore 8 to 15 miles of riparian and riverine aquatic habitat in the East Delta Ecological Unit of which 40% is more that 75 feet wide and 20% over 300 feet wide,*
- *develop a cooperative program to restore 1,000 acres of perennial grassland in the East Delta Ecological Unit through either conservation easements of purchase from willing sellers, and*
- *generally, cooperatively manage agricultural lands in a wildlife friendly manner.*

SEASONAL WETLANDS

TARGET 1: Protect existing seasonal wetland habitat through fee acquisition or perpetual easements (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of existing, degraded seasonal wetland habitat.

RATIONALE:*Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates. Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Eastside Delta Tributaries Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.*

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Restore a minimum of 1,240 acres of self-sustaining or managed diverse natural riparian habitat along the Mokelumne River, and protect existing riparian habitat (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restrict further riparian vegetation removal, and establish riparian corridor protection zones.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to implement riparian restoration activities.

PROGRAMMATIC ACTION 1C: Encourage improved land management and livestock grazing practices along stream riparian zones.

PROGRAMMATIC ACTION 1D: Purchase streambank conservation easements from willing sellers to widen riparian corridors.

PROGRAMMATIC ACTION 1E: Develop a cooperative program to restore riparian woodlands along the entire Mokelumne River.

TARGET 2: Restore a minimum of 1,240 acres of self-sustaining or managed diverse, natural riparian habitat along the Calaveras River, and protect existing riparian habitat (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restrict further riparian vegetation removal. Establish riparian corridor protection zones along all three rivers.

PROGRAMMATIC ACTION 2B: Develop a cooperative program to implement riparian restoration activities.

PROGRAMMATIC ACTION 2C: Encourage improved land management and livestock grazing practices along stream riparian zones.

PROGRAMMATIC ACTION 2D: Purchase streambank conservation easements from willing sellers to widen riparian corridors.

PROGRAMMATIC ACTION 2E: Develop a cooperative program to restore riparian woodlands along the entire Calaveras River.

TARGET 3: Restore a minimum of 1,240 acres of self-sustaining or managed diverse, natural riparian habitat along the Cosumnes River, and protect existing riparian habitat (◆◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to restrict further riparian vegetation removal, and establish riparian corridor protection zones.

PROGRAMMATIC ACTION 3B: Develop a cooperative program to implement riparian restoration activities.

PROGRAMMATIC ACTION 3C: Encourage improved land management and livestock grazing practices along stream riparian zones.

PROGRAMMATIC ACTION 3D: Purchase streambank conservation easements from willing sellers to widen riparian corridors.

PROGRAMMATIC ACTION 3E: Develop a cooperative program to restore riparian woodlands along the entire Cosumnes River.

RATIONALE: *The DFG is developing a strategy to establish a stream corridor protection zone on the Cosumnes River to prevent incompatible land use from affecting existing salmonid habitat. Riparian vegetation along the lower Mokelumne River is diminishing (U.S. Fish and Wildlife Service 1993), however, EBMUD and the Natural Resources Conservation Service are developing a strategy for establishing a stream corridor protection zone on the lower Mokelumne River. In many areas, there is no regeneration along the relatively thin riparian corridor (California Department of Fish and Game 1991). Riprapping long sections of streambank has reduced tree growth and decreased stream shading, resulting in increased stream temperatures (East Bay Municipal Utility District 1994). Bankside erosion has potentially affected salmonid production in several areas where livestock grazing is permitted.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Eastside Delta Tributaries Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse* *sediment supplies, maintain stream meander, maintain or restore connectivity of streams in this zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

STRESSORS

WATER DIVERSION

TARGET 1: Install fish screens representing the best available technology and operational constraints, as necessary, to minimize losses in diversions that limit the recovery of fish populations (◆◆◆).

PROGRAMMATIC ACTION 1A: Consolidate diversions, seek alternative water sources, and install a permanent fish screen at North San Joaquin Conservation District diversion on the lower Mokelumne River.

PROGRAMMATIC ACTION 1B: Improve fish screens and the fish bypass system at Woodbridge Dam on the lower Mokelumne River.

PROGRAMMATIC ACTION 1C: Evaluate the feasibility of installing state-of-the-art screens on small pump diversions.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to operate temporary screens at diversions where juvenile salmon rear or during seasons when they pass the diversion site.

PROGRAMMATIC ACTION 1E: Consolidate and install screens on diversions in the Cosumnes River.

RATIONALE: *On the lower Calaveras River, most of the existing diversions are not screened or are inadequately screened (California Department of Fish and Game 1993). Nearly all water in the river is diverted, especially in the summer and fall of drier years. During the winter and spring, unscreened diversions between the spawning areas and the river mouth are a potential threat to juvenile salmon.*

Stockton East Water District has an appropriative water right to divert up to 100 cfs from the Calaveras River. This diversion is currently unscreened. There are several other unscreened diversions along the river. It is probable that juvenile salmon losses occur during years when chinook salmon enter and spawn in the Calaveras River (California Department of Fish and Game 1993).

On the lower Mokelumne River, more than 90 pumps withdraw water from the river between Camanche Dam and the Delta. Few, if any, are screened to prevent fish entrainment (BioSystems 1992). The Woodbridge Irrigation District (WID) diversion at Woodbridge Canal allows juvenile chinook salmon and steelhead losses, because the screen does not meet present DFG criteria for approach velocity and mesh size, nor does it effectively screen the opening of the diversion (California Department of Fish and Game 1993). North San Joaquin Water Conservation District is the second largest diversion below Camanche Dam; temporary fish screens were installed in 1993 (U.S. Fish and Wildlife Service 1995).

Most Cosumnes River diversions are unscreened and likely entrain juvenile salmonids (U.S. Fish and Wildlife Service 1995).

Screening or eliminating diversions from areas where juvenile salmon are rearing or actively migrating will increase production of naturally produced juvenile salmon from these three streams.

DAMS AND OTHER STRUCTURES

TARGET 1: Improve anadromous fish passage at dams and diversion structures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the need for passage improvements at small dams on the lower Cosumnes River.

PROGRAMMATIC ACTION 1B: Cooperatively improve fish passage at WID diversions and Lake Lodi on the lower Mokelumne River.

PROGRAMMATIC ACTION 1C: Cooperatively isolate the City of Lodi's Recreational Lake Lodi on the lower Mokelumne River to improve adult salmon and steelhead passage and juvenile fish survival.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to provide fish passage at temporary irrigation dams in the Calaveras River, Mormon Slough, and the Stockton Diverting Canal.

PROGRAMMATIC ACTION 1E: Develop a cooperative program to install fish passage facilities at Bellota Weir, Clements Dam, and Cherryland Dam on the Calaveras River, and provide passage flows.

RATIONALE: *Small flashboard dams and some illegal dirt and gravel dams exist on the lower portions of the three rivers (U.S. Fish and Wildlife Service 1997). These dams may impede up- and downstream chinook salmon migration. On the lower Mokelumne River, Woodbridge Dam and the WID diversion may kill fish or delay downstream migrating juvenile salmonids and upstream passage of adult salmonids. DFG (1993) and USFWS (1997) recommended evaluating improvements to the existing fishway on Woodbridge Dam.*

The channels that carry Calaveras River water, and are migratory routes for salmon below Bellota Dam, include the original Calaveras River stream channel, Mormon Slough, and the Stockton Diverting Canal (into which drains Mormon Slough) (California Department of Fish and Game 1993). In some years, typically in March, partial or complete blockage of the adult salmon migration coincides with the annual placement of approximately 30 temporary irrigation dams in these channels. Fish are prevented from reaching the deep holding pools and spawning gravel above Bellota and are subjected to poaching below the flashboard dams. Reclamation Board Permit No. 7594 (August 27, 1971) requires that some of the flashboards and slide gates be removed from the channel prior to November 1 of each year and not replaced before April 15. Two of the diversion structures, Clements Dam and Cherryland Dam, have been identified as barriers to salmon movement and require fish passage facilities. The Bellota Dam (weir) has also been known to block upstream salmon migrants at flows below approximately 200 cfs (California Department of Fish and Game 1982). In some years, salmon have been observed in the tidewater reach, apparently unable to move upstream at lower flows. Juvenile salmon have trouble finding the downstream outlets to the dam and fish ladder.

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce the adverse effects of invasive riparian plants on native species and ecosystem processes, water quality and conveyance systems, and major rivers and their tributaries (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a coordinated control program to reduce or eliminate invasive plant species from the riparian corridor along the Cosumnes, Mokelumne, and Calaveras Rivers.

RATIONALE: *Non-native plant species, such as Arundo, also known as giant reed or false bamboo, can be highly invasive, fast-growing plants that outcompete and displace native riparian vegetation. These plants restrict water flow, increase sedimentation, and form large debris piles in streams and rivers. Arundo has been introduced into the watersheds of the Eastside Delta Tributary Ecological Management Zone. Its presence is impairing existing riparian communities and will likely hinder riparian* *corridor restoration. Riparian regeneration programs will require a coordinated approach to controlling invasive or non-native species through public education and chemical, biological, and mechanical methods.*

PREDATION AND COMPETITION

TARGET 1: Reduce predation level on juvenile salmonids below Woodbridge Dam on the lower Mokelumne River (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to modify the stream channel and rebuild the Woodbridge Dam fish passage and diversion screening facilities. This will help minimize losses of downstream migrating salmon and steelhead, while maintaining other important functions.

PROGRAMMATIC ACTION 2A: Modify and improve the fish bypass discharge at Woodbridge Dam.

RATIONALE: *High spring flows attract striped bass, American shad, and squawfish to the base of Woodbridge Dam on the lower Mokelumne River. Studies suggest that a significant proportion of the juvenile salmon smolt production in the Mokelumne River basin may be lost to predation (Boyd 1994, East Bay Municipal Utility District 1994). Juvenile salmon must first pass the reservoir, then the dam, and then the predators concentrated immediately below the dam (striped bass and American shad are unable to ascend the ladder and move upstream; therefore, they tend to gather in large numbers below the dam).*

CONTAMINANTS

TARGET 1: Restore and maintain water quality in Camanche Reservoir on the Mokelumne River (◆).

PROGRAMMATIC ACTION 1A: Support EBMUD in developing operating procedures at Pardee and Camanche Reservoirs that optimize water quality below Camanche Dam.

PROGRAMMATIC ACTION 1B: Support implementation of the cooperative agreement for the long-term remediation of Penn Mine contamination.

TARGET 2: Reduce the input of nonpoint source contaminants into the Mokelumne River (◆◆).

PROGRAMMATIC ACTION 2A: Develop an integrated program to coordinate and minimize agricultural pesticide and herbicide use in areas that drain into the Mokelumne River.

RATIONALE: *Poor water quality has been identified by USFWS (1997) as a limiting factor affecting fall-run chinook salmon and steelhead in the Mokelumne River. USFWS (1995) stated that managing Camanche Reservoir elevations and Pardee Reservoir inflows have not consistently provided suitable water quality to the Mokelumne River Fish Facility and to the lower river. Occurrences of low dissolved oxygen, elevated hydrogen sulfide, and elevated heavy metal levels have been documented, occasionally resulting in fish kills. Presently, reservoir operations have successfully maintained the Camanche release water quality to the lower Mokelumne River. Recently, EBMUD and others have adopted a long-term plan to remediate Penn Mine contamination. The final EIR/EIS has been completed and a Restoration Plan adopted by EBMUD, CVRWQCB, CSM, and federal ESA.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow the spawning population of wild, naturally produced fish to attain levels that fully utilize existing and restored habitat and allow harvest to focus on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Reduce or eliminate the illegal salmon and steelhead harvest by increasing enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders that support ecosystem restoration and protect important species.

PROGRAMMATIC ACTION 1C: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations to levels that take full advantage of habitat may require harvest restrictions during, and even after, the recovery period. Involvement of the various stakeholder organizations should help provide a balanced and fair allocation of available harvest. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit wild fish harvest, while harvesting hatchery fish to reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-produced salmon and steelhead could stray into adjacent non-natal rivers and streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of limiting stocking in the Mokelumne River with salmon and steelhead produced at the Mokelumne River Hatchery.

TARGET 2: Employ methods to limit straying and reduced genetic integrity of wild and hatchery supported stocks (◆◆◆).

PROGRAMMATIC ACTION 2A: Rear hatchery salmon and steelhead in hatcheries on natal streams to limit straying.

PROGRAMMATIC ACTION 2B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

PROGRAMMATIC ACTION 2C: Develop a plan to stop importing egg or fry chinook salmon and steelhead to the Mokelumne River.

RATIONALE: *In watersheds like the eastside tributaries to the Delta, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary. This would help to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited in extent and to levels that do not inhibit recovery and maintenance of wild populations. Hatchery-produced salmon and steelhead might directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds might also threaten the genetics of wild stocks. Hatchery fish might also threaten the genetic makeup of stocks in natal rivers. Further research and experimentation are necessary to determine how this issue is addressed. Long-term hatchery augmentation of healthy wild stocks may genetically undermine those stocks and threaten the genetic integrity of other stocks.*

Straying of adults into non-natal streams may result in interbreeding with a wild population specifically adapted to that watershed, and thus lead to the loss of genetic integrity in the wild population. Release of hatchery-produced fish into the San Joaquin River and its tributaries, other than the Mokelumne River, could lead to a loss in the genetic integrity of wild salmon and steelhead populations.

References Used to Develop the Vision for the Eastside Delta Tributaries Ecological Management Zone

Bjorn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication No. 19.

Boyd, S. 1994. Predation on fall-run chinook salmon smolts below Woodbridge Dam in the Mokelumne River. East Bay Municipal Utility District, Orinda, CA.

California Department of Fish and Game. 1982. Calaveras River winter-run king salmon. Memorandum to the file (Bellota fish screen and ladder and Calaveras River, Calaveras County). Region 2. Rancho Cordova, CA.

__________. 1991. Lower Mokelumne River fisheries management plan. Rancho Cordova, CA.

__________. 1993. Restoring central valley streams: a plan for action. November. Sacramento, CA.

Chapman, D. W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117(1):1-21.

East Bay Municipal Utility District. 1994. Major limiting factors affecting salmon and steelhead production in the lower Mokelumne River (1967-1991) and options for restoration. Draft report. Orinda, CA.

Envirosphere Co. 1988. Spawning gravel mobility: addendum to the Lower Mokelumne River Fisheries Study. Envirosphere Company, Sacramento, CA.

Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

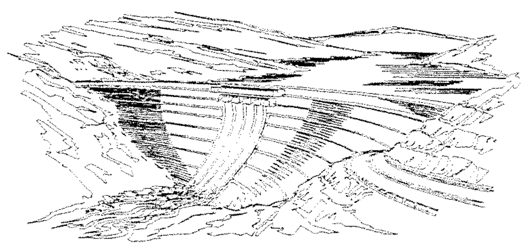
Setka, J. 1997 (draft). 1996 lower Mokelumne River chinook salmon (Oncorhynchus tshawytscha) spawning survey report. East Bay Municipal Utility District, Orinda, California.

U.S. Fish and Wildlife Service. 1993. Memorandum to the U.S. Bureau of Reclamation re: Stanislaus River basin--Calaveras River conjunctive use water program study: a preliminary evaluation of fish and wildlife impacts with emphasis on water needs of the Calaveras River. Washington, D.C.

__________. 1997. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

Walsh, R. W., C. Marzuola, and E. Bianchi. 1992. Task report fisheries studies on the Mokelumne River 1990-1991. Draft report. BioSystems Analysis, Inc. Tiburon, CA.

◆ SAN JOAQUIN RIVER ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

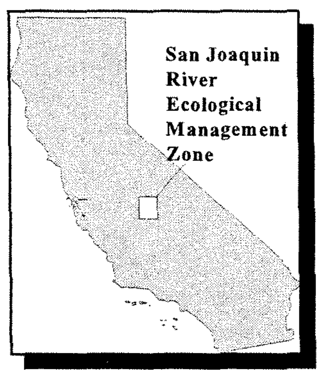
The health of the Sacramento-San Joaquin Delta is dependent on its tributaries for inflows of water along with their sediments and nutrients. The tributaries also provide spawning, rearing, and migration habitats for aquatic species. The Delta also depends on quality riparian corridors that connect it with the upper watershed habitats needed by many terrestrial species. The ecological integrity of the San Joaquin River below Friant Dam is critical to the ecological health of the Bay-Delta system. The ecological quality of the mainstem San Joaquin River below the mouth of the Friant Dam is particularly important for the anadromous (migrating between rivers and ocean) fish that annually migrate into and out of the Stanislaus, Tuolumne, and Merced rivers.

The San Joaquin Ecological Management Zone encompasses four Ecological Management Units:

- Vernalis to Merced Ecological Management Unit,
- Merced to Mendota Pool Ecological Management Unit,
- Mendota Pool to Gravelly Ford Ecological Management Unit, and
- Gravelly Ford to Friant Ecological Management Unit.

DESCRIPTION OF THE MANAGEMENT ZONE

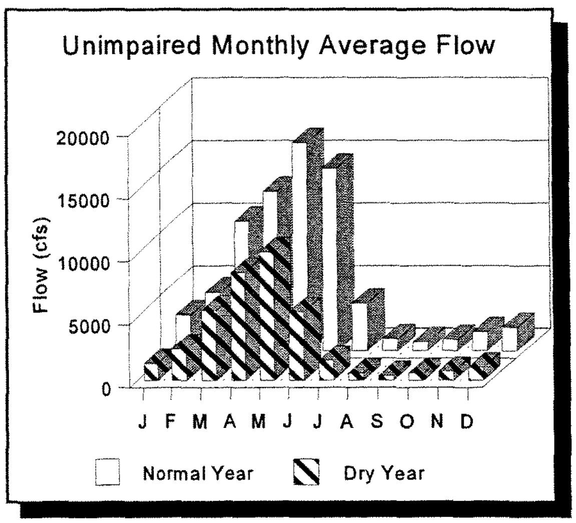
The 290-mile-long San Joaquin Valley occupies the southern half of the Central Valley and has an average width of 130 miles. The Tulare Lake basin to the south is normally considered a separate drainage basin but, during wet years, has contributed occasional floodflows and subsurface flows to the San Joaquin River. 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.



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. Natural runoff from westside sloughs is augmented by contaminated agricultural drainage and spill flows. On the east side, many streams and three major rivers drain 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.

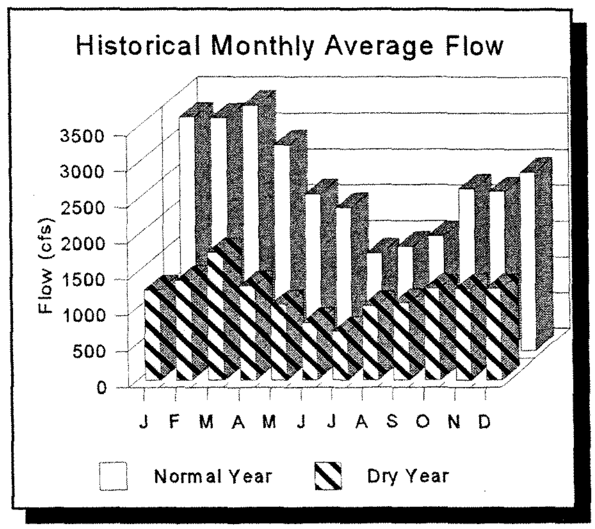
Precipitation in the San Joaquin River basin averages about 27.3 inches per year. Snowmelt runoff is the major source of water to the upper San Joaquin River and the larger eastside tributaries. Historically, peak flows were in May and June, and natural overbank flooding took place in most years along all the major rivers. When floodflows reached the valley floor, they spread out over the lowlands, creating several hundred thousand acres of permanent tule marshes and more than 1.5 million acres of seasonally flooded wetlands and native grasslands. The rich alluvial soils of natural levees once supported large, diverse riparian (waterside) forests. As much as 2 million acres of riparian vegetation are estimated to have grown on levees, on floodplains, and along small stream courses. Above the lower floodplain, the riparian zone graded into higher floodplains supporting valley oak, savanna, and native grasslands interspersed with vernal pools. Less than 10% of the historic wetland acreage and less than 2% of the historic riparian acreage exist as remnant vestiges.

Agricultural development in the basin, which began in the 1850s, brought dramatic changes in the hydrologic system. The upper San Joaquin River drainage (1,650 square miles) now has seven power-generation reservoirs, which alter flows in the upper basin. Friant Dam near Fresno is the major storage reservoir there. Completed in 1949, the dam is operated by the U.S. Bureau of Reclamation (Reclamation) to provide flood control, irrigation, and power generation. Millerton Lake, formed by Friant Dam, has a gross storage capacity of 520,000 acre-feet (af) and provides for deliveries into the Friant-Kern Canal, the Madera Canal, and other Central Valley Project (CVP) facilities. Mean annual runoff of the San Joaquin River into Millerton Lake totals 1.9 million af, with 2.2 million af per year committed in water contracts.



Unimpaired Streamflow on the San Joaquin River at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Water development caused a great change in the natural streamflow pattern of the river. The high flows of spring are now captured in storage reservoirs in the basin except for the years of highest rainfall. Summer and fall flows are higher than before to provide water for irrigation and urban water supply.



Historical Streamflow on the San Joaquin River at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Historically, the upper San Joaquin River supported spawning and rearing habitat for the southernmost stocks of spring- and fall-run chinook salmon and for steelhead. Early dams along the river restricted passage of adult salmon. By the early 1940s, large runs of salmon in the upper San Joaquin River near Fresno were mostly spring-run fish. This spring run, ranging from 2,000 to 56,000 fish between 1943 and 1948, was extirpated after 1949 when the Friant Dam closed the channel. The fall run, averaging about 1,000 spawning adults in the 1940s, was also eliminated by the dam. Streamflow releases to the San Joaquin River below the dam are now insufficient to support salmon passage, spawning, or rearing. No water passes through the Gravelly Ford to Mendota Pool reach except during extremely high runoff periods.

There is historical documentation of steelhead in the San Joaquin river system, south to and including the Kings River and Tulare Lake (Yoshiyama et al. 1996). The widespread distribution of chinook salmon in this system provides further indication of the extent of steelhead distribution. In the Klamath River drainage, for instance, all streams that contain a chinook salmon population have steelhead as well and, in nearly all cases, steelhead go higher into the drainage and utilize more of the stream system than do chinook salmon. This indicates that if chinook salmon were able to access and utilize habitat of a particular stream, steelhead could as well. Because steelhead utilize smaller tributaries for spawning and rearing, they were probably more widely distributed in the San Joaquin River system (and the rest of the Central Valley) than were chinook salmon (Yoshiyama et al. 1996).

Friant Dam's closure of the channel and reduction of total basin outflow damaged anadromous fish runs in other tributaries as well. Reducing fall attraction flows and spring outflows on the mainstem San Joaquin River reduced adult returns, production, and survival of salmon throughout the system. When spring outflow at Vernalis on the mainstem San Joaquin River is high, the total adult salmon escapement (fish that survive migration to spawn) in the San Joaquin River basin increases 2.5 years later. Since Friant Dam began operating, low spring outflows from the basin in most years have contributed substantially to low salmon production.

The three major eastside tributaries to the San Joaquin River—the Stanislaus, Tuolumne, and Merced rivers—support spawning and rearing habitat for fall-run chinook salmon, steelhead, rainbow trout, and perhaps late-fall-run chinook salmon. Substantial evidence exists to show that there is an extant self-sustaining steelhead run in the San Joaquin Basin. Since 1995, a small, but consistent, number of juvenile steelhead that exhibit smolt characteristics have been captured in rotary screw traps at two chinook salmon monitoring sites on the lower Stanislaus River (Demko and Cramer 1997; 1998). The presence, over multiple years, of juvenile steelhead that have undergone smoltification and are actively migrating to the ocean is sufficient evidence to conclude that natural production is occurring and a self-sustaining population exists. This is also the opinion of the Department of Fish and Game (CDFG 1997), the Steelhead Project Workteam of the Interagency Ecological Program (IEP Steelhead Project Workteam 1999) and apparently the Department of Water Resources and the U.S. Bureau of Reclamation (DWR and USBR 1999). It is the opinion of the Department of Fish and Game that small runs of steelhead still exist in the Tuolumne and Merced Rivers as well (CDFG 1997).

Recent genetic analysis by the National Marine Fisheries Service of Stanislaus River rainbow trout/steelhead collected from the anadromous reach below Goodwin Dam show that this population has close genetic affinities to upper Sacramento River steelhead (NMFS 1997). Further, this Central Valley group forms a genetic group that is distinct from all other samples of steelhead analyzed (132 samples from Washington, Oregon, Idaho, and California) (Busby et al. 1996), hence may be representative of native Central Valley steelhead. In most years, a few salmon are observed spawning in late January and February on the lower Stanislaus River. Whether these fish are a remnant of a distinct late fall run in the San Joaquin River basin or whether they are strays or fall-run fish spawning later than usual is not known.

In recent years, fall-run chinook spawning escapements in the San Joaquin River basin have declined to alarmingly low levels. In fall 1991, an estimated 658 fish returned to the basin to spawn, compared to 135,000 in 1944, 80,500 in 1953, 53,400 in 1960, and 70,000 in 1985.

A streamflow of 35 to 230 cubic feet per second (cfs) is required in the river between Friant Dam and Gravelly Ford to support riparian water diversions. Major reaches of the river between Gravelly Ford and the confluence with the Merced River are essentially dry for much of the year. The stream channel has been affected by inchannel gravel mining and by vegetative encroachment resulting from the absence of frequent scouring flows. The mainstem San Joaquin River downstream from the confluences with the major eastside tributaries provides the migration corridor for anadromous fish to the Delta and the Pacific Ocean.

In recent years, drainage practices in western Merced County have increased agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River. These flows attracted significant numbers of adult salmon into the sloughs and, subsequently, into irrigation canals with no suitable spawning habitat. As spawning runs have declined, the proportion of the San Joaquin drainage salmon straying into the westside area has increased. In fall 1991, 31% of the salmon in the basin was estimated to have strayed into westside canals.

Fish screens were installed on the El Solyo, West Stanislaus, and Patterson Irrigation District diversions in the late 1970s. Because of the low number of returning adult salmon and juveniles the inappropriate design and inefficiency of the screens, and the high cost of maintenance; the screens were abandoned within a few years. The El Soyo diversion has the capacity to withdraw as much as 80 cfs; each of the other diversions has a capacity of 249 cfs. Together, these diversions can withdraw a significant proportion of the mainstem river flow, particularly in dry years.

Many small and medium-size irrigation diversions on the mainstem San Joaquin River entrain juvenile salmon in addition to those at the El Soyo, West Stanislaus, and Patterson Irrigation District diversions. Cumulative losses at these other sites may be significant.

San Joaquin River basin outflow standards should be established to protect adults migrating upstream in the fall and emigrating smolts in the spring.

High water temperatures during emigration probably reduce smolt survival in the mainstem river. California Department of Fish and Game (DFG) Exhibit 15 to the California State Water Resources Control Board (SWRCB) for Phase I of the Bay-Delta hearings showed that, in years when the flow at Vernalis was 5,000 cfs or less in May, water temperatures were at levels of chronic stress for these fish. Temperature stress is additive and increases with successive exposures to diversions, predation, handling in the Delta fish salvage process, and migration delays.

Restoring and maintaining important ecological processes and functions in the San Joaquin River Ecological Management Zone depend on conditions in both the main tributaries to the river (the East San Joaquin Basin Ecological Management Zone) and the downstream Sacramento-San Joaquin Delta Ecological Management Zone. Water flow, channel incision (cutting by water flow), levee construction, gravel mining, sediment and nutrient supply, and input of contaminants from the tributary streams all influence habitat conditions in the mainstem San Joaquin River. Changes of these factors in the tributaries from historical conditions have degraded habitat on the mainstem river. Conditions in the Delta have a significant effect on anadromous fish production in the basin because, in most years, a significant proportion of inflow from the San Joaquin River is diverted at the Delta.

List of Species to Benefit from Restoration Actions in the San Joaquin River Ecological Management Zone

- chinook salmon
- steelhead trout
- splittail
- white sturgeon
- American shad
- giant garter snake
- Swainson's hawk
- greater sandhill crane
- western yellow-billed cuckoo
- shorebirds
- wading birds
- waterfowl
- neotropical migratory birds
- San Joaquin Valley woodrat
- riparian brush rabbit
- native resident fishes
- plants and plant communities.

Descriptions of Ecological Management Units

Vernalis to Merced Ecological Management Unit

The Vernalis to Merced Ecological Management Unit (43 miles, from river mile [RM] 75 to RM 118) is the nontidal reach of the river that includes the confluences with the Merced, Tuolumne, and Stanislaus rivers. These major tributaries drain the west slope of the Sierra Nevada and provide most of the flow to this reach. On the arid west side of the basin, relatively small intermittent streams drain the eastern slopes of the Coast Ranges but their waters rarely reach the river, which flows in this reach through a broad alluvial channel and floodplain. Levees set close to the main channel confine the floodplain throughout most of its length, including along the lower tributaries.

Merced to Mendota Pool Ecological Management Unit

The Merced to Mendota Pool Ecological Management Unit (87 miles, from RM 118 to RM 205) includes the mouth of Salt Slough and the Chowchilla and Fresno rivers. Flows in this reach have been significantly reduced from historical conditions by the Friant Dam project upstream and by the Eastside Bypass and levee system. The reach receives inflow from the Delta-Mendota Canal into Mendota Pool. Irrigation deliveries in the local area use this reach as a conduit. Agricultural drainage practices in western Merced County result in significant return flows from Salt and Mud Sloughs into this reach.

Mendota Pool to Gravelly Ford Ecological Management Unit

The vision for the Mendota Pool to Gravelly Ford Ecological Management Unit (24 miles, from RM 205 to RM 229) includes no significant tributary inflow. Because of the Friant Dam project upstream, most of this reach is dry for much of the year. The stream channel has been altered by inchannel gravel mining, floodplain confinement by levees and incision, and vegetation encroachment into the abandoned channel and floodplain.

Gravelly Ford to Friant Ecological Management Unit

The Gravelly Ford to Friant Dam Ecological Management Unit (31 miles, from RM 229 to RM 260) includes no significant tributary inflow. At Friant Dam, almost all the mainstem riverflow is diverted into the Friant-Kern Canal. Except during spill conditions at Friant Dam, the reach from the dam to Gravelly Ford receives a flow release of 35-230 cfs to support riparian water diversions; any streamflow reaching Gravelly Ford sinks into the channel bed because of the highly permeable substrate (bottom material) in that area. The stream channel has been altered by inchannel gravel mining, incision, and vegetation encroachment into the channel and floodplain.

Significant stressors of ecological functions, habitats, and species on the San Joaquin River are:

- artificial confinement of the river channel within levees
- dams the block access to historical habitat
- poor land use and livestock grazing practices on riparian lands,
- lack of floodflows, which alters the natural sediment balance and reduces riparian vegetation growth, and
- reservoir management and diversions on the mainstem and tributary streams that significantly reduce streamflow and alter stream temperature.

Additional stressors are:

- direct removal and fragmentation of riparian habitat for agricultural and urban development and floodway maintenance,
- entrainment of fish and other aquatic organisms in water diversions, and
- inchannel and floodplain gravel extraction, which alters channel forms.

Channel instability and floodplain disturbance have caused bank and floodplain deposits to erode and release too much fine sediment into the river. This sediment damages spawning habitat and bars fish passage. Construction of levees close to channels, as well as flood bypasses and weirs, has fragmented and degraded floodplain habitats (e.g., by causing unnaturally high salt concentration in surface soils). Levees have also caused excessive scour of the channel and instability of riparian and aquatic habitats within the leveed channel. In some reaches, native vegetation is being replaced by non-native invasive plants, such as giant reed. This reduces the quality of fish and wildlife habitat, increases sediment deposits, and decreases floodway capacity.

Important habitats provided by the San Joaquin River and its ecological processes include riparian and riverine (of rivers) aquatic habitats; riparian forest; valley oak woodland; perennial grassland; various cropland habitats (e.g., agricultural wetlands and uplands); and migration, holding, spawning, nursery, and emigration habitats for anadromous and resident fish populations.

Important fish, wildlife, and plant species occupying the San Joaquin River Ecological Management Zone and its habitats include steelhead, fall-run chinook salmon, splittail, white sturgeon, green sturgeon, and American shad.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the San Joaquin River Ecological Management Zone includes restoring important fishery, wildlife, and plant communities and ecological processes to healthy conditions and reducing stressors that inhibit health and limit restoration. This will require reactivating natural ecological processes, including streamflow and natural stream meander, to accomplish most of the restoration. In addition, stressors such as unscreened diversions and levee confinement of the floodplain must be reduced. The vision includes significant improvements in floodplain and stream-channel habitats consistent with flood control, urban, and agricultural development plans in the San Joaquin Valley floodplain.

Throughout the San Joaquin River, restoring a healthy riparian zone and improving stream meander corridor will increase the shaded riverine aquatic (SRA) habitat, the woody debris, and the natural sediment regime (pattern) in the aquatic system.

In the lower part of the zone from the Merced River to Vernalis, restoring the stream meander corridor will benefit upstream and downstream migration of fall-run chinook salmon and steelhead and restore spawning and rearing habitat for American shad, striped bass, white and green sturgeon, and splittail. Reducing losses of fish to water diversions, improving streamflows at critical times of year, reestablishing a functional floodplain and a balanced sediment budget, and improving water quality by reducing input of contaminants to the river will also benefit fish and wildlife.

In the reach from the Merced River confluence to Mendota Pool, emphasis will be on reducing the input of contaminants from westside drainage and reducing straying of fall-run chinook salmon upstream of the confluence with the Merced River.

In the reach from Friant Dam to Gravelly Ford, the vision focuses on maintaining native resident fishes and waterfowl and wildlife habitat by restoring minimum streamflows, stream-channel configuration, and the riparian corridor.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

VERNALIS TO MERCED RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Vernalis to Merced River Ecological Management Unit would:

- restore the ecological processes needed to support spawning and rearing habitat for American shad, white and green sturgeon, and splittail and the migratory corridor for upstream and downstream migration of fall-run and late-fall-run chinook salmon, steelhead, and resident rainbow trout.
- restore and maintain streamflows that provide habitat and adequate temperature levels for migrating salmon and steelhead and resident native fishes,
- maintain a diverse, self-sustaining riparian zone,
- reestablish a functional floodplain,
- restore a balanced sediment regime,
- reduce entrainment of aquatic resources at water diversions, and
- reduce the input of salt and other contaminants.

Restoring fall-run chinook salmon and steelhead runs in the San Joaquin River basin could contribute significantly to recovery of Central Valley stocks. In the past, natural fall-run spawning escapements in the basin have accounted for as much as 27% of the total natural escapement of fall-run chinook salmon in the Central Valley.

Floodway capacity should be expanded by a combination of:

- levee setbacks,
- levee abandonment where new land use and public ownership justify restoring the floodplain,
- widening and extending the bypass system throughout this reach, and
- establishing a new design floodflow capacity that includes a firm commitment to natural vegetation not subject to maintenance or removal.

These measures are environmentally superior alternatives to rebuilding and riprapping existing banks and levees without modifying the undersized flood-control infrastructure damaged by the 1997 floods.

The vision sets a high priority on connecting fragmented riparian and seasonal floodplain habitat corridors and restoring ecological structures and processes, such as natural channel meanders and unconfined lower floodplains, that promote self-sustaining riparian succession and creation of aquatic habitat. Wildlife refuges and undeveloped historical floodplains that support seasonal wetlands and other natural habitats, but that have inadequate water supplies and high surface salt concentrations, will be flooded by the restored flood cycles from modified flood control system described above.

Instream sand and gravel mining on the major tributaries in this reach should be phased out and replaced by off-channel, high-terrace mines and relocation to other sources. Such sources may include reservoir delta deposits or abandoned floodplain terraces where the channel is unnaturally confined by recent downcutting. Abandoned inchannel pits that cause channel instability and trap fish should be filled, where this is feasible, or modified and restored to create stable habitats and landforms. Revegetation programs and levee and grade modifications should be implemented at abandoned mine pits to provide greater bank cohesion and channel stability and to route low flows away from potential fish entrapments.

MERCED RIVER TO MENDOTA POOL ECOLOGICAL MANAGEMENT UNIT

The vision for the Merced River to Mendota Pool Ecological Management Unit would reduce the input of contaminants, which will improve aquatic habitat quality in this unit and downstream in the Vernalis to Merced River Ecological Management Unit and in the Sacramento-San Joaquin Delta Ecological Management Zone. Other parts of the vision are to restore ecological processes that create and sustain the habitats of a diverse, self-sustaining riparian corridor linked with upstream and downstream Ecological Management Units; to reduce the straying of adult fall-run chinook salmon into areas with no suitable spawning habitat; and to improve land management and livestock grazing practices along streams and riparian zones.

Other requirements are to maintain a diverse, self-sustaining riparian habitat zone, to reestablish a functional floodplain, to restore a balanced sediment regime, to reduce entrainment of aquatic resources at water diversions, and to reduce the input of salt and other contaminants.

Floodway capacity should be expanded by a combination of:

- levee setbacks,
- levee abandonment where new land use and public ownership justify restoring the floodplain,
- widening and extension of the bypass system throughout this reach, and
- establishment of new design floodflow capacity that includes a firm commitment to natural vegetation not subject to maintenance or removal.

These measures are environmentally superior alternatives to rebuilding and riprapping existing banks and levees without modifying the undersized flood-control infrastructure damaged by the 1997 floods.

The vision sets a high priority on reconnecting fragmented riparian and seasonal floodplain habitat corridors and restoring ecological structures and processes, such as natural channel meanders and unconfined lower floodplains, that promote self-sustaining riparian succession and the creation of aquatic habitat. Wildlife refuges and undeveloped historical floodplains that support seasonal wetlands and other natural habitats, but that have inadequate water supplies and high surface salt concentrations, will be flooded frequently by the restored flood cycles from the modified flood control system described above.

Mendota Pool to Gravelly Ford Ecological Management Unit

The vision for the Mendota Pool to Gravelly Ford Ecological Management Unit would restore the ecological processes needed to support a diverse, self-sustaining riparian corridor linked with upstream and downstream Ecological Management Units and that does not encroach on the stream channel. The vision would also improve land management and livestock grazing practices along streams and riparian zones.

Instream sand and gravel mining should be phased out and replaced with off-channel, high-terrace mines and relocation to other sources. Such sources may include reservoir delta deposits or abandoned floodplain terraces where the channel is unnaturally confined by recent downcutting. Abandoned inchannel pits that cause channel instability and trap fish should be filled, where feasible, or modified and restored to create stable habitats and landforms. Revegetation programs and levee modifications should be implemented at abandoned mine pits to provide greater bank cohesion and channel stability and to route flows away from potential fish entrapments.

Gravelly Ford to Friant Dam Ecological Management Unit

The vision for the Gravelly Ford to Friant Dam Ecological Management Unit would restore a diverse, self-sustaining riparian corridor linked with upstream and downstream Ecological Management Units. The vision would also maintain streamflows for resident native fishes and improve livestock grazing practices along streams and riparian zones.

Instream sand and gravel mining should be phased out and replaced with off-channel, high-terrace mines and relocation to other sources. Such sources may include reservoir delta deposits or abandoned floodplain terraces where the channel is unnaturally confined by recent downcutting. Abandoned inchannel pits that cause channel instability and trap fish should be filled, where feasible, or modified and restored to create stable habitats and landforms. Revegetation programs and levee modifications should be implemented at abandoned mine pits to provide greater bank cohesion and channel stability and to route flows away from potential fish entrapments.

Visions for Ecological Processes

Central Valley Streamflows: Instream flows are inadequate and need to be supplemented where possible, consistent with existing agreements. The vision is that instream flows will be high enough to support the restoration of ecological processes and functions that maintain important fish, wildlife, and plants along with their habitats.

Coarse Sediment Supply: The vision is that existing sources of coarse sediments will be protected and cooperative programs or conservation easements will be developed to reduce the amount of coarse sediments harvested from the active stream channel.

Natural Floodplains and Flood Processes: Natural river-floodplain interaction has been impaired by the construction of dams and levees. Seasonal flooding is needed to promote ecological health and restoration of important species. The vision is that floodplains along the San Joaquin River will be expanded, reconnected to their channels, and seasonally flooded by increased stream flows that will regenerate natural riparian habitat, carry nutrients to the Delta, and create seasonal habitat for splittail spawning and the rearing and emigration of juvenile fish.

STREAM MEANDER: Natural stream meander in the San Joaquin River is constrained by dams, flood-control levees, and altered flow patterns. The vision is to create and maintain any possible meander to sustain habitats similar to those that occurred naturally to provide sediment for the Delta and rearing habitats for chinook salmon and steelhead.

CENTRAL VALLEY STREAM TEMPERATURES: High stream temperatures limit or interrupt the natural life cycle of aquatic organisms. The vision is that water temperatures below major dams will be suitable for maintenance of important aquatic organisms and biological functions such as steelhead rearing and chinook salmon spawning, egg development, and fry and juvenile rearing and emigration.

VISIONS FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian plant communities are important components of a healthy ecosystem and contribute in many ways to sustaining fish and wildlife populations. The vision is to restore diverse self-sustaining riparian and riverine aquatic habitat along the San Joaquin River which will serve as an important migratory corridor to upstream habitats for terrestrial and aquatic species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native fish species. The San Joaquin River is a low elevation, valley floor river (Moyle and Ellison 1991). The quality of freshwater fish habitat in the San Joaquin River will be maintained through actions directed at streamflows, sediment supply, stream meander, natural floodplain and flood processes, maintaining and restoring riparian and riverine aquatic habitats, and reducing the adverse effects of stressors such as contaminants.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Butte Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: The vision for water diversions is that the diversion of water from the lower San Joaquin River will not adversely influence efforts to rebuild fish populations and maintain riparian and riverine aquatic habitats.

LEVEES, BRIDGES, AND BANK PROTECTION: Levees, bridges, and bank protection measures along the San Joaquin River have inhibited overland flow and erosion and depositional processes that develop and maintain the floodplain. The vision is to modify, remove, or reoperate structures in a manner that greatly lessens adverse affects on ecological processes and aquatic organisms.

CONTAMINANTS: The vision is to reduce losses of fish and wildlife due to pesticide, hydrocarbon, heavy metal, and other pollutants.

VISIONS FOR SPECIES

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA or CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. The vision is that improved habitats and flows in the San Joaquin River below the mouth of the Merced River will contribute to the survival of adult and juvenile chinook salmon.

STEELHEAD: The vision for steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat.

SPLITTAIL: The vision for splittail is to achieve recovery of this federally listed threatened species. The vision is that splittail will have access to seasonally flooded spawning habitat and that their offspring will have unimpaired access to rearing and foraging areas.

WHITE STURGEON: The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Improved flows in late winter and early spring will benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon. The vision is that restoration of ecological processes and habitats along with a reduction of stressors will contribute to stable and larger sturgeon populations.

AMERICAN SHAD: The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, and riparian habitats in the East San Joaquin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

SWAINSON'S HAWK: The vision for Swainson's hawk is to contribute to the recovery of this State-listed threatened species. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected as a result of improved habitat.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this California species of special concern. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitat.

WESTERN YELLOW-BILLED CUCKOO: The vision for the western yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. The yellow-billed cuckoo along the San Joaquin River and its tributaries is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be expanded by improvements in riparian habitat areas. These improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the San Joaquin River and East San Joaquin Ecological Management Zones, thus sustaining the river meander belt, and increasing the natural sediment supply to support meander and riparian regeneration.

SHOREBIRDS AND WADING BIRDS: The vision for the shorebird and wading bird guilds is to maintain and restore healthy populations through habitat protection and restoration. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the East San Joaquin Ecological Management Zone by these birds should increase.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the East San Joaquin Ecological Management Zone and possibly increases in some populations would be expected.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta.

RIPARIAN BRUSH RABBIT: The vision for the riparian brush rabbit is to contribute to the recovery of this federally proposed and State-listed endangered species through improvements in riparian habitat and reintroduction to former habitat.

SAN JOAQUIN VALLEY WOODRAT: The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this federally proposed endangered species through improvement in its habitat.

NATIVE RESIDENT FISHES: The vision for native resident fish species is to maintain and restore the distribution and abundance.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The Ecosystem Restoration Program Plan (ERPP) proposes targets and actions for the San Joaquin River Ecological Management Zone to augment other current and future restoration efforts for the zone.

SAN JOAQUIN RIVER MANAGEMENT PROGRAM

The San Joaquin River Management Program was established through State legislation (Chapter 1068/90) to develop comprehensive and compatible solutions to water supply, water quality, flood control, fisheries, wildlife habitat, and recreational needs in the San Joaquin River basin.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Section 3406(c) of the Central Valley Project Improvement Act directed the Secretary of the Interior to develop a comprehensive plan to address fish, wildlife, and habitat concerns on the San Joaquin River. The vision for the San Joaquin River Ecological Management Zone will also complement efforts of the U.S. Fish and Wildlife Service (USFWS) Anadromous Fish Restoration Program. The goal of the program is to double the natural production of anadromous fish in the system over average production during 1967 through 1991.

CALFED BAY-DELTA PROGRAM

CALFED has funded eight ecosystem restoration projects in the San Joaquin River Ecological

Management Zone. One project acquires and restores 6,169 acres of land along the San Joaquin River to be incorporated into the San Joaquin River National Wildlife Refuge. Another project studies the use of bacteria to reduce selenium in agricultural drain water.

Salmon, Steelhead Trout and Anadromous Fisheries Program Act

Established in 1988 by Senate Bill 2261, this Act directs the California DFG to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and to assist in obtaining funding for feasibility studies, environmental permitting, and project construction. The ERPP vision for this Ecological Management Zone will also assist DFG as it progresses toward its goal of doubling the number of anadromous fish over 1988 population levels.

Sacramento-San Joaquin River Basins Comprehensive Study

This study proposes coordination between the U.S. Army Corps of Engineers (Corps), USFWS, California Department of Water Resources (DWR), and other participating agencies to review and reevaluate the San Joaquin River flood control system in light of the inadequate capacity demonstrated by the 1997 floods, and consistent with floodplain habitat recommendations contained in the 1995 San Joaquin River Management Plan. Emphasis will be placed on managing the floodplain and detaining floodflows to meet safety, infrastructure reliability, and habitat objectives, along with reconstructing and upgrading existing levees.

Agreement on San Joaquin River Protection

In an effort to resolve issues brought forth in the State Water Resources Control Board's 1995 Water Quality Control Plan for the Bay/Delta, the San Joaquin River Tributaries Association, San Joaquin River Exchange Contractors Water Authority, Friant Water Users Authority, and the San Francisco Public Utilities Commission collaborated to identify feasible, voluntary actions to protect the San Joaquin River's fish resources. In spring 1996, these parties agreed on a "Letter of Intent to Resolve San Joaquin River Issues." This agreement, when finalized, has the potential of providing the following:

- higher minimum base flows,
- significantly increased pulse flows,
- installation and operation of a new fish barrier on the mainstem San Joaquin River,
- set up a new biological monitoring program, and
- set aside federal restoration funds to cover costs associated with these measures.

One of the important components of the Agreement is the development of the Vernalis Adaptive Management Program (VAMP) to improve environmental conditions on the San Joaquin River. Elements of this potential adaptive management program include a range of flow and non-flow habitat improvement actions throughout the watershed, and an experimental program designed to collect data needed to develop scientifically sound fishery management options for the future.

The future of the Agreement is unknown at this time. However, several actions by the San Joaquin River Stakeholders Policy Group and other parties have been or are presently being implemented throughout the watershed. These actions include:

- Increased flow from the Tuolumne River, and implementation of non-flow programs through a settlement between the Federal Energy Regulatory Commission and numerous other parties;
- An interim operating plan for the New Melones Project to provide additional flows on the Stanislaus River;
- New fishery response test programs on the Merced River;
- Actions by water users on the Stanislaus and Merced rivers to sell water purchase options that would help meet Central Valley Project Improvement Act objectives;
- Salmon smolt out-migration studies conducted by Oakdale Irrigation District, South San Joaquin Irrigation District, USFS, and DFG on the Stanislaus River;
- A two-year water purchase by USBR from Oakdale Irrigation District and South San Joaquin Irrigation Districts of up to 50,000 acre-feet to help implement fish-doubling objectives of the Central Valley Project Improvement Act; and
- Seasonal installation of a fish barrier at the head of Old River for a five-year period.

SAN JOAQUIN RIVER RIPARIAN HABITAT RESTORATION PROJECT

The San Joaquin River Riparian Habitat Restoration Project is a collaborative effort of the Friant Water Users Authority, the Natural Resources Defense Council, the Pacific Coast Federation of Fishermen's Associations, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, with participation by other local and state interests, who share a strong interest in the mainstem of the San Joaquin River. The group agreed to pursue mutually acceptable restoration activities and initially will focus on riparian habitat restoration along the San Joaquin River from Friant Dam to the confluence with the Merced River. There are many benefits to developing and implementing a riparian restoration plan, including improved flood control, groundwater recharge, and fish and wildlife enhancement. Other projects may be pursued as consensus is reached.

Riparian restoration may take a variety of forms and the project will be developed to ensure that it is consistent with other goals and objectives established for the San Joaquin River. This is a stakeholder driven project that will need the assistance of all the interested parties and the public.

In October 1998, the Program reported an analysis of the affects of physical processes on the potential for riparian habitat on the San Joaquin River from Friant Dam to the confluence of the Merced River. They reported that natural physical processes affecting the river and riparian vegetation included surface and groundwater hydrology, bank and bed erosion and deposition, channel and floodplain hydraulics and sediment transport, and other channel-forming processes. The timing, pattern, and magnitude of these natural physical processes have been altered by local and state flood control projects, operation of reservoir dams and weirs, reclamation of the river floodplain and basin lands for agricultural and urban uses, and mining of sand and gravel from channel deposits.

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 San Joaquin River Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

Restoring and maintaining important ecological processes and functions in the San Joaquin River Ecological Management Zone depends on conditions in both the main tributaries to the river (the East San Joaquin Basin Ecological Management Zone) and the downstream Sacramento-San Joaquin Delta Ecological Management Zone. Water, sediment, nutrient supply, and input of contaminants from tributary streams all influence habitat conditions in the mainstem San Joaquin River. Changes in these factors from historical conditions have degraded habitat on the mainstem river. Maintaining a healthy riparian zone and balanced sediment budget in the mainstem San Joaquin River will depend on an appropriate input of nutrients, water, and sediment from the major tributaries. Water supply from the tributaries is critical to maintaining aquatic habitat in the mainstem river between the Merced River confluence and Vernalis because Friant Dam diverts almost all the flow from the upper San Joaquin River watershed.

The Sacramento-San Joaquin Delta Ecological Management Zone provides habitat for upstream migration of adult anadromous fish and downstream migration and rearing of juvenile anadromous fish from the San Joaquin River basin. Conditions in the Delta have a significant effect on anadromous fish production in the San Joaquin River basin because, in most years, a significant proportion of inflow from the basin is diverted at the Delta and entrainment losses of juveniles are high. In turn, the volume of inflow and the input of nutrients, contaminants, and sediments from the San Joaquin River significantly affect the health of the Delta ecosystem. Restoring and maintaining a healthy ecosystem in this zone will be critical to ecosystem restoration in the Delta.

Although delta smelt (federally listed as threatened) do not inhabit the San Joaquin River Ecological Management Zone, flows from this zone have significant effects on habitat for the species in the Delta. Delta smelt spawn in different locations in the Delta each year. Some always spawn on the San Joaquin side of the Delta; however, and sometimes hydrologic conditions cause larvae and juveniles to move from the Sacramento to the San Joaquin side. In the 1995 USFWS biological opinion for delta smelt, year-round base flows and April and May flows from the San Joaquin River are specified to protect delta smelt. The biological opinion also states that contaminants entering the Delta from the San Joaquin River likely affect delta smelt and its food organisms, as well as juvenile chinook salmon and striped bass.

Additionally, stressors affecting fish and wildlife species that use the San Joaquin River during at least part of their life cycle occur outside the identified Ecological Management Zones. For example, ocean recreational and commercial fisheries have a significant effect on the numbers of anadromous fish returning to spawn and rear in the San Joaquin River basin. New harvest management strategies for ocean fisheries may be needed in addition to restoration work inland.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: Manage flow releases from tributary streams to provide adequate upstream and downstream passage of fall-run and late-fall-run chinook salmon, resident rainbow trout, and steelhead and spawning and rearing habitat for American shad, splittail, and sturgeon from the Merced River confluence to Vernalis (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to purchase water from willing sellers or develop alternative sources of water.

TARGET 2: Manage flow releases from Friant Dam to Gravelly Ford to maintain sustainable populations of resident native fish (◆◆).

PROGRAMMATIC ACTION 2A: Evaluate the feasibility of increasing flows below Friant to restore terrestrial and aquatic habitats for fish and wildlife including anadromous salmonids.

TARGET 3: Optimize the ecological value of wet year flood releases below Friant Dam.

PROGRAMMATIC ACTION 3A: Evaluate the feasibility of modifying flood operation guidelines and schedules in wet years to include more variable hydrographs with higher peak flows of shorter duration and more overall flow variability.

RATIONALE: *Flows in the major eastside tributaries to the San Joaquin River (Stanislaus, Tuolumne, and Merced rivers) are controlled by releases from foothill storage reservoirs (New Melones, New Don Pedro, and New Exchequer reservoirs, respectively). Flows from the mainstem San Joaquin River are controlled by Friant Dam. The significant reduction in outflow from the San Joaquin River caused by water development in the basin has significantly reduced production of chinook salmon in the basin. Increasing base-flow releases from the tributary reservoirs would increase habitat in the mainstem San Joaquin River for rearing and for upstream and downstream migration of fall-run and late-fall-run chinook salmon, rainbow trout, and steelhead and for spawning and rearing habitat of American shad, white and green sturgeon, and splittail from the Merced River confluence to Vernalis.*

Escapement of chinook salmon in the San Joaquin River basin appears to be strongly improved by high April through June flows at Vernalis and low exports during the year of outmigration (California Department of Fish and Game 1992, 1993; Carl Mesick Consultants 1994). Based on this relationship, the USFWS (1995) recommended base flows for Vernalis by water-year type to meet the goals of the Anadromous Fish Restoration Program.

Flows from Friant Dam to Gravelly Ford should be managed to maintain native resident fish populations until an evaluation of the potential to restore anadromous salmonids is completed.

Natural stream-meander belts in alluvial systems transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish, as well as substrates (surfaces on which plants and animals can live) for colonization by riparian vegetation.

Present flood operations below Friant Dam typically result in uniform flows for long durations during the winter and spring months. Providing a more variable hydrograph which emulated natural inflow patterns to Millerton Lake would increase habitat complexity and diversity, mobilize bar material, and create better seed dispersal and more favorable sites for colonization by riparian species. A particular emphasis should be placed on flow peaks during at least portions of the early spring months when seed of cottonwood and sycamore trees is being dispersed in the river. The purchase of easements or fee title on lands that become subject to greater flood frequency from peak overbank flows could be used to expand the area of low floodplain along the river to be colonized naturally or planted with riparian vegetation (San Joaquin River Riparian Habitat Restoration Program 1998).

COARSE SEDIMENT SUPPLY

TARGET 1: Conserve existing natural sources of coarse sediments below Friant Dam.

PROGRAMMATIC ACTION 1A: Develop a cooperative incentive program to relocate gravel mining operations from the active floodplain.

RATIONALE: *Dry Creek enters the river below Friant Dam and is the only remaining tributary that supplies a significant source of coarse sediments with high flows. Bedload entering the river from Dry Creek during high flows reduces the tendency of the channel to incise and forms shifting river deposits on bars that are needed for riparian colonization and succession to occur.*

STREAM MEANDER

TARGET 1: Restore and maintain a defined stream-meander zone on the San Joaquin River between Vernalis and the mouth of the Merced River (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative strategy to acquire or obtain easements on floodplain and riparian land.

PROGRAMMATIC ACTION 1B: Establish a river meander corridor between the Chowchilla Bypass and Mendota Pool.

RATIONALE: *Preserving and improving the stream meander belt below the mouth of the Merced River will ensure that this important natural process is maintained in the San Joaquin River. This reach is important for migrating and rearing salmon and steelhead and other anadromous and resident fish species. A natural meander process will provide excellent habitat for spawning (through gravel recruitment), rearing (channel form, cover, and foodweb), and migration. The stream channel meander program must be consistent with flood control requirements and, in the longer term, should reduce the need for future flood control efforts by using natural system resilience and flood control characteristics.*

The river between Chowchilla Bypass and Mendota Pool has the highest sinuosity and a greater tendency for bank migration, bendway cutoffs, and overbank flow across meander bends. The suggested approach to restoring meander in this section allows river bends to migrate within a designated meander corridor and allows high flows to overtop the large point bars. These alluvial processes will promote the regeneration of riparian vegetation and overall habitat complexity.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore floodplain-river interactions in the San Joaquin River between Vernalis and the mouth of the Merced River (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the potential for levee deauthorization, levee removal, or levee setbacks.

PROGRAMMATIC ACTION 1B: Develop a cooperative strategy to acquire or obtain easements or ownership of floodplain along the lower San Joaquin River.

PROGRAMMATIC ACTION 1C: Conserve remaining natural floodplain topography and sloughs.

RATIONALE: *Setback levees will provide more floodplain flooding, room for stream meander, and more riparian forest and seasonal wetland habitats along the lower San Joaquin River. Channel form adjustments may be necessary to accelerate restoration of natural floodplain habitats and to restore and maintain configurations that may not occur naturally due to remaining constraints from the new setback levees. Permanent structures such as bridges and diversions dams can interrupt and impair natural floodplain processes and habitat development and succession, thus requiring removal of the structures, rebuilding, or some continuing maintenance or mitigation to minimize their effects.*

Major flood flows along the San Joaquin River periodically exceed flow capacity within the river levees, causing local and regional flooding. Even lesser flows can result in seepage damage to levees and lands adjacent to the floodway. The U.S. Army Corps of Engineers investigated the potential for a demonstration project for distributing peak flood flows over land on wildlife refuges adjacent to the river. A previous analysis of the West Bear Creek Floodplain Restoration Project was a joint effort by the U.S. Fish and Wildlife Service and the California Department of Water Resources using the San Joaquin Basin Action Plan interagency agreement and the San Joaquin River Management Program funding. Recently, the CALFED Category III restoration program provided funding to the USFWS to conduct a feasibility study for this floodplain restoration program.

Large areas of the historic floodplain still support natural topography and sloughs on both sides of the levee network, while other areas have been laser leveled for irrigated agriculture or managed wetlands. The potential for rewetting the floodplain varies by reach, based on the changes in bankfull channel capacity and the magnitude of the reduction of flow under present hydrology. Many areas would derive ecological benefits from the reintroduction of managed or natural overbank flows, generally within a range of average annual to 10-year frequency inundation (San Joaquin River Riparian Habitat Restoration Program 1998).

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Manage reservoir releases and other factors to provide suitable water temperatures for important resources from the Merced River confluence to Vernalis (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of releasing sufficient instream flows to improve the temperature regime for important resources.

PROGRAMMATIC ACTION 1B: Evaluate the use of upstream temperature control devices and reservoir management options to reduce water temperatures during critical periods.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to evaluate the potential for restoring riparian vegetation to reduce water temperatures.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to evaluate the impact of discharge returns on stream temperature.

RATIONALE: *Water temperatures in the mainstem San Joaquin River between the Merced River confluence and Vernalis in the fall and spring often exceed stressful or lethal levels for upstream and downstream migrating fall-run chinook salmon. High temperatures are thought to delay migration in the fall (DFG 1992) and increase mortality of rearing and outmigrating juveniles in the spring (DFG 1993). When the Vernalis flow is 5,000 cfs. or less in May, water temperatures are at levels of chronic stress. Maintenance of improved base flows in the fall and spring will increase survival of up and downstream migrating chinook salmon.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Assist in protecting 52,500 acres of existing seasonal wetland habitat through fee acquisition or perpetual easements consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 52,500 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 120,300 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Improve and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Joaquin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the San Joaquin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Restore 50 stream miles of diverse, self-sustaining riparian community (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to protect large remnant stands of old growth riparian woodlands.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to restore riparian habitat.

PROGRAMMATIC ACTION 1C: Improve land management and livestock grazing practices along streams and riparian zones.

TARGET 2: Revegetate low floodplains formerly cleared for agricultural purposes or during past floodway clearing projects.

PROGRAMMATIC ACTION 2A: Identify potential revegetation sites that are subject to inundation at least every 5-10 years.

RATIONALE: *Because of high-flow-event reduction, stream channelization, livestock grazing, gravel extraction, and direct loss of habitat to agriculture and urban development; the extent of riparian vegetation along the mainstem San Joaquin River has been significantly reduced. Before they were disturbed, riparian forests were an important component of the mosaic of habitats in the San Joaquin Valley, providing habitat for a variety of native wildlife species. The riparian community provides nutrients and woody debris to the aquatic system, along with shade and increased bank stability. The importance of restoring riparian habitat has been identified by DFG (1993) and USFWS (1997).*

Old-growth stands of cottonwood forest, sycamore and valley oak woodlands, and wooded grassland savanna are scattered throughout the area. Some of these stands occur within State and federal refuges or parks, while others are found on private lands. Landowners at these sites should be contacted to determine if the old growth sites are secure under existing land management practices or if special conservation easements or management plans are needed to ensure the long-term survival of these unique relict-age classes and their wildlife habitat and aesthetic values (San Joaquin River Riparian Habitat Restoration Program 1998).

There are also many sites along the San Joaquin River where low floodplains along the channel are subject to infrequent inundation every 5-10 years. The Corp's comprehensive new hydraulic model of the entire river and bypass system may reveal segments of designated floodways where actual capacity exceed design capacity and can therefore safely convey large flood events, even with an increase in channel roughness. In other instances, forest may have been cleared within a meander corridor for agricultural use, though many sites on agricultural fields appeared in aerial photos to be abandoned. Planted species mixes should conform to the vertical range of cohorts in the general vicinity of the river corridor (San Joaquin River Riparian Habitat Restoration Program 1998).

FRESHWATER FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat is evaluated in terms of its quality and quantity. Actions described for San Joaquin River ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the San Joaquin River and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively enhance 15, 290 acres of private agricultural land to support nesting and wintering waterfowl consistent with the objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success.

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit.. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Reducing or Eliminating Stressors

Water Diversions

Target 1: Reduce entrainment of fish and other aquatic organisms into diversions by 50%, by volume, from the Merced River confluence to Vernalis (◆◆◆).

Programmatic Action 1A: Develop a cooperative approach to install state-of-the-art fish screens at El Solyo, Patterson, and West Stanislaus Irrigation District diversions.

Programmatic Action 1B: Develop a cooperative program to evaluate the feasibility of installing state-of-the-art screens on small and medium-sized diversions.

Target 2: Eliminate the loss of adult fall-run chinook salmon straying into the San Joaquin River upstream of the Merced River confluence (◆◆◆).

Programmatic Action 2A: Continue annually installing a temporary weir on the San Joaquin River immediately upstream from the confluence with the Merced River to block adult salmon migration.

Rationale: *Three large water diversions are between the Merced River confluence and Vernalis on the mainstem San Joaquin River: El Solyo, West Stanislaus, and Patterson Irrigation District diversions. Fish screens were installed at these diversions in the late 1970s; however, because of the scarcity of returning salmon, the inappropriate design and inefficiency of the screens, and the high cost of maintenance; the screens were abandoned within a few years. Together, these diversions can withdraw a significant portion of the mainstem riverflow, particularly during dry water years. Irrigation diversions take place during the juvenile salmon outmigration. In addition, many, small or medium-sized diversions are on this reach of the San Joaquin River.*

In recent years, drainage practices in western Merced County have increased agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River. These flows attract significant numbers of adult salmon into the sloughs and, subsequently, into irrigation canals where no spawning habitat is available (DFG 1993). In fall 1991, 31% of the run in the San Joaquin River basin is estimated to have strayed into westside canals. In the late 1980s, DFG established an adult trapping station at Los Banos Wildlife Refuge at which eggs were taken for rearing at the Merced River Fish Facility. In fall 1992, DFG installed a temporary electrical barrier across the mainstem San Joaquin River immediately upstream from the confluence with the Merced River; this was extremely effective in blocking fish passage into the westside irrigation canals. Since then, a temporary weir has been installed at the site annually, and this has also been effective in blocking passage.

Levees, Bridges, and Bank Protection

Target 1: Set back 10 miles of levees along the San Joaquin River between the Merced River confluence and Vernalis where feasible to reestablish the hydrologic connectivity between these channels and natural floodplains (◆◆).

Programmatic Action 1A: Develop a cooperative strategy to evaluate the potential for levee deauthorization or relocation.

Programmatic Action 1B: Develop a cooperative program to acquire or obtain easements on floodplain and riparian land needed to meet restoration goals.

Rationale: *Natural stream meander belts in alluvial systems function to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and* *fish, as well as providing substrates for colonization by riparian vegetation. Setting back levees along the San Joaquin River encourages natural stream meander and flooding processes.*

This measure includes removing site-specific local levees or deauthorizing unneeded segments of state levees to expand the area of flood basin and floodplain inundation. Additional information is needed to make these determinations. Each site-specific project will require a subreach hydraulic model and sediment transport analysis to evaluate the feasibility of breaching or removing levees or constructing controlled release weirs to restore periodic inundation of the flood basin and rewater formerly abandoned channels outside existing levees (San Joaquin River Riparian Habitat Restoration Program 1998).

INVASIVE RIPARIAN PLANTS

TARGET 1: Eradicate or suppress populations of exotic, invasive trees and shrubs.

PROGRAMMATIC ACTION 1A: Evaluate and implement effective new techniques to control invasive plant species that combine low-impact, mechanical removal or prescribed fire with low concentrations of selective herbicides.

RATIONALE: *Expansions of giant reed (Arundo), tamarisk, and eucalyptus in some river segments threatens riparian habitat diversity and quality. Because of their growth characteristics, expansion of these invasive, non-native species will reduce channel floodway capacity and increase bank stability. The recommended action would involve a program to map and monitor the distribution of these harmful species. In vulnerable subreaches of the San Joaquin River with small, developing populations immediate eradication by be a cost effective strategy (San Joaquin River Riparian Habitat Restoration Program 1998).*

CONTAMINANTS

TARGET 1: Reduce losses of fish and wildlife from use of pesticides, hydrocarbons, heavy metals, and other pollutants in the basin (◆◆).

PROGRAMMATIC ACTION 1A: Provide additional funding to enforce State laws regarding point- and nonpoint-source pollution.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to strengthen water quality standards as needed.

PROGRAMMATIC ACTION 1C: Work with local landowners and State and federal agencies to improve land management practices to reduce contaminant input.

PROGRAMMATIC ACTION 1D: Evaluate the use of real-time releases from tile drainage.

TARGET 2: Reduce sediment sources entering the river and bypass system.

PROGRAMMATIC ACTION 2A: Conduct an hydraulic analysis of the stability of bypasses.

PROGRAMMATIC ACTION 2B: Cooperatively develop streambed and bank protection and erosion control management alternatives to reduce sources of sediment.

RATIONALE: *Poor water quality resulting from point- and nonpoint-source discharge of toxic chemicals and other pollutants may affect anadromous fish survival in the San Joaquin River basin. Drainage practices in western Merced County result in highly saline and pollution-laden agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River above the confluence with the Merced River. Contaminant input from this area also affects water quality in the downstream Sacramento-San Joaquin Delta Ecological Management Zone.*

Sediment deposition within the mainstem San Joaquin River and its bypasses is a recognized problem. The potential for aggradation of sand in the river bed is a serious constraint to revegetation of riparian habitat in some river segments. Much of the problem sediments appears to originate from erosive processes within the bypasses and some of the eastside tributaries. Therefore the reduction of the sediment problem requires solution of the erosion occurring within the bypasses and eastside tributaries (San Joaquin River Riparian Restoration Program 1998).

REFERENCES USED TO DEVELOP THE VISION FOR THE SAN JOAQUIN RIVER ECOLOGICAL MANAGEMENT ZONE

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-27.

California Dept. of Fish and Game. 1997. Letter from Jacqueline Schafer to Garth Griffen (NMFS) regarding CDFG comments on Proposed Rule to list steelhead under the Endangered Species Act, dated 1/6/97.

Demko, D.B. and S.P. Cramer. 1997. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park site 1996. Final Report submitted to the U.S Fish and Wildlife Service. 144 pp.

California Department of Fish and Game. 1992. Interim actions to reasonably protect San Joaquin fall-run chinook salmon. (WRINT-DFG Exhibit 25.) Prepared for the Water Rights Phase of the State Water Resources Control Board Bay-Delta Hearing Proceedings. Sacramento, CA. June.

______________. 1993. Restoring Central Valley Streams: a plan for action. Sacramento, CA. November.

______________. 1996. Steelhead restoration and management plan for California. February 1996.

California Department of Water Resources and U.S. Bureau of Reclamation. 1999. Effects of the Central Valley Project and State Water Project operations from October 1998 through March 2000 on steelhead and spring-run chinook salmon. Biological Assessment for ESA Section 7 consultation.

Carl Mesick Consultants. 1994. The effects of streamflow, water quality, Delta exports, ocean harvest, and El Niño conditions on fall-run chinook salmon escapement in the San Joaquin River drainage from 1951 to 1989. Prepared for the Stanislaus River Council.

Central Valley Habitat Joint Venture. 1990. Central Valley Habitat Joint Venture Implementation Plan, a component of the North American Waterfowl Management Plan. February 1990.

Demko, D.B. and S.P. Cramer. 1998. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park site 1997. Final Report submitted to the U.S Fish and Wildlife Service. 102 pp.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. *in* Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. App. VII-A-11

National Marine Fisheries Service. 1997. Status review update for deferred and candidate ESUs of west coast steelhead. Prepared by NMFS West Coast Steelhead Biological Review Team.

San Joaquin River Management Program Advisory Council. 1993. An action plan for San Joaquin fall-run chinook salmon populations. Fisheries Subcommittee, January. 30 p.

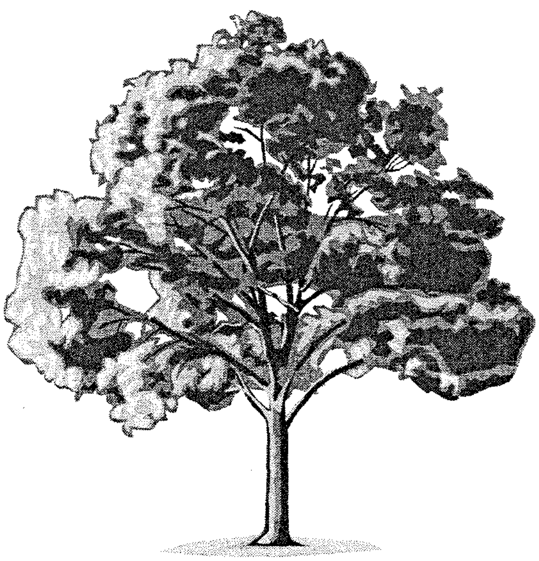
San Joaquin River Riparian Habitat Restoration Program. Analysis of physical processes and riparian habitat potential of the San Joaquin River, Friant Dam to the Merced River. October 1998.

San Joaquin River Interests. 1997. Agreement on San Joaquin River Protection. Status Report. April 1997. 19 p.

U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: Final report to Congress, vol.III. Centers for Water and Wildland Resources, Univ. Cal. Davis. pg. 309-361.

◆ East San Joaquin Basin Ecological Management Zone



Introduction

The East San Joaquin Basin Ecological Management Zone includes the lower Stanislaus, Tuolumne, and Merced rivers. These rivers support Sacramento-San Joaquin Delta health by supplying freshwater inflow, sediments, nutrients, and seasonal habitats for Delta species, especially fall-run chinook salmon, steelhead, waterfowl (including the endangered Aleutian Canada goose), riparian brush rabbit, Swainson's hawk, giant garter snake, and western pond turtle. The overall health of the Delta depends on habitat quality and quantity in this zone and the health of its fish, wildlife, and plant populations.

Important ecological processes that would maintain or increase the health of the East San Joaquin Basin Ecological Management Zone are:

- streamflow,
- stream meander,
- floodplain processes,
- coarse sediment supply including gravel recruitment, transport, and cleansing, and
- water temperature.

Riparian and riverine aquatic is an important habitat within zone and has close links to wetlands areas. Caswell Memorial State Park is the best example of remaining Great Valley riparian habitat in the San Joaquin Valley (with the exception of the Cosumnes River Preserve in the Eastside Delta Tributaries Ecological Management Zone). Seasonally flooded wetlands are common through the lower portions of the basin and are important habitats for waterfowl, shorebird, and wading bird guilds. Important aquatic habitat designations include freshwater fish habitat and essential fish habitat.

Important species include fall-run chinook salmon, steelhead trout, native resident fishes, waterfowl guilds, shorebird and wading bird guilds, and riparian wildlife guilds.

Stressors include:

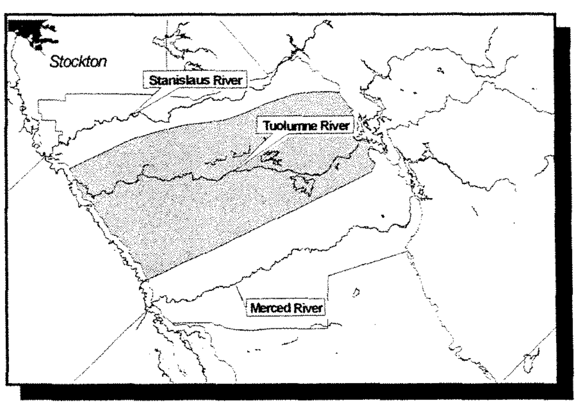
- dams that hinder or block fish migration,
- legal and illegal fish harvest,
- water diversions that result in insufficient flow in the lower portions of most streams,
- high water temperature during salmon and steelhead spawning and rearing,
- poor water quality,
- hatchery stocking of salmon and steelhead,
- gravel mining in the stream channel,
- poor livestock grazing practices,
- high predation levels on juvenile salmon by non-native fish,
- salmon and steelhead harvest,
- and unscreened or poorly screened water diversions.

These stressors have reduced the health of fish wildlife, and plant populations in the zone. Fall-run chinook salmon populations are generally unhealthy because of poor habitat conditions within the zone, entrainment at the Delta pumping plants, and potentially high ocean harvest rates. The status of steelhead in the zone is unknown and will require more focused research to determine specific restoration actions that need to be implemented to improve conditions for its recovery. Wildlife populations are adversely affected by loss of riparian and wetland habitats and the ecological functions that maintain them.

DESCRIPTION OF THE MANAGEMENT ZONE

The East San Joaquin Basin Ecological Management Zone includes the three major eastside tributaries to the San Joaquin River and consists of the following Ecological Management Units:

- Stanislaus River Ecological Management Unit,
- Tuolumne River Ecological Management Unit, and
- Merced River Ecological Management Unit.



Location Map of the East San Joaquin Ecological Management Zone and Unit.

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 are located in this zone: Merced NWR and San Joaquin NWR. In addition to the larger ecological values, these units also provide habitat for many fish, wildlife, and plant species. They are particularly important as spawning and rearing areas for chinook salmon.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE EAST SAN JOAQUIN ECOLOGICAL MANAGEMENT ZONE

- chinook salmon
- steelhead trout
- giant garter snake
- Swainson's hawk
- greater sandhill crane
- western yellow-billed cuckoo
- riparian brush rabbit
- San Joaquin Valley woodrat
- shorebirds
- wading birds
- waterfowl
- neotropical migratory birds
- native resident fishes
- lamprey
- plants and plant communities.

DESCRIPTION OF ECOLOGICAL MANAGEMENT UNITS

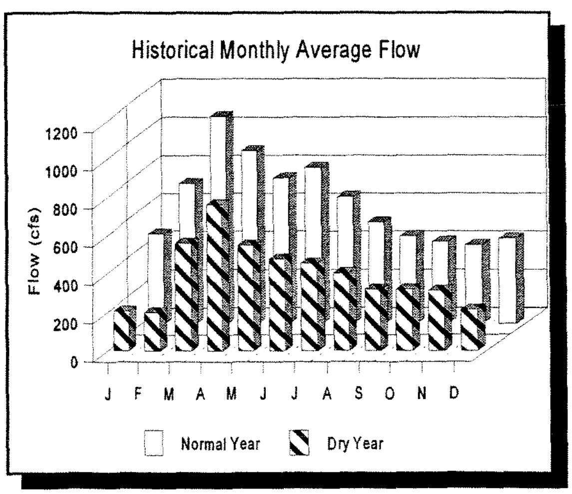
STANISLAUS RIVER ECOLOGICAL MANAGEMENT UNIT

The Stanislaus River is the northernmost major tributary in the San Joaquin River basin. The river flows westward into the Central Valley, draining approximately 1,100 square miles in the Sierra Nevada. The average unimpaired runoff in the basin is about 1.2 million acre-feet (af).

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 af. The project is operated by the U.S. Bureau of Reclamation (Reclamation) 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.

Monthly unimpaired flows at New Melones (900-square-mile watershed) average approximately 1,600 cubic feet per second (cfs), with highest runoff in the rainfall months of December through March and in the snowmelt months of April, May, and June. This pattern is typical of San Joaquin basin streams originating from the high Sierra. During dry years, inflows are 500 to 1,800 cfs from February through June, whereas summer inflows are less than 50 cfs from August through October. In driest years, inflows are less than 50 cfs from July through February but still reach peaks near 1,500 cfs in April and May. In highest rainfall years, average monthly inflows are 6,000 to 11,000 cfs from February through June, and 600 to 1,400 cfs from August through October.



Stanislaus River Streamflow at Ripon (Highway 99), 1981-1991 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Monthly historical average flow at Ripon (near the mouth of the Stanislaus River) is approximately 950 cfs and is more uniformly distributed throughout the year than unimpaired flow at New Melones Dam. In dry years, monthly average flows vary between 200 cfs and 500 cfs, except for a small increase to 750 cfs in April. Normal year flows range from 400 cfs to 1,100 cfs, with a peak in April and lowest flows from September through January. In driest years, flows vary from 200 cfs to 400 cfs. In highest precipitation years, flows are similar to unimpaired flows, ranging from monthly averages of 2,000 to 5,000 cfs, with peaks in March and April.

Although considerable flow is diverted for irrigation upstream of Ripon, much of the water released from New Melones is used for water quality control in the San Joaquin River at Vernalis during the irrigation season and is diverted at south Delta pumping plants. Fall minimum flows and spring flow pulses are prescribed to sustain fall-run salmon.

Interim flow releases for fishery purposes in the lower Stanislaus River were designated in a 1987 agreement between Reclamation and the California Department of Fish and Game (DFG). This agreement, enacted under a DFG protest of Reclamation's water right applications to redivert water from New Melones Dam, specified interim annual flow allocations for fisheries between 98,300 af and 302,100 af, depending primarily on the carryover storage at New Melones and inflow. Under the agreement, a 7-year cooperative study program was established to evaluate flows in the lower Stanislaus River.

In addition to flow allocations for fisheries, 70,000 af are a minimum annual allocation for water quality purposes. To meet Delta water quality standards, Reclamation commonly releases additional water over the 70,000-acre-foot requirement. In recent years, coordinating fishery and water quality flow releases and releases for water sales and transfers have resulted in schedules that significantly benefit anadromous fish.

Flows needed for fall-run chinook salmon smolt (the life stage at which salmon are ready for saltwater), emigration, in particular, can be adequately met in drier years with the present annual flow allocations. The results of IFIM and water temperature model for the Stanislaus River indicates that about 99,000 acre-feet can provide suitable conditions between October 16 and June 7 for chinook salmon. There is a positive relationship between spring outflow at Vernalis on the San Joaquin River and at Ripon on the Stanislaus River to the number of adults reaching the river 2½ years later. Smolt survival studies have not been completed for the Stanislaus River and the existing data do not indicate that higher flows would improve smolt survival. Three survival tests have conducted at a range of flow releases between 800 and 1,200 cfs in the Stanislaus River and no obvious relationship between flow and smolt survival resulted from these tests. On the other hand, flow releases made since the 1987 Reclamation and DFG agreement have been substantially greater than those made during the 1967-1991 and yet the chinook salmon population did not rebound.

DFG has developed flow recommendations for the Stanislaus River (California Department of Fish and Game 1993). Recommended flows for the October 1 through March 31 period were based on results of the instream flow study for salmon spawning, egg incubation, and rearing. Flows during April 1 through May 31 for late rearing and smolt emigration were based on results of the smolt survival studies. These flows for the lower Stanislaus River are consistent with spring outflow objectives proposed for the basin at Vernalis on the San Joaquin River. Summer flow recommendations incorporate the needs of oversummering yearling salmon and steelhead. The recommended flows represent the minimum needed for salmon spawning, rearing, and emigration on the lower Stanislaus River. These flows would represent a significant improvement over existing required stream releases but are not optimum flows, particularly in drier water years. The U.S. Fish and Wildlife Service (USFWS 1995) recommended similar flows to double anadromous fish production in the basin.

Water temperature in the Stanislaus River is influenced by ambient air temperatures, late summer storage levels and thermocline development at New Melones Reservoir, the depth of diversions from New Melones Reservoir, and Tulloch Reservoir temperatures and operations.

Fall flow releases to the lower Stanislaus River sometimes exceed critical temperatures for salmon spawning and egg incubation when storage levels at New Melones Reservoir are low. Elevated water temperatures are a problem in critically dry water years, a problem exacerbated by low reservoir storage and the presence of the Old Melones Dam in the reservoir which restricts access to the remaining cold water pool. During the 1987 through 1992 drought, the first fish entering the river to spawn did not arrive until early November, rather than in October, because of low water and high water temperatures. Elevated water temperatures were the major cause of the delay. With such a delay in spawning, juvenile fish are not ready to emigrate until later in spring when high water temperatures again occur in the river and in the mainstem San Joaquin River.

Delayed spawning also reduces survival of eggs in gravel, the number of fry rearing in the river, and the number of young salmon traveling to and through the Delta to San Francisco Bay and the Pacific Ocean. Egg mortality has been shown to increase when temperatures exceed 56°F. When storage levels at New Melones are low, water temperature exceeds 56°F in much of the salmon spawning reach until ambient air temperatures cool the river during November. Water temperatures above 65°F are stressful to juvenile salmon.

Forty-four small pump diversions have been identified on the lower Stanislaus River, none of which are adequately screened to prevent entrainment (carrying into the diversion) of juvenile salmon and other aquatic organisms. Although losses at these diversions are unknown, the diversions are considered a serious threat to these populations.

Goodwin Dam, located approximately 15 miles downstream of New Melones Dam, is the upstream barrier for steelhead and salmon migration. Spawning occurs in the 23-mile reach downstream of Goodwin Dam (California Department of Fish and Game 1993) and juvenile chinook salmon and steelhead rear in the entire lower river. Historically, the river supported steelhead and spring- and fall-run chinook salmon. The river now supports fall-run chinook salmon and steelhead and perhaps late-fall-run chinook.

Substantial evidence exists to show that there is an extant self-sustaining steelhead run in the Stanislaus River. Since 1995, a small, but consistent, number of juvenile steelhead that exhibit smolt characteristics have been captured in rotary screw traps at two chinook salmon monitoring sites on the lower river (Demko and Cramer 1997; 1998). These fish do not appear to be the result of straying of juvenile hatchery steelhead planted in the Mokelumne River because none of the smolts captured in the screw traps in 1988 were adipose-fin clipped (1997 was the first year of 100% marking of hatchery steelhead at Mokelumne River Hatchery). The presence, over multiple years, of juvenile steelhead that have undergone smoltification and are actively migrating to the ocean is sufficient evidence to conclude that natural production is occurring and a self-sustaining population exists. We note that this is the opinion of the Department of Fish and Game (CDFG 1997) and the Steelhead Project Workteam of the Interagency Ecological Program (IEP Steelhead Project Workteam 1999) as well. Other evidence that a self-sustaining run exists includes:

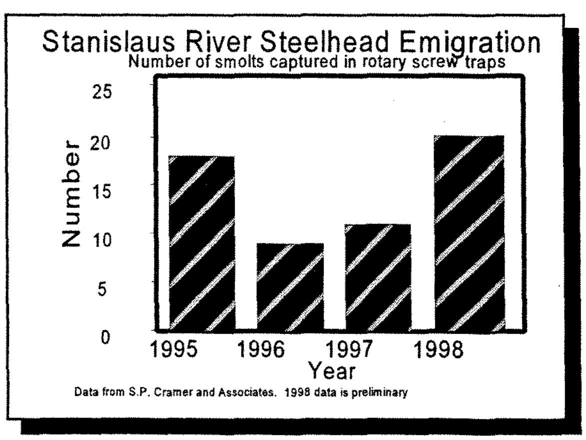
- CDFG fishery biologists have documented successful reproduction (in the form of juvenile emigrants) in the lower San Joaquin River since 1987 (CDFG 1997).

- Anglers in the Oakdale area report occasional steelhead from 2 to 10 pounds and CDFG creel census information documents the catch of rainbow trout greater than 20 inches (CDFG unpublished data). Examination of scale samples from these larger trout by CDFG biologists show an accelerated growth period typical of estuary or ocean residence (CDFG unpublished data).

- A 28-inch steelhead illegally harvested from the Stanislaus River was confiscated by CDFG wardens in 1995.

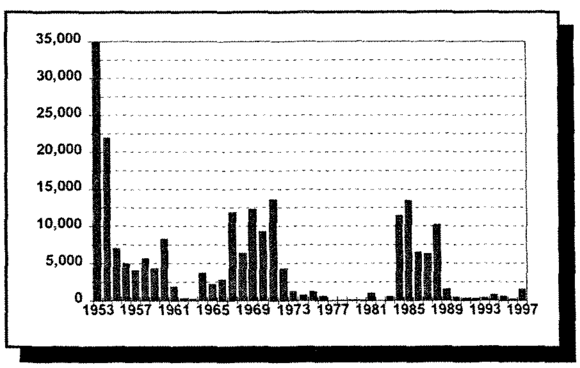
Recent genetic analysis by the National Marine Fisheries Service of Stanislaus River rainbow trout/steelhead collected from the anadromous reach below Goodwin Dam show that this population has close genetic affinities to upper Sacramento River steelhead (NMFS 1997). Further, this Central Valley group forms a genetic group that is distinct from all other samples of steelhead analyzed (132 samples from Washington, Oregon, Idaho, and California) (Busby et al. 1996), hence may be representative of native Central Valley steelhead.

This analysis also provides further evidence that Stanislaus River steelhead are not derived from adults straying from Mokelumne River Hatchery.



The analysis showed that steelhead from Nimbus Hatchery on the American River are more closely related to coastal steelhead, which accurately reflects the founding history of Nimbus Hatchery steelhead (Nimbus broodstock was founded from Eel River steelhead eggs). Mokelumne River Hatchery, which rears steelhead from eggs obtained every year from Nimbus Hatchery, is the nearest steelhead hatchery population in proximity to the Stanislaus River, therefore if the Stanislaus River steelhead population is derived from Mokelumne River Hatchery strays, then this population would show close genetic affinities to Nimbus Hatchery steelhead and other coastal steelhead populations.

As in other tributaries in the basin, fall-run chinook spawning escapements (fish that survive migration and spawn) in the lower Stanislaus River have varied considerably since surveys were initiated in 1939. In recent years, spawning escapements have declined to very low levels. In the falls of 1991 and 1992, fewer than 300 salmon returned to spawn in the lower Stanislaus, compared to a recent historic high of 35,000 fish in 1953. Peak runs in the past 30 years have generally followed a series of high rainfall years. Poor runs occur during and following droughts.



Fall-run Chinook Salmon Returns to the Stanislaus River, 1953-1997.

Physical habitat for salmon and steelhead spawning and rearing on the lower Stanislaus River has been lost or degraded because of low instream flow releases. A variety of factors, including low flows, have cumulatively resulted in degradation of spawning gravel, loss of side channels and channel diversity, and reduced spawning gravel recruitment to the active stream channel. Siltation of spawning gravel is primarily caused by watershed disturbance. Existing fine sediments in the lower system may be a result of the intensive hydraulic mining that occurred in the mid-1800s, particularly near the town of Columbia. This problem can best be corrected by minimizing erosion in the watershed and by routinely adding clean gravel to the active channel. The loss of side channels and channel diversity was probably caused by road construction, instream gravel mining, armoring of streambanks by landowners, and by the current practice of removing woody debris from the active channel to protect rafters. Upstream dams and the practice of in-channel gravel mining have removed spawning gravel, altered the migration corridor, and created salmon predator habitat.

Habitat improvement opportunities for chinook salmon in the San Joaquin basin, including the lower Stanislaus River, have been assessed through a DFG-funded study. Projects identified include gravel renovation projects, channel modifications to create new spawning riffles, channel modifications to isolate existing excavated areas from the active river channel to reduce predation and improve the migration corridor, and riparian vegetation restoration.

Recovery options for steelhead in the Stanislaus River have not been assessed, but, as with other regulated rivers in the Central Valley, recovery measures will focus on providing access to historical habitats and/or maintaining adequate water temperatures below dams for oversummer rearing of juveniles. These issues will need to be addressed. The canyon reach between Knights Ferry and Goodwin Dam contains the highest quality habitat for steelhead, and there is a substantial, self-sustaining "wild trout" population in this reach. Juvenile steelhead probably utilize the entire reach between Goodwin Dam and Riverbank for rearing. Water temperatures of 60° F or less should be maintained during the summer months in this reach to provide the necessary conditions for rearing.

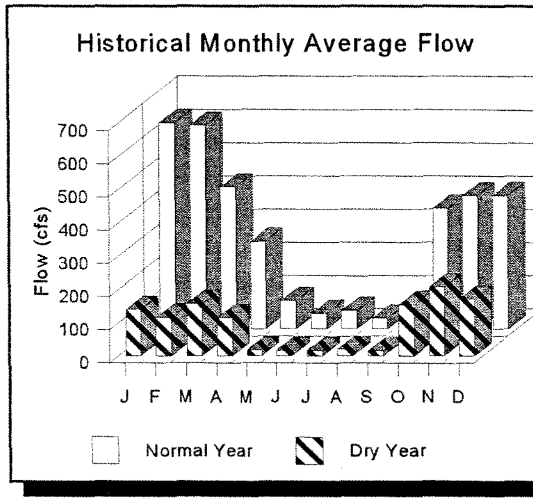
The remnant population of riparian brush rabbit is restricted to 198 acres of native riparian forest along the Stanislaus River in Caswell Memorial State Park. A population census following the January 1997 flood indicates that this species is close to extinction.

TUOLUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

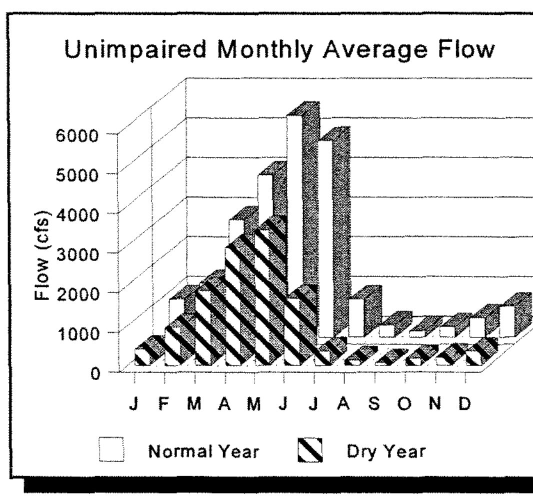
The Tuolumne River is the largest tributary in the San Joaquin River basin, with an average annual runoff of 1.95 million af and a drainage area of approximately 1,900 square miles, including the northern half of Yosemite National Park. The lower Tuolumne River below La Grange Dam is divided into two 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.

Hetch Hetchy Reservoir (located in Yosemite) was constructed by the City and County of San Francisco in 1923 for drinking water supply, with a capacity of approximately 360,000 af. Cherry Lake (capacity 260,000 af) was completed in 1953 to increase the aqueduct yield to the maximum of approximately 300 cfs (220,000 af per year) currently exported in the Hetch-Hetchy aqueduct to San Francisco. The Modesto and Turlock Irrigation Districts jointly regulate the flow to the lower river from New Don Pedro Reservoir, with a gross storage capacity of 2.03 million af. The reservoir, completed in 1970, provides power, irrigation, and flood control protection. LaGrange Dam, located downstream from New Don Pedro Dam, diverts approximately 900,000 af per year for power, irrigation, and domestic purposes.

Streamflow in the Tuolumne River is typical of southern Sierra streams originating from the high mountains. Monthly unimpaired flows at New Don Pedro Dam average approximately 2,500 cfs, with peak runoff as snowmelt from April through July. Rainfall can cause substantial runoff from November through March. In highest rainfall years, average monthly inflows range from 10,000 to 18,000 cfs from February through July, 5,000 to 9,000 cfs from November through January, and 1,500 to 3,500 cfs from August through October. In driest years, April and May average monthly inflows peak at only 1,500 cfs, with August through October flows of only 15-30 cfs.



Tuolumne River Streamflow at LaGrange, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)



Tuolumne River Unimpaired Streamflow at Don Pedro Reservoir, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th or median percentile year.)

The average historical flow at La Grange near the river mouth is approximately 880 cfs, with most of this flow occurring during winter periods when storms cause reservoir flood control releases in all but low rainfall years. In highest rainfall years, monthly average flows peak in April and May at 8,000 to 10,000 cfs, with summer and fall flows of 900 to 4,000 cfs. Summer flows range from less than 10 cfs to 50 cfs in all but wet years. Irrigation return flows along the lower Tuolumne increase summer flows near Modesto to approximately 100 cfs. Flows in dry and normal years generally peak in January to March at 150 to 600 cfs and are minimum in June to September at 10 to 50 cfs.

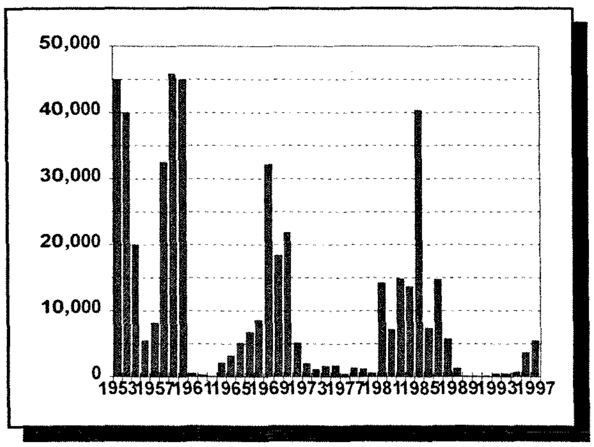
Streamflow strongly influences chinook salmon production in the Tuolumne River. Flow requirements for the lower Tuolumne River are specified in the New Don Pedro Proceeding Settlement Agreement (February 1996) and the Federal Energy Regulatory Commission (FERC) Order Amending License for the New Don Pedro Project (July 1996). USFWS (1995) recommended an alternative flow schedule to achieve the goals of the Anadromous Fish Restoration Program (AFRP).

Low flows can lead to poor water quality, which can delay spawning, decrease egg survival, and cause high juvenile mortality during the spring emigration period. Results of the stream temperature modeling study on the lower Tuolumne River indicate that in recent years, temperature limits for salmon spawning were commonly exceeded in a portion of the spawning reach in October. This contributed to delayed upstream migration and spawning. In recent drought years, the first fish have returned to spawn in the lower Tuolumne River in early November, rather than in October as in previous years, because high water temperatures blocked their upstream migration. As with the other San Joaquin basin tributaries, high water temperatures on the lower Tuolumne River during the spring emigration period may be a significant factor affecting smolt survival. Results of the stream temperature modeling study indicate that in May, and at times in late April, smolts emigrating from the Tuolumne River encounter stressful or lethal water temperatures. Temperature was a consideration in formulating the FERC and AFRP revised flow schedules. However, these new schedules will not ease temperature problems under all ambient conditions, especially in the lower portion of the river during low flows.

LaGrange Dam is the upstream barrier to salmon and steelhead migration. Salmon spawn in the 25-mile reach between LaGrange Dam and the town of Waterford and rear in the entire lower river. Historically, the river supported spring- and fall-run chinook salmon and steelhead trout. A total of 66 adult steelhead were counted at Dennett Dam near the City of Modesto in 1940. Other historical information and the presence of spring-run chinook salmon also provide ample evidence of a steelhead run in the Tuolumne River (Yoshiyama et al. 1996; CDFG 1997)

The river now supports fall-run chinook salmon and steelhead and perhaps late-fall-run chinook salmon. The presence of distinct anadromous runs of late-fall-run chinook salmon is not confirmed. Evidence of natural production (observations of young-of-the-year rainbow trout), creel census information, and anecdotal observations of adult steelhead by anglers, provides some evidence that a steelhead population persists in the Tuolumne River (CDFG 1997). Because there has been no focused effort to assess the steelhead population in the Tuolumne River, and there is essentially no indirect or bycatch information from other monitoring programs on which to estimate a probability of extinction, there is no information available to conclude that steelhead are extirpated from the Tuolumne River. This fact, and the anecdotal information and observations cited above, has led CDFG to conclude that a remnant steelhead population still exists in the Tuolumne River (CDFG 1997).

As in the other basin tributaries, fall-run spawning escapements in the lower Tuolumne River have varied substantially. Population fluctuations are the result of extreme variations in environmental conditions in the river, Bay-Delta, and ocean. Since surveys were initiated, the Tuolumne River, on average, has supported the highest spawning escapements (fish that survive migration and spawn) among the San Joaquin basin tributaries. During the 1987 through 1992 drought, chinook salmon spawning runs in the lower Tuolumne River declined drastically. In the falls of 1991 and 1992, fewer than 300 adults returned to spawn, as compared to a recent peak of 40,000 in 1985 and an earlier estimate of 130,000 in 1944.



Fall-run Chinook Salmon Returns to the Tuolumne River, 1953-1997.

The San Joaquin NWR (780 acres) is located at the confluence of the San Joaquin and Tuolumne rivers. This refuge provide important riparian and seasonal wetland habitats for Aleutian Canada goose, greater sandhill crane, western yellow-billed cuckoo, waterfowl, shorebirds, and neotropical migrant birds.

Chinook salmon smolt survival studies completed thus far on the lower Tuolumne River indicate that adequate spring flows improve smolt survival. Smolt appears to be the critical bottleneck in the life cycle, because smolt production determines adult run size. Unnaturally high summer flows in the salmon spawning and rearing areas below the dams from storage releases for irrigation sustains large populations of predatory fish. These predators are then present in other months and can cause significant young salmon losses.

Steelhead and chinook salmon spawning and rearing habitat has been degraded because of low instream flow releases, which resulted in siltation of spawning gravel, and lack of spawning gravel recruitment. EA Engineering (1992) examined the distribution and abundance of chinook spawning habitat and concluded that spawning habitat was a significant factor limiting salmon production in the Tuolumne River. In addition, the study suggested that lack of gravel supply, combined with Tuolumne fall-run chinook's preference to spawn in the upper reach, led to substantial superimposition of redds, with this being a major cause of chinook mortality.

In major portions of the spawning reach and below, riparian vegetation has been removed because of agricultural development, cattle grazing, urban development, and gravel mining. Gravel mining in the active stream channel has removed gravel from long stretches of the spawning reach. In roughly half of the spawning reach, extensive mining has left long, deep pools and a widened channel. These pools provide habitat for salmon predators, such as largemouth and smallmouth bass, and contribute to warming the river. The 1992 EA Engineering study also revealed that these introduced bass species may be a dominant cause of juvenile chinook mortality, especially under low flow conditions in the Tuolumne River. The highest densities of predatory fish were observed in former in-channel gravel extraction pits.

Thirty-six small irrigation pump diversions have been identified on the lower Tuolumne River; none are screened. Juvenile salmon losses at these sites are unknown, but cumulatively, they may cause a measurable loss of young salmon and steelhead.

Illegal harvest of upstream migrating chinook salmon has been identified as a factor limiting production in the basin. With many miles of migratory habitat that are often under low-flow conditions, salmon are particularly vulnerable to poaching.

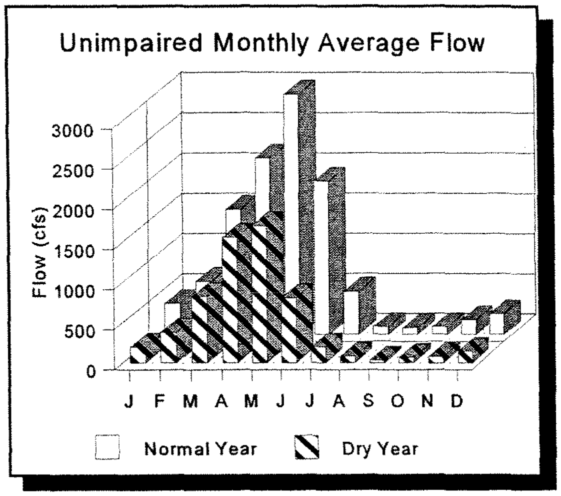
Steelhead recovery options for the Tuolumne River have not been addressed by the management agencies. However, the ESA listing of steelhead populations in the San Joaquin tributaries will necessitate that options be identified and implemented. As with other regulated rivers in the Central Valley, recovery measures will need to focus on providing access to historical habitats and/or maintaining adequate water temperatures below dams for oversummer rearing of juveniles. These issues will need to be addressed in future recovery planning.

MERCED RIVER ECOLOGICAL MANAGEMENT UNIT

The Merced River is the southernmost stream used by chinook salmon in the San Joaquin River basin and in California. The river flows westward into the valley, draining approximately 1,275 square miles in the Sierra Nevada mountains and foothills, including the southern half of Yosemite National Park The average unimpaired runoff in the basin is approximately 1.02 million af, similar to the Stanislaus River drainage.

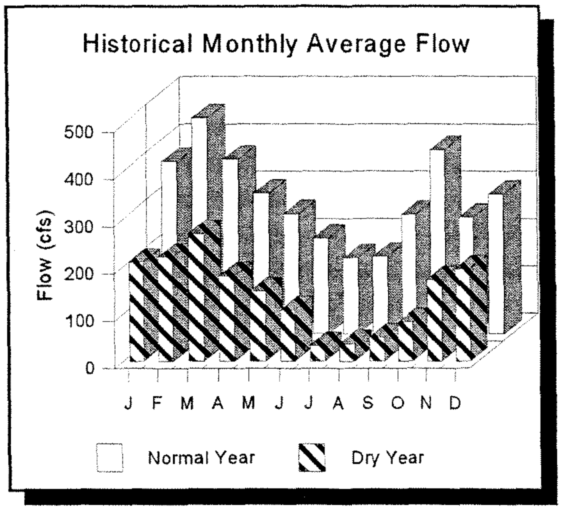
Agricultural development began in the 1850s, and significant changes have been made to the hydrologic (water circulation) system since that time. The enlarged New Exchequer Dam, forming Lake McClure with a gross storage capacity of 1,024,000 af, was constructed in 1967 and now regulates releases to the lower Merced River. The dam is operated by Merced Irrigation District (MID) for power production, irrigation, and flood control. The river is also regulated by McSwain Dam (an afterbay for New Exchequer Dam) and Merced Falls and Crocker-Huffman diversion dams located downstream. Approximately 500,000 af of water is diverted each year at Merced Falls and Crocker-Huffman Dams.

Merced River unimpaired inflows to its watershed are typical of southern Sierra streams with headwaters in the high mountains. Monthly unimpaired flows at Lake McClure average approximately 1,325 cfs, with peak runoff as snowmelt from April through June. Rainfall can cause substantial runoff from December through March. Unimpaired flows in late summer and early fall are generally less than 100 cfs in all but wet years. In highest rainfall years, average monthly inflows range from 6,000 cfs to 12,000 cfs from February through July. In driest years, flows are less than 20 cfs from August through December, whereas April through June flows average 300 to 600 cfs. In dry and normal years, spring inflows average 800 to 1,700 cfs and 2,000 to 3,000 cfs, respectively, whereas August through October flows range from 30 to 100 cfs.



Unimpaired Merced River Streamflow at Lake McClure, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Monthly historic flow data near the mouth of the Merced River at Stevinson indicate that the water storage and delivery systems are extremely efficient on the Merced River. The historical average flow is approximately 650 cfs (50% of unimpaired), with most of this flow occurring during winter rainfall periods or in fall during reservoir flood control releases. Summer flows are less than 50 cfs in driest years. In highest rainfall years, flows in February through June average 4,000 to 5,500 cfs, whereas flows in August and September average 1,000 to 2,000 cfs. In dry and normal years November to April flows range from 150 to 450 cfs, while July to September flows range from 30 to 200 cfs.



Merced River Streamflow at Stevinson, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

In addition to streamflow, available natural spawning habitat also limits salmon production in the Merced River. 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, reducing stream shading and bank stability; and in-channel mining, which has removed spawning gravel, altered the migration corridor, and created excellent salmon predator habitat.

Spawning and rearing habitat in the Merced River is the most degraded among the San Joaquin basin tributaries. Legally required summer flow releases are low (15 to 25 cfs) and are usually depleted before they reach the river mouth because of small water diversions throughout the lower river. In portions of the spawning reach and below, riparian (waterside) vegetation has been removed for agricultural development, cattle grazing, urban development, and gravel mining.

Gold dredging in the early 1900s removed significant quantities of spawning gravel from the Merced River. Large tailing piles remain along the spawning reach, and there is a lack of recruitment of new spawning gravel due to the dams, gravel mining, bank protection, and levee construction. In many riffles, significant armoring has also occurred, with only large cobbles remaining. In-channel gravel mining was extensive along the Merced River. Downstream from the State Route 59 bridge, the river flows through large mined-out pits in the channel. Some pit areas have been isolated from the active channel by levees; however, most of these levees were poorly designed and have been breached during flood flows. The ponds and small lakes resulting from these pits create excellent salmon predator habitat, disrupt salmon migration, trap juvenile salmon when water recedes, and raise stream temperatures.

Juvenile salmon are lost in water diverted at the six medium-sized irrigation diversions in the salmon spawning portion of the Merced River. The Davis-Grunsky contract between the California Department of Water Resources (DWR) and MID requires the district to install and maintain fish screening devices at these diversions. Rock screens, consisting of perforated conduit buried in cobble-filled gabions, have been installed at four of the diversions. These structures are only moderately effective at preventing juvenile salmon loss in diverted water. The screens quickly become clogged with vegetation, and the bypass gates, which allow diversion without water passing through the screens, are often opened when the screens become clogged.

DFG surveys on the lower Merced River have identified 68 small pump irrigation diversions; none is adequately screened to prevent entrainment of juvenile salmon. Cumulative losses at these sites are unknown.

Flow releases are not sufficient to accommodate salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Merced River. Flows in the spawning reach during the spawning and early rearing period are further depleted by water diversions. Spring flows for smolt emigration are particularly inadequate.

Streamflow for fishery purposes in the lower Merced River is mandated in FERC License No. 2179 for the New Exchequer Project, issued in April 1964, and Davis-Grunsky Contract No. D-GG417 (DWR Contract No. 160282) between DWR and MID, executed in October 1967. The Davis-Grunsky contract requires MID to maintain a continuous flow of between 180 cfs and 220 cfs from November 1 through April 1 throughout the reach from Crocker-Huffman Dam to Shaffer Bridge.

Adequate releases for upstream attraction of adults and spawning begin on November 1, but upstream migration typically begins in October. The present spawning and rearing flow requirements were not established by scientific studies and are too low to meet spawning and rearing needs. In addition, six major riparian diversions in the spawning reach from Crocker-Huffman Dam to below Snelling deplete these flows. At times, significant portions of the spawning reach receive flows less than the legally required amounts. Required streamflows are measured at the Shaffer Bridge gage, which is downstream from several irrigation returns.

The most significant deficiencies in the present flow requirements for chinook salmon occur in the spring emigration period. April and May flows required in the FERC license are 75 cfs in a normal year and 60 cfs in a dry year. Smolt survival studies conducted in the other tributary streams in the San Joaquin drainage indicate that significantly higher spring flows are needed in the lower Merced River.

A revised flow schedule for the lower Merced River was formulated by DFG (1993) based on instream flow study and smolt survival data from similar drainages. DFG concluded that, although the recommended flows are a significant improvement over the presently required releases, they are not optimal for salmon spawning, rearing, or emigration, particularly in drier years. USFWS (1995) recommended flows that would contribute to its Central Valley Project Improvement Act (CVPIA) goal of doubling anadromous fish production in the basin, but did not include any measures to recover steelhead. The most significant deficiencies for steelhead are unsuitable water temperatures for summer rearing.

Poor water quality delays spawning, decreases egg survival, and causes high juvenile mortality. Stream temperature on the river often exceeds temperature tolerances for salmon spawning and egg incubation in October and early November in at least a portion of the spawning reach. High water temperature delays upstream migration and spawning. In recent drought years, salmon have not spawned in the river until after the first week of November, when water temperature has dropped to tolerable levels.

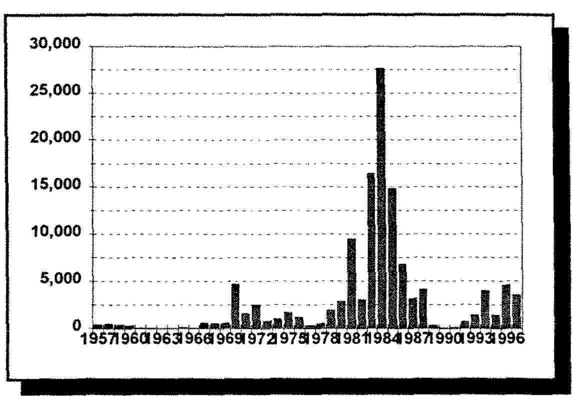
In late April and May, stream temperature often exceeds stressful levels for emigrating smolts. Elevated spring temperatures are a more significant problem in the lower Merced River than in the other San Joaquin tributaries because of higher ambient air temperatures and lower flows.

Crocker-Huffman Dam, near the town of Snelling, is the upstream barrier for salmon and steelhead migration. Salmon spawn in the 24-mile reach between Crocker-Huffman Dam and the Town of Cressey. Rearing habitat extends downstream of the designated spawning reach to the mouth.

Historically, the river supported spring- and fall-run chinook salmon and steelhead. Historical information and the presence of spring-run chinook salmon provides ample evidence that a steelhead run was present historically in the Merced River (Yoshiyama et al. 1996; CDFG 1997), and there is some evidence that they were able to migrate as far upstream as Yosemite Valley (Hubbs and Wallis 1948; Snyder 1993). The river now supports fall-run chinook salmon and perhaps steelhead and late-fall-run chinook salmon.

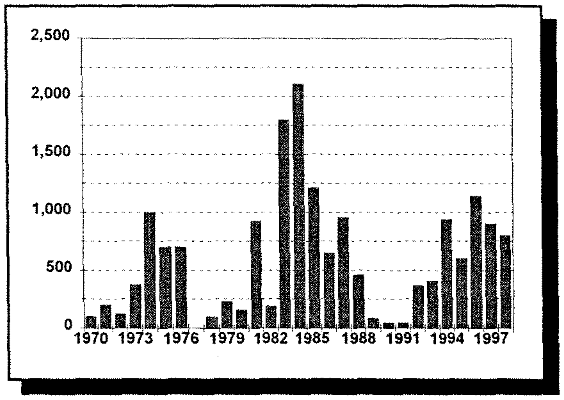
As with the Stanislaus and Tuolumne Rivers, the number of late-fall-run chinook salmon and steelhead in the Merced River is unknown. Each year, a few large rainbow trout, possibly steelhead, enter the Merced River Hatchery (MRH). Also, an adult steelhead was captured immediately above the Hills Ferry Salmon Barrier just upstream of the Merced River confluence in November, 1996 (Mayott 1997). Because there has been no focused effort to assess the steelhead population in the Merced River, and there is essentially no indirect or bycatch information from other monitoring programs on which to estimate a probability of extinction, there is no information available to conclude that steelhead are extirpated from the Merced River. This fact, and the anecdotal information and observations cited above, has led CDFG to conclude that a remnant steelhead population still exists in the Merced River (CDFG 1997).

As with other tributaries in the basin, fall-run chinook salmon spawning escapements in the lower Merced River have varied significantly since surveys were initiated. Construction and operation of MRH, in combination with increases in instream flows related to the 1967 Davis-Grunsky Contract, have increased the Merced River salmon run. Before 1970, spawning escapements were generally less than 500 fish annually; since that time, annual runs have averaged 5,800 fish. During the 1987 through 1992 droughts, spawning escapements in the lower Merced River declined to seriously low levels. In fall 1991, fewer than 100 fish returned to spawn, compared to a recent high of 23,000 fish



Naturally Spawning Fall-run Chinook Salmon Returns to the Merced River, 1957-1997.

in 1985. Extremely low returns to MRH in recent years have severely limited the hatchery's ability to sustain San Joaquin basin salmon through droughts.



Returns of Fall-run Chinook Salmon to Merced River Hatchery, 1970-1998.

MRH, located below Crocker-Huffman Dam, is presently the only salmon hatchery in the San Joaquin River drainage south of the Delta. Operated by the DFG, MRH was constructed in 1970 and operated for 10 years with funding provided in the Davis-Grunsky Agreement. The hatchery has been valuable in augmenting and sustaining salmon runs in the lower Merced River and in the Stanislaus and Tuolumne Rivers and providing fish for study purposes throughout the San Joaquin basin. The facility was recently modernized using funding from the Salmon Stamp Program and the DWR Four Pumps Agreement.

Merced NWR is located in the southern portion of this Ecological Management Zone. The refuge encompasses 2,561 acres and provides about 700 acres of seasonally flooded marsh and 600 acres of corn, alfalfa, irrigated pasture, and winter habitat. The marshes are flooded from October through April and attract thousands of migrating and wintering birds, especially ducks, geese, cranes, and shorebirds. The agricultural land provides forage for lesser sandhill cranes and four species of geese.

Preliminary surveys on the Merced River indicate that the major needs for salmon habitat improvement include rehabilitating riffle areas, constructing or repairing levees and channels to isolate mining pit areas from the active stream channel, and modifying diversion structures. The existing abandoned gravel pits also serve as predator habitat and trap sediments transported from upstream areas.

Steelhead recovery options for the Merced River have not been addressed by the management agencies. However, the ESA listing of steelhead populations in the San Joaquin tributaries will necessitate that options be identified and implemented. As with other regulated rivers in the Central Valley, recovery measures will need to focus on providing access to historical habitats and/or maintaining adequate water temperatures below dams for oversummer rearing of juveniles. These issues will need to be addressed in future recovery planning.

Illegal harvest of upstream-migrating adult salmon has also been identified as a factor limiting salmon production in the Merced River. Low water flows during the fall salmon migration make salmon easy prey for poachers.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the East San Joaquin Basin Ecological Management Zone includes improved streamflow, greater sediment supplies, lower spring through fall stream temperatures, improved upper watershed health, improved foodweb productivity, and improved habitats, including riparian, wetland, and seasonally flooded aquatic habitats. In addition, actions to reduce stressors, such as screening unscreened diversions, reducing the effects of gravel mining, reducing wild salmon and steelhead harvest, and limiting the adverse effects of introducing hatchery fish, will help restore salmon and steelhead populations in zone rivers.

The vision focuses on restoring important fish, wildlife, and plan communities and their habitats by restoring ecological processes and reducing stressors. Primary focus will be on restoring or reactivating the ecological processes that create and maintain habitats for anadromous salmonids and riparian vegetation. In each of the zone rivers, focus will be on restoring and protecting a self-sustaining stream meander corridor and an associated diverse riparian community that provide shade, nutrients, and woody debris to the rivers, as well as habitat for plants and wildlife communities. Because dams on each of the rivers interrupt the natural sediment supply on which natural stream meander depends, it will be necessary to artificially sustain some natural sediment supply, including silt, sand, and gravel.

In addition to restoring a natural stream channel process, it will also be necessary to restore natural floodplain processes needed to enhance foodweb productivity. These processes provide habitat for juvenile salmon and steelhead and spawning habitat for splittail and other native resident (non-migratory) fish, and habitat for migratory waterfowl and shorebirds. Natural floodplain processes occur in areas that receive seasonal flooding overflows adjacent to the stream channel, such as riparian forests, oxbows, and seasonal wetlands. These habitats depend on seasonal flooding, and the rivers and Delta depend on floodplain recruitment. Gravel is needed to maintain stream channel configuration (structure) and spawning habitat for salmon and steelhead. Throughout the basin, restoring and/or protecting a self-sustaining, diverse riparian community will be emphasized to maintain nutrient and woody debris input to the aquatic system, enhance bank stability and stream shading, and provide valuable habitat for a variety of species.

In the lower Stanislaus, Tuolumne, and Merced rivers, emphasis will be on restoring fall-run chinook salmon and steelhead populations. Because spawning and rearing habitats are degraded, and poor streamflows and stressors have depressed the populations, it may be necessary to continue or expand hatchery rearing of salmon and steelhead, at least in the short term, to maintain sufficient production in these rivers to support sport and commercial fisheries. However, hatcheries will be operated to preserve the genetic identity of endemic (native to a particular locality), naturally spawning stocks of chinook salmon and steelhead trout. Hatchery-produced fish will be used to support sustainable ocean recreational and commercial fisheries and directed fisheries in the rivers. Marking techniques will enable sport and commercial anglers to distinguish between hatchery-produced and naturally produced fish to minimize wild fish harvest.

The Ecosystem Restoration Program Plan (ERPP) envisions that the fish, wildlife, and riparian needs of the East San Joaquin Basin Ecological Management Zone will be met and acceptable ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

STANISLAUS RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Stanislaus River Ecological Management Unit is to improve natural fall-run chinook salmon and steelhead populations by providing suitable water temperatures for rearing juveniles and improving spring flows below New Melones Dam in dry and normal water years, summer through winter base flows, and spawning and rearing habitat.

The vision for the Stanislaus River Ecological Management Unit includes improving streamflow, gravel recruitment, stream channel and riparian habitat, and screening diversions to increase the survival of chinook salmon, steelhead, and native resident fish and wildlife. Managing flow releases to provide suitable habitat and water temperatures for key resources is critical to ecosystem restoration. Also important will be restoring natural channel configurations and gravel recruitment, transport, and cleansing processes. Improved land use and livestock grazing practices will contribute to improved riparian habitat. Reducing non-native fish populations, entrainment of aquatic resources at water diversions, contaminant input, and illegal harvest will further benefit salmon and steelhead. Restoring a diverse, self-sustaining riparian corridor linked with upstream and downstream areas will be critical in restoring ecosystem function.

Restoring fall-run chinook salmon in the Stanislaus River could have significant benefits to sport and commercial fisheries. Historically, spawning escapements of fall-run chinook in the Stanislaus River have numbered up to 7% of the total fall-run salmon escapement in the Central Valley. The restoration program has the potential to return populations to recent historic levels, which could improve coastal sport and commercial fisheries.

The vision for the Stanislaus River includes reactivating and maintaining important ecological processes that create and sustain habitats for salmon and steelhead. Streamflow should be enhanced below Goodwin Dam by providing base flows recommended by the AFRP and a spring flow event in late April or early May in normal and wet years, and suitable temperatures for juvenile steelhead rearing in summer. Higher, more natural spring flow events will assist young salmon and steelhead on their downstream migration to the Bay-Delta and ocean and also support natural stream channel and riparian habitat restoration. Pulse flows also benefit the river and Bay-Delta foodweb production. The added flows in the Stanislaus River, in combination with similar flow events from the Tuolumne and Merced Rivers, will assist young salmon from all three rivers on their downstream journey through the lower San Joaquin River, Delta, and Bay to the ocean. An improved stream meander corridor and associated SRA habitat, in combination with improved gravel recruitment and water temperatures, will provide more suitable habitat for salmon and steelhead spawning and rearing, which should lead to greater natural salmon and steelhead production in the Stanislaus River. Improvements in the upper watershed health from reduced forest fuel levels and less risk of catastrophic wild fires, along with less erosion from improved road construction and maintenance, will help protect water supply and water quality.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting the natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Planting vegetation or regrading the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery.

Stressors, including unscreened or poorly screened diversions and illegal and legal harvest, will be evaluated to determine whether actions are necessary to protect salmon and steelhead populations. Measures being considered to reduce harvest of naturally spawning chinook salmon in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. Enforcement would be increased to reduce poaching.

TUOLUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Tuolumne River Ecological Management Unit includes maintaining suitable water temperatures, restoring streamflow, gravel recruitment, and stream channel and riparian habitat to improve habitat for chinook salmon, steelhead, native resident fish, native amphibians and reptiles, and wildlife. The vision also includes restoring important ecological processes that will improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, riparian vegetation, and wildlife resources. Managing flow releases to maintain suitable habitat and water temperatures for salmon and steelhead will be essential for restoring the ecosystem. Flow improvements in the revised agreement and FERC license should be implemented and monitored for effectiveness. Streamflow management for the Tuolumne River will need to be integrated with flow management on the other San Joaquin tributaries and the lower San Joaquin River to obtain the greatest benefits.

Also, important will be restoring more natural channel configurations; restoring gravel recruitment, transport, and cleansing processes; and restoring a balanced fine sediment budget. This will be accomplished by implementing improved land use and livestock grazing practices, reducing non-native fish populations and habitats that support them, reducing young salmon losses at water diversions, reducing the input of contaminants, and reducing the illegal salmon harvest. Restoring a diverse, self-sustaining riparian and stream channel corridor linked with upstream and downstream areas will be an essential element in the ecosystem restoration plan.

Restoring fall-run chinook salmon in the lower Tuolumne River could have significant benefits. Historically, spawning escapements in the river have numbered up to 12% of the total fall-run salmon escapement in the Central Valley. Implementing the restoration program has the potential to restore the population to recent historic levels, which will also benefit sport and commercial fisheries along the coast of California.

Streamflows should be enhanced below Don Pedro Dam by providing base flows recommended by DFG. In addition to the DFG recommendation, a spring flow event in late April or early May in dry, normal, and wet years would be provided to support downstream emigration of juvenile salmon and steelhead and to benefit stream channel and riparian habitat. Also, adequate cold water releases from Don Pedro Dam should be made to maintain suitable water temperatures in summer and early fall for juvenile steelhead rearing.

Existing gravel recruitment sources will be protected and supplemented where and when necessary with gravel introductions. A cooperative program among the local counties, agencies, and the aggregate resource industry will be developed to improve or relocate gravel mining from the active stream channel.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Vegetation planting or regrading of the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery.

Stressors will be addressed. A cooperative evaluation of unscreened and inadequately screened diversions will determine the feasibility of installing positive-barrier fish screens. Measures being considered to reduce naturally spawning chinook salmon harvest in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. A selective fishery on hatchery-produced fish will reduce harvest of naturally produced Tuolumne chinook salmon. Enforcement would be increased to reduce poaching.

If future baseline chinook salmon populations do not respond favorably to improved flow and habitat conditions in the Tuolumne River, San Joaquin River, and the Delta, a comprehensive evaluation will be made of the need for additional artificial propagation of chinook salmon in the basin. This evaluation would consider direct and indirect effects on the wild population, the role of hatchery fish in maintaining naturally spawning and hatchery derived salmon, disease transmission between hatchery and natural stocks, genetic structure and diversity of all stocks in the basin, and the likelihood of maintaining existing genetic diversity of the Tuolumne stock. Efforts relating to artificial propagation of salmon and steelhead will be the subject of monitoring, focused research, and adaptive management.

TUOLUMNE RIVER WATERSHED DEMONSTRATION PROJECT: The Tuolumne River watershed has tentatively been selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1 CALFED will support ongoing and enhanced management and restoration efforts in the watershed. Success in Stage 1 will set the stage for subsequent implementation phases as the restoration and management information gained from the effort in the Tuolumne watershed will have broad application in designing and implementing similar programs in similar watersheds in the San Joaquin Basin and elsewhere in the Central Valley.

Although the ecological integrity of the Tuolumne River has declined, considerable opportunities exist to improve the river corridor through rehabilitating important ecological processes. The following descriptions of attributes of alluvial river ecosystem integrity are cited directly from McBain and Trush (1998). These not only form a basis for the Tuolumne River restoration vision but also provide a basis for selecting actions for CALFED Stage 1 Implementation.

SPATIALLY COMPLEX CHANNEL MORPHOLOGY: No single segment of channel bed provides habitat for all species, but the sum of channel segments provides high-quality habitat for native species. A wide range of structurally complex physical environments supports diverse and productive biological communities.

FLOWS AND WATER QUALITY ARE PREDICTABLE VARIABLE: Inter-annual and seasonal flow regimes are broadly predictable, but specific flow magnitudes, timing, durations and frequencies are unpredictable due to runoff patterns produced by storms and droughts. Seasonal water quality characteristics, especially water temperature, turbidity, and suspended sediment concentration are similar to regional unregulated rivers and fluctuate seasonally. This temporal "predictable unpredictability" is a foundation of river ecosystem integrity.

FREQUENTLY MOBILIZED CHANNELBED SURFACE: In gravel-bedded reaches, channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge, which on average occurs every 1-2 years. In sand-bedded reaches, bed particles are in transport much of the year, creating migrating channebed "dunes" and shifting sand bars.

PERIODIC MOBILIZED CHANNELBED SCOUR AND FILL: Alternate bars are scoured deeper than their coarse surface layers by floods exceeding 3-to-5 year annual maximum flood recurrences. This scour is typically accompanied by redeposition, such that net change in channelbed topography following a scouring flood usually is minimal. In gravel-bedded reaches, scour was most likely common in reaches where high flows were confined by valley walls.

BALANCED FINE AND COARSE SEDIMENT BUDGETS: river reaches export fine and coarse sediment at rates approximately equal to sediment inputs. The amount and mode of sediment storage within a given river reach fluctuates, but sustains channel morphology in dynamic quasi-equilibrium when averaged over many years. A balanced coarse sediment budget implies bedload continuity; most particle sizes of the channelbed must be transported through the river reach.

PERIODIC CHANNEL MIGRATION AND/OR AVULSION: The channel migrates a variable rates and establishes meander wavelengths consistent with regional rivers with similar flow regimes, valley slopes, confinement, sediment supply, and sediment caliber. In gravel-bedded reaches, channel relocation can also occur by avulsion, where the cannel moves from one location to another, leaving much of the abandoned channel morphology intact. In sand-bedded reaches, meanders decrease their radius of curvature over time, and are eventually bisected, leaving oxbows.

A FUNCTIONAL FLOODPLAIN: On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage. Lower terraces are inundated by less frequent floods, with their expected inundation frequencies dependent on norms exhibited by similar, but unregulated river channels. These floods also deposit finer sediment onto the floodplain and low terraces.

INFREQUENT CHANNEL RESETTING FLOODS: Single large floods (e.g., exceeding 10-to-20 years recurrences) cause channel avulsions, rejuvenate mature riparian stands to early-successional stages, form and maintain side channels, and create off-channel wetlands (e.g., oxbows). Resetting floods are as critical for creating and maintaining channel complexity as lesser magnitude floods, but occur less frequently.

SELF-SUSTAINING DIVERSE RIPARIAN PLANT COMMUNITIES: Based on species life history strategies and inundation patterns, initiation and mortality of natural woody riparian plants culminate in early- and late-successional stand structures and species diversities (canopy and understory) characteristic of self-sustaining riparian communities common to regional unregulated river corridors.

NATURALLY-FLUCTUATING GROUNDWATER TABLE: Inter-annual and seasonal groundwater fluctuation patterns in floodplains, terraces, sloughs, and adjacent wetlands are similar to regional unregulated river corridors.

In summary, the types of actions that should be further examined to promote restoration of the Tuolumne River corridor include:

- Encourage inter-annual and seasonal flow variability,
- Increase the magnitude and frequency of short duration peak flows to initiate bed mobility and localized scour and deposition,
- Increase the magnitude and frequency of peak flows to initiate bed scour on alluvial deposits along the low water margin to reduce riparian encroachment,
- Increase coarse sediment input to balance mainstem transport capacity,
- Reduce fine sediment input to the river,
- Reduce human encroachment onto floodplains to allow limited channel migration, and
- Restore channel morphology, with a bankfull channel and floodway scaled to the expected high flow regime.

Cumulatively, an investment in the Tuolumne River watershed during Stage 1 will provide direct benefits to the creek and dependent fish and wildlife resources and provide the types of information required to successfully move the Ecosystem Restoration Program into subsequent implementation phases. A few of the lessons to be learned in the Tuolumne River watershed include methods to improve overall watershed and ecosystem health; how to effectively integrate local, state, federal and private efforts in a large-scale restoration program; how to design and implement actions to benefit anadromous and resident fish species, riparian systems and riparian-dependent mammals and birds; and how to best implement actions below dams in a highly altered hydrologic system to restore function sediment transport and other important ecological processes.

MERCED RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Merced River Ecological Management Unit includes maintaining suitable water temperatures, restoring streamflow, coarse sediment recruitment, and stream channel and riparian habitat to improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, riparian vegetation, and wildlife resources. The vision also includes restoring the important ecological functions and processes that will improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, native amphibians and reptiles, riparian vegetation, and wildlife resources. Managing flow releases to provide suitable habitat and water temperatures for these resources will be essential to restoring the ecosystem. Streamflow management for the Merced River will need to be integrated with flow management on the other San Joaquin tributaries and the lower San Joaquin River to obtain the greatest possible benefits, because the salmon and steelhead must also pass through the lower San Joaquin River and Bay-Delta on their way to and from the Pacific Ocean.

Also important will be:

- restoring more natural channel configurations; restoring gravel recruitment, transport, and cleansing processes,
- restoring a balanced fine sediment budget by implementing improved land use and livestock grazing practices,
- reducing non-native fish habitat,
- reducing the loss of young salmon at water diversions,
- reducing the input of contaminants,
- reducing the number of adult fish straying into areas with no suitable spawning habitat,
- and reducing illegal salmon harvest.

Restoring a diverse, self-sustaining riparian corridor linked with upstream and downstream areas will be critical to restoring ecological health to the Merced River watershed. MID plays an important role in restoration efforts on the lower Merced River. The district is working in cooperation with resource agencies on research and restoration projects for fall-run chinook salmon in the basin.

Streamflow should be enhanced below Lake McClure by providing minimum flows recommended by DFG. In addition to the DFG recommendation, a spring flow event would be provided in dry, normal, and wet years. The pulse flow would emulate a natural pulse flow that would normally occur if flows were unimpaired. A spring flow event will support juvenile salmon and steelhead emigrating to the Delta, Bay, and ocean. It would also support natural stream channel and riparian habitat development. Also, adequate cold water releases from Lake McClure should be made to maintain suitable water temperatures in summer and early fall for juvenile steelhead rearing.

Existing gravel sources will be protected and the natural gravel supply supplemented where and when necessary. A cooperative effort among local counties, agencies, and the aggregate resource industry will be encouraged to evaluate relocating gravel mining to areas outside of the active stream channel.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting the natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Vegetation planting or regrading of the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery. Large mined-out gravel pits in the stream channel will be isolated or restored to natural conditions.

The effects of stressors, including artificial propagation of salmon and steelhead, water diversions, and illegal and legal harvest, will be assessed and reduced, if necessary. Stocking fall chinook salmon reared in the MRH requires careful consideration of the effects to naturally spawning stocks, not only in the Merced River, but in adjacent Central Valley watersheds. Choice of genetic types of adult salmon selected for the hatchery will be carefully evaluated to minimize potentially damaging effects on the genetic integrity of wild populations in the Central Valley. A cooperative evaluation will be made of the need and feasibility of installing positive-barrier fish screens on diversions. Measures being considered to reduce wild chinook salmon harvest in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. Enforcement would be increased to reduce poaching.

Restoring and maintaining the Merced River could be facilitated by developing and implementing a comprehensive watershed management plan to protect the channel (e.g., maintain flood control capacity and reduce bank erosion) and preserve and restore the riparian corridor.

VISIONS FOR ECOLOGICAL PROCESSES

Important ecological processes and functions in the East San Joaquin Basin Ecological Management Zone include the annual streamflow regime (pattern), coarse sediment supply, stream meander, natural stream channel configurations, and water temperature regime. These processes are in various states of health in the zone. The greatest need is to restore the functions and processes linked to streamflow.

CENTRAL VALLEY STREAMFLOWS: Streamflow shapes stream channels and riparian vegetation; provides fish habitat; keeps water temperature lower in rivers; attracts anadromous fish to spawning streams; and transports young anadromous fish to downstream nursery areas in the San Joaquin River, Bay-Delta estuary, and ocean. Streamflow in each of these rivers is impaired by upstream storage reservoirs and diversions, particularly in dry and normal rainfall years. A healthy streamflow pattern in the rivers would emulate the natural runoff pattern, with a spring flow event and summer-fall-winter base flows that maintain important ecological processes and functions, habitats, and important species. The vision for streamflows is to provide a short-term (10-day) flow event in spring that typically occurred at least once in dry and normal years before dams and reservoirs were built. In addition, base flows would be provided during the remainder of the year to sustain habitats and species.

COARSE SEDIMENT SUPPLY: Gravel recruitment into the rivers is important in providing a natural stream meander process, channel configuration, and stream substrate (bottom materials where plants and animals thrive), as well as essential spawning gravels for salmon and steelhead. A natural sediment supply is also important for restoring riparian and wetland habitat. Sediment transport and gravel recruitment have been greatly reduced below major dams in zone rivers. Not only has sediment from the upper watersheds been eliminated, but sediment from the lower rivers has been interrupted by bank protection, levees, and gravel mining. The vision is to supplement natural gravel below major dams on the three rivers, where needed for salmon and steelhead spawning habitat, riparian habitat, and natural stream channel and meander development. In addition, where bank protection, levees, and gravel mining have hindered natural sediment supply to the river, wherever possible, local sediment supplies will be made available to the river.

STREAM MEANDER: In their floodplains, Central Valley rivers naturally meander through floodplain sediments, progressively eroding the next bank while adding to the previous bank. This stream meander process occurred in the stream corridors of the Stanislaus, Tuolumne, and Merced rivers. A limited stream-meander process in the lower floodplain of the rivers would provide much needed habitat to support healthy riparian systems, wildlife, and aquatic species. Today, the natural meander process in each of the streams is inhibited by dams, altered stream flows, bank protection, bridge abutments, and flood control levees. In some places, bank erosion occurs, but lack of sediment stops forming of the previous banks. The vision is to restore a portion of the natural meander to the rivers by setting back levees, where possible, and removing structures that inhibit the process from the meander corridor.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: The San Joaquin Valley formerly had many natural overflow basins that retained floodwaters, permitted sediment deposition, and provided fish and waterfowl habitat. Partially reactivating these important ecological functions will contribute to overall system health and provide for prolonged periods of natural streamflow and sediment input. Natural overflow basins would also supply important habitat for fish, including chinook salmon and splittail, as well as foraging habitat for many waterfowl. The vision is to restore natural overflow basins within the lower floodplains of the three rivers. This would provide additional flood control protection for other areas in this zone and downstream, as well as valuable natural wetland, riparian, and aquatic habitats for fish and wildlife.

CENTRAL VALLEY STREAM TEMPERATURES: Salmon and steelhead depend on cool water for their survival. In the Stanislaus, Tuolumne, and Merced rivers, salmon and steelhead are confined to the floodplains of the rivers below large, impassable dams. Maintaining cool water below the dams is essential to maintaining salmon and steelhead in these rivers. Summer and early fall water temperatures in floodplains of these rivers are naturally warm, but are kept cool, at least in the upper reaches below the dams, by coldwater releases from deeper bottom waters of the major reservoirs. The extent of cool water habitat below the dams depends on the amount of cold water released from the dams, the extent of shade provided by riparian (waterside) vegetation, the extent that dredger ponds are connected to the rivers, the amount of water diverted from the river channel, and the amount of warm water discharge into the rivers from urban and agricultural drainage. Improving water temperatures in the three rivers below the major reservoirs in this zone can contribute to the overall ecological health of the system and promote sustainable fisheries. Steelhead particularly depend on cool summer water temperatures, because their young remain in the rivers through summer before migrating to the ocean. High fall water temperatures in the lower rivers hinder upstream migrations of adult fall-run chinook salmon and steelhead. The vision for water temperatures in these rivers is to provide sufficient summer and early-fall base flows in the river channels and restore the riparian corridors and natural stream channel characteristics that limit heating of the rivers. Storing sufficient coolwater in the reservoirs during drought will also help to maintain a minimum of coolwater habitat in the rivers.

VISIONS FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian and shaded riverine aquatic (SRA) habitats are important to the health of the rivers. They provide shade, insects and organic debris that are important to the aquatic foodweb, and soil and bank protection. The riparian corridors and related SRA habitat are impaired by lack of a natural functioning stream meander process, confinement of the river channels by bank protection and levees, and loss of streamside vegetation to animal grazing, levee construction, removal of large woody debris from stream channels and banks, and agricultural clearing. The vision is to improve and restore riparian and SRA habitat along the three rivers, where possible and as needed. Included in this vision is the consideration of other riparian communities such as Great Valley valley oak, Great Valley mixed riparian, cottonwood-willow-sycamore, and elderberry savanna.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The Stanislaus, Tuolumne, and Merced rivers are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The quality of freshwater fish habitat in these rivers should be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Stanislaus, Tuolumne, and Merced rivers have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these rivers include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions along the rivers divert not only water, but small fish. Many diversions are screened to reduce young fish loss. Reducing losses to screened and unscreened diversions will contribute to overall ecosystem health by promoting sustainable fisheries and higher population levels. The vision is to screen those diversions that have no screens or inadequate screens where there is a potential to screen young fish in significant numbers.

DAMS AND OTHER STRUCTURES: Upstream fall-run chinook salmon passage is often limited by the presence of seasonally constructed diversion dams. The vision is to provide alternative diversion methods and to coordinate the annual removal of these dams to improve fish passage. Some adult chinook salmon tend to stray from their natal streams by remaining in the mainstem San Joaquin River and attempting to migrate above the Merced River mouth into agricultural return water. The vision is that chinook salmon spawning populations in the East San Joaquin Basin Ecological Management Zone will be increased by a seasonal weir that prevents fish from migrating above the mouth of the Merced River.

PREDATION AND COMPETITION: Predation on juvenile chinook salmon by warmwater fish, such as largemouth and smallmouth bass, in the lower reaches of streams in the East San Joaquin Basin Ecological Management Zone is a significant source of mortality. The vision is that predation will be reduced by a combination of actions to control predator populations and isolate predator habitat. These actions will contribute to improved survival of native San Joaquin Basin chinook salmon.

HARVEST OF FISH AND WILDLIFE: The legal and illegal anadromous fish harvest in the river, estuary, and ocean limits recovery of wild fall-run chinook salmon populations in the three rivers. Reducing the harvest may be necessary to allow recovery of wild populations. The vision is to continue to reduce the harvest of wild anadromous fish and focus legal harvest on hatchery stocks of salmon and steelhead.

ARTIFICIAL PROPAGATION OF FISH: Stocking hatchery-reared salmon in the Merced River supports important sport and commercial fisheries and helps to compensate for the loss of salmon and steelhead caused by the construction of large dams and reservoirs. Hatchery fish also supplement the numbers of naturally spawning salmon and steelhead in the river. Hatchery supplementation helps sustain fishable populations through periods of poor wild fish production (e.g., droughts). However, hatchery salmon and steelhead may impede the recovery of wild populations by competing with and preying on young of wild fish and reducing the genetic integrity of the wild populations by breeding with wild fish. The vision is to improving hatchery adult fish selection, spawning, rearing, and release practices to minimize potential conflicts with the naturally-spawning salmon and steelhead populations.

SPECIES VISIONS

CHINOOK SALMON: The vision for chinook salmon is to recover all stocks presently listed or proposed for listing under ESA or CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. Fall-run chinook salmon will benefit from improved flows. Enhanced spring flow events will improve transport conditions for downstream migrating fall-run chinook. Fall and winter base-flow improvements will benefit upstream migrating fall-run chinook salmon and survival of eggs and fry. Improvements in wetland, riparian, and SRA habitats; stream channel and meander; and gravel recruitment will also improve spawning and rearing habitat. Screening unscreened and poorly screened diversions will improve young salmon production. Limiting harvest will provide adequate numbers of spawners and help sustain long-term fishery harvest.

STEELHEAD: The vision for steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitat. Steelhead will benefit from improved spring flow events in dry and normal years. Spring flows will provide attraction for upstream migrating adults and support downstream migrating juveniles. Improved summer, fall, and winter base flows will maintain fall and winter upstream migrants and over-summering physical habitat and lower water temperatures. Steelhead will also benefit from improved gravel spawning habitat and stream rearing habitat, especially if summer heating of the river is reduced in the process. Screening unscreened and poorly screened diversions will improve young steelhead production.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, and riparian habitats in the East San Joaquin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

SWAINSON'S HAWK: The vision for Swainson's hawk is to contribute to the recovery of this State-listed threatened species. Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected as a result of improved habitat.

GREATER SANDHILL CRANE: The vision for the greater sandhill crane is to contribute to the recovery of this California species of special concern. Improvements in pasture lands and seasonally flooded agricultural habitats, such as flooded corn fields, should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitat.

WESTERN YELLOW-BILLED CUCKOO: The vision for the western yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. The yellow-billed cuckoo along the San Joaquin River and its tributaries is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be expanded by improvements in riparian habitat areas. These improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the San Joaquin River and East San Joaquin Ecological Management Zones, thus sustaining the river meander belt, and increasing the natural sediment supply to support meander and riparian regeneration.

RIPARIAN BRUSH RABBIT: The vision for the riparian brush rabbit is to assist in the recovery of this State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat. Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding.

SAN JOAQUIN WOODRAT: The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this federally proposed endangered species through improvement in its habitat.

SHOREBIRDS AND WADING BIRDS: The vision for shorebirds and wading birds is to maintain and restore healthy populations through habitat protection and restoration. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the East San Joaquin Ecological Management Zone by these birds should increase.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the East San Joaquin Ecological Management Zone and possibly increases in some populations would be expected.

NEOTROPICAL MIGRATORY BIRDS: The vision for the neotropical migratory bird guild is to restore and maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta.

NATIVE RESIDENT FISHES: The vision for native resident fish species is to maintain and restore the distribution and abundance.

LAMPREY: The vision for anadromous lampreys is to maintain and restore population distribution and abundance to higher levels that at present. The vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Maintaining and restoring the health of the Ecological Management Units in the East San Joaquin Basin Ecological Management Zone will depend on the efforts of local and State water management agencies. Efforts in the basin will be linked to activities of the California Waterfowl Association, Ducks Unlimited, and The Nature Conservancy. Overall, these efforts will require cooperation from resource agencies such as DFG, DWR, USFWS, and the National Marine Fisheries Service (NMFS), as well as participation and support from Reclamation, the U.S. Natural Resources Conservation Service, and other private organizations, water districts, and landowners. These groups will work together to maintain and restore streamflows and fish and wildlife habitat, reduce impacts of diversions, minimize poaching, and minimize habitat and water quality degradation in basin streams. In support of this effort, funding may be provided to enhance streamflows, reduce fish-passage problems, screen diversions, restore habitats, and increase enforcement of the California Fish and Game Code to protect recovering populations of salmon and steelhead. Oakdale and South San Joaquin Irrigation Districts also are active participants in ecosystem restoration efforts on the lower Stanislaus River. The Modesto and Turlock Irrigation Districts play important roles in restoration efforts on the lower Tuolumne River. The districts are working in cooperation with resource agencies on research and restoration projects for fall-run chinook salmon in the basin.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the East San Joaquin Basin Ecological Management Zone will augment other important ongoing and future restoration efforts for the zone. This program will complement efforts of the USFWS's AFRP (USFWS 1995). The goal of the program is to double the natural anadromous fish production in the system over the average production during 1967 to 1991. CVPIA authorized the dedication and management of 800,000 af of CVP yield annually to implement fish, wildlife, and habitat restoration purposes and measures. Because the Stanislaus River is a CVP-controlled stream, a portion of this allocation has been released to the lower river to improve salmon rearing and emigration (the needs of steelhead were not included in this allocation). CVPIA also directed the Secretary of the Interior to evaluate and determine the existing and anticipated future basin needs in the Stanislaus River basin while preparing the Stanislaus River Basin and Calaveras River Water Use Program Environmental Impact Statement.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

The vision will also help the DFG reach its goal of doubling the number of anadromous fish that were produced in 1988.

AGREEMENT ON SAN JOAQUIN RIVER PROTECTION

In an effort to resolve issues brought forth in the State Water Resources Control Board's 1995 Water Quality Control Plan for the Bay/Delta, the San Joaquin River Tributaries Association, San Joaquin River Exchange Contractors Water Authority, Friant Water Users Authority, and the San Francisco Public Utilities Commission collaborated to identify feasible, voluntary actions to protect the San Joaquin River's fish resources. In spring 1996, these parties agreed on a "Letter of Intent to Resolve San Joaquin River Issues." This agreement, when finalized, has the potential of providing the following:

- higher minimum base flows,
- significantly increased pulse flows,
- installation and operation of a new fish barrier on the mainstem San Joaquin River,
- set up a new biological monitoring program, and
- set aside federal restoration funds to cover costs associated with these measures.

One of the important components of the Agreement is the development of the Vernalis Adaptive Management Program (VAMP) to improve environmental conditions on the San Joaquin River. Elements of this potential adaptive management program include a range of flow and non-flow habitat improvement actions throughout the watershed, and an experimental program designed to collect data needed to develop scientifically sound fishery management options for the future.

The future of the Agreement is unknown at this time. However, several actions by the San Joaquin River Stakeholders Policy Group and other parties have been or are presently being implemented throughout the watershed. These actions include:

- Extensive scientific studies of the chinook salmon fishery and habitats on the Tuolumne, Merced, and Stanislaus Rivers;
- Districts have assisted in the bypassing of high river flows around spawning areas as requested by State and federal agencies to provide more stable flows during the fall spawning period;
- Improved instream flows in order to increase naturally occurring chinook salmon populations;
- Water transfers to the USBR pursuant to the CVPIA to help implement a portion of the Anadromous Fish Restoration Program;
- Chinook salmon habitat restoration work;
- Spawning gravel rehabilitation;
- Inventory and development of habitat restoration project proposals;
- Feasibility studies of establishment of a salmon hatchery and rearing facilities.

San Joaquin River Management Program (SJRMP)

This program will complement the SJRMP, which was established through State legislation (Chapter 1068/90) to develop comprehensive and compatible solutions to water supply, water quality, flood control, fisheries, wildlife habitat, and recreational needs in the San Joaquin River basin. The program resulted in a final report with recommendations to the California Legislature in February 1995 and has now entered the implementation phase.

FERC Licence Program

Minimum flow requirements below each of the dams on the rivers are required by FERC hydropower licenses. Existing minimum flows in the lower Merced River are designated in FERC License No. 2179 for the New Exchequer Project, issued in April 1964, and the Davis-Grunsky Contract No. D-GGR17 (DWR Contract No. 160282) between DWR and MID, executed in October 1967. The Davis-Grunsky contract requires MID to maintain a continuous flow of between 180 cfs and 220 cfs in the lower Merced River from November 1 through April 1 throughout the reach from Crocker-Huffman Dam to Shaffer Bridge. An agreement was executed in 1995 for the Tuolumne River between 10 stakeholder and resource agencies. It amended the license for the New Don Pedro Project to increase instream flow releases from New Don Pedro Dam. Flows in this agreement were incorporated into a FERC Order Amending License for the New Don Pedro Project.

CALFED Bay-Delta Program

CALFED has funded 13 ecosystem restoration projects in the East San Joaquin Ecological Management Zone. Many of the projects restore portions of the Tuolumne and Merced rivers that have been damaged by gravel extraction operations. Another project places gravel in the Tuolumne River to replace gravel captured by upstream reservoirs.

Linkage to Other Ecological Management Zones

Many of the resource elements in the East San Joaquin Basin Ecological Management Zone depend extensively on conditions or elements in other zones. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem San Joaquin River, the Delta, San Francisco Bay, and the nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, toxic contaminants, water quality, and harvest, restoring populations in the East San Joaquin Basin Ecological Management Zone will require corresponding efforts in other zones.

The ecosystem health of the East San Joaquin Basin Ecological Management Zone is highly dependent on conditions in the San Joaquin River and Sacramento-San Joaquin Delta Ecological Management Zones. Stressors there (water diversions and water quality) have a significant effect on resources in this zone. Conditions in San Francisco Bay and the Pacific Ocean can also have a significant effect on resources in this zone.

Stressors in the mainstem San Joaquin River have significant effects on resources in its tributary streams. In particular, reduced streamflow and the high input of contaminants into the mainstem San Joaquin River reduces survival of anadromous fish migrating up and down the river, to and from spawning and rearing areas in the tributary streams.

Water, sediment, nutrient supply, and input of contaminants from the tributary streams in this zone all influence habitat conditions in the mainstem San Joaquin River. Changes in these factors from historical conditions have contributed to habitat degradation on the mainstem river.

Maintaining a healthy riparian zone and balanced sediment budget in the mainstem San Joaquin River will depend on appropriate nutrient, water, and sediment input from the major tributaries. Water supply from the tributaries is critical to maintaining aquatic habitat in the mainstem river between the Merced River confluence and Vernalis, because Friant Dam diverts nearly all of the flow from the upper San Joaquin River watershed.

The Sacramento-San Joaquin Delta Ecological Management Zone provides essential habitat for upstream migration of adult anadromous fish and downstream migration and rearing of juvenile anadromous fish from the San Joaquin River basin. Conditions in the Bay-Delta significantly affect anadromous fish production in the San Joaquin River basin, because, in most years, much of the inflow from the basin is diverted in the Delta, and the loss of juvenile salmon and steelhead in Delta water diversions is high. In turn, the magnitude of inflow and the input of nutrients, contaminants, and sediments from the San Joaquin River and its tributaries significantly affect the health of the Bay and Delta ecosystem. Restoring and maintaining a healthy ecosystem in this zone will be critical to restoring the ecosystem in the Bay and Delta.

Additionally, stressors affecting fish and wildlife species using the San Joaquin River basin during at least part of their life cycle occur outside the identified Ecological Management Zones. For example, ocean recreational and commercial fisheries have a significant effect on the numbers of anadromous fish returning to spawn and rear in the San Joaquin River basin. New harvest management strategies for the ocean fisheries may be needed to ensure restoration of San Joaquin tributary salmon runs.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: Maintain the following base flows in the Stanislaus River below Goodwin Dam (◆◆):

- in critical, dry, and below-normal years, minimum flows should be 200 to 300 cfs, except for a flow event of 1,500 cfs for 30 days in April and May,
- in above-normal years, minimum flows should be 300 to 350 cfs, except for 800 cfs in June and 1,500 cfs in April and May, and
- in wet years, minimum flows should be 300 to 400 cfs, except for 1,500 cfs from April through June.

PROGRAMMATIC ACTION 1A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 2: Provide the following 10-day spring flow events on the Stanislaus River: 2,500 to 3,000 cfs in late April or early May in normal years and 3,000 to 4,000 cfs in wet years. Such flows would be provided only when inflows to New Melones Reservoir are at these levels (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 3: Maintain the following base flows in the Tuolumne River below Don Pedro Dam (◆◆):

- in critical and below years, flow release should be 50 cfs from June through September, 100 cfs from October 1-15, 150 cfs from October 16-May 31, plus an 11,091 acre-foot outmigration pulse flow,

- in median critical dry years, flow release should be 50 cfs from June through September, 100 cfs from October 1-15, 150 cfs from October 16- May 31, plus a 20,091 acre-foot outmigration pulse flow,

- in intermediate critical dry years, flow release should be 50 cfs from June through September, 150 cfs from October 1-15, 150 cfs from October 16- May 31, plus a 32,619 acre-foot outmigration pulse flow,

- in median dry years, flow release should be 75 cfs from June through September, 150 cfs from October 1-15, 150 cfs from October 16-May 31, plus a 37,060 acre-foot outmigration pulse flow,

- in intermediate dry-below normal years, flow release should be 75 cfs from June through September, 180 cfs from October 1-15, 180 cfs from October 16- May 31, plus a 35,920 acre-foot outmigration pulse flow and a 1,676 acre-foot attraction pulse flow,

- in median below normal years, flow release should be 75 cfs from June through September, 200 cfs from October 1-15, 175 cfs from October 16- May 31, plus a 60,027 acre-foot outmigration pulse flow and a 1,736 acre-foot attraction pulse flow,

- in all other year types (intermediate below normal/above normal, median above normal, intermediate above normal-wet, and median wet/maximum years), flow release should be 250 cfs from June through September, 300 cfs from October 1-15, 300 cfs from October 16-May 31, plus a 89,882 acre-foot outmigration pulse flow and a 5,950 acre-foot attraction pulse flow.

PROGRAMMATIC ACTION 3A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 4: Maintain the following base flows in the Merced River below Lake McClure:

- in dry years, minimum instream flows at Shaffer Bridge should be 15 cfs from June through October 15, 60 cfs from October 16 through October 31 and January through May, and 75 cfs in November and December, and

- in normal years, minimum instream flows at Shaffer Bridge should be 25 cfs from June through October 15, 75 cfs from October 16 through October 31 and January through May, and 100 cfs in November and December.

PROGRAMMATIC ACTION 4A: Develop a cooperative approach to coordinate flow releases to attain target levels.

TARGET 5: Provide the following 10-day spring flow events on the Merced River: 1,000 to 1,500 cfs in late April or early May in dry years, 2,000 to 2,500 cfs in normal years, and 3,000 to 4,000 cfs in wet years. Such flows would be provided only when inflows to Lake McClure are at these levels (◆◆).

PROGRAMMATIC ACTION 5A: Develop a cooperative approach to coordinate flow releases to attain target levels.

RATIONALE: *Flows in the Stanislaus, Tuolumne, and Merced Rivers are controlled by releases from foothill storage reservoirs (New Melones, New Don Pedro, and New Exchequer Reservoirs, respectively). Improving base flows would increase habitat for spawning, rearing, and migration of salmon and steelhead. Pulse flows in spring would help to restore natural stream channel processes; gravel recruitment, cleansing, and transport; and riparian vegetation development and survival. These flows also would* *help to support juvenile salmon and steelhead emigration to the Delta.*

In all cases, flows will continually subject to the developing aspects of adaptive management in which decisions are based on the development and evaluation of testable hypotheses. Flow recommendations are linked to water quantity and quality and in the long-term should be designed to contribute to species maintenance and restoration, improving natural or semi-natural ecological functions, and assist in promoting the sustainability of specific types of habitat important to fish, wildlife and plant communities.

Given the wide variety of past and recent flow recommendations, it is apparent that much additional information is required to better use existing water supplies to meet all the beneficial uses, with particular focus on the ecosystem requirements. The basis for ERPP flow recommendations eventually will differ significantly from flow recommendations based on the needs of chinook salmon migration, spawning, and rearing. Salmon flows will likely continue to form the core of flow needs, but from the ecosystem perspective, flows will need to meet the need of sediment transport and other channel maintenance processes as well as contribute to sustaining a diversity of aquatic, floodplain and other closely linked habitats such as seasonal wetlands and riparian forests. Still, the present recommendations for "ecosystem" flows suffer from insufficient data regarding better estimates of sediment transport and channel maintenance flows. These are very important aspects of integrating flow prescriptions with actual ecosystem restoration requirements and will require the development of testable hypotheses and the monitoring and research programs necessary to collect and evaluate data to support or refute the hypotheses.

The recommended flow event on the Stanislaus River may be constrained in the short-term by flood control concerns below Goodwin Dam. Full implementation of the proposed flows may depend on land use changes in the floodplain that could be inundated by the flow events. The flow event is closely related to recommendations in this section regarding stream meander corridor and natural floodplains and flood processes.

Minimum flows are necessary in the salmon and steelhead spawning and rearing areas of each of the three rivers to sustain adequate physical habitat, water temperatures, and food supply for juvenile salmon and steelhead, both of which may be year-round residents. In some cases, base flows may be higher than unimpaired flow. Such flows are necessary, because spawning and rearing habitats for juvenile salmon and steelhead, traditionally located upstream of the dams, now are located downstream.

Flow events are recommended during spring to more closely emulate the natural spring peak-flow pattern. Such flows stimulate and support downstream juvenile salmon and steelhead migration. The spring flow will also mobilize, clean, and transport spawning gravels; create point bars and other instream habitat types; and contribute to a natural channel meandering pattern and riparian scrub and woodland habitat development and maintenance.

DFG (1993) believes existing flow requirements are inadequate for fall-run chinook salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Merced River. Adequate releases for upstream attraction of adults and spawning begin on November 1, but migration typically begins in October. The current spawning and rearing flow requirements are not the result of scientific studies and may be too low to meet spawning and rearing needs. Flows in the spawning reach during the spawning and early rearing period are further depleted by water diversions. Spring flows for smolt emigration are particularly inadequate.

Flow targets recommended by DFG (1993) for the lower Merced River were derived from instream flow study and smolt survival data from similar *drainages. Recommended flows during the spring emigration period are consistent with proposed spring outflow objectives for the basin at Vernalis on the San Joaquin River. Although the proposed flows are a significant improvement over the current flow releases, they are not the most favorable for salmon spawning, rearing, or emigration, particularly in drier years (California Department of Fish and Game 1993).*

Flow targets recommended by USFWS (1995) for the Merced River were developed by the AFRP San Joaquin Basin Technical Team. Recommended flows were derived from historical flows and results of biological studies. The team believes that implementing the flow schedule, along with other recommended actions, would double natural fall-run chinook salmon production in the Merced River.

For the lower Tuolumne River, an agreement was executed in 1995 between 10 stakeholder and resource agencies. It amended the license for the New Don Pedro Project to increase instream flow releases from New Don Pedro Dam. Flows in this agreement were incorporated into a FERC Order Amending License for the New Don Pedro Project (July 1996). This new flow agreement is based on ten different water year types. These new flows should be viewed as the experimental baseline for restoring chinook salmon and for their contribution in promoting a healthy alluvial river system.

Flow targets were recommended by DFG (1993) for the lower Tuolumne River following results of an instream flow study (U.S. Fish and Wildlife Service 1993) and smolt survival studies. Flow needs recommended by DFG are met in many year-types by flows specified in the settlement agreement. However, DFG (1993) stated that, although its flow recommendations were a significant improvement over the recent historical flow releases, they are not the most favorable for salmon spawning, rearing, or emigration, particularly in drier years. The recommended flow pulses in April and May are prescribed to better meet these needs in drier years and to support stream channel and riparian habitat processes.

Existing minimum fishery flows in the lower Stanislaus River are designated in a 1987 study agreement between Reclamation and DFG. This agreement, enacted under a DFG protest of Reclamation's water right applications to redivert water from New Melones Dam, specifies interim annual flow allocations for fisheries between 98,300 af and 302,100 af, depending primarily on carryover storage at New Melones and inflow. Instream flow schedules are set annually by DFG in the total annual flow allocation specified in the agreement. In recent years, coordinating fishery and water quality flow releases and releases for water sales and transfers have resulted in additional flow releases that significantly benefit anadromous fish.

DFG (1993) stated that the existing flow requirements are inadequate for fall-run chinook salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Stanislaus River. Spring flows for smolt emigration are particularly inadequate. There is a positive relationship between spring outflow at Vernalis on the San Joaquin River and at Ripon on the Stanislaus River to adult escapements into the basin 2½ years later. Results of smolt survival studies completed on the Stanislaus River thus far indicate a positive relationship between smolt survival and spring flow releases. April through May flow events are prescribed for these reasons.

Flow targets recommended by DFG (1993) for the lower Stanislaus River were formulated from results of an instream flow study (U.S. Fish and Wildlife Service 1993) and smolt survival studies. Flows for October through March were determined from results of the instream flow study for salmon spawning, egg incubation, and rearing. Flows during April and May determined from results of the smolt survival studies. The flows are consistent with spring outflow objectives proposed for the basin at Vernalis on the San Joaquin River. Summer flows addressed needs of oversummering *yearling salmon and steelhead. Although these flow targets are a significant improvement over the current flow releases, they are not the best possible for salmon spawning, rearing, or emigration, particularly in drier years (California Department of Fish and Game 1993). Again, this is the reason for recommending additional April through May flow pulses.*

Flow targets recommended by USFWS (1995) for the Stanislaus River were developed by the San Joaquin Basin Technical Team. Recommended flows were derived from historic flows and results of biological studies. The team believes that implementing the flow schedule, in concert with other recommended actions, would double natural fall-run chinook salmon production in the Stanislaus River.

It is important to note that all of the agreed upon or proposed flows (AFRP, Tuolumne River Settlement Agreement, FERC, VAMP, Davis-Grunsky, and DFG recommended flows) in the Stanislaus, Tuolumne, and Merced rivers were designed to facilitate chinook salmon recovery, and little or no consideration was given to steelhead recovery in the design of these flow strategies. Flow and temperatures requirements of steelhead will need to be evaluated and integrated into the proposed flow regimes.

COARSE SEDIMENT SUPPLY

TARGET 1: Reduce existing levels of erosion and maintain gravel recruitment in tributaries that sustain an adequate level of gravel recruitment, or restore desirable levels by directly manipulating and augmenting gravel supplies where the natural flow process has been interrupted by dams or other features that retain or remove the gravel supply (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility and need for establishing long-term coarse sediment augmentation and fine sediment control programs for streams below major impoundments in the East San Joaquin Ecological Management Zone.

PROGRAMMATIC ACTION 1B: Evaluate spawning gravel quality in areas used by chinook salmon in the Stanislaus River. If indicated, renovate or supplement gravel supplies to enhance substrate quality by importing additional gravel as conditions require.

PROGRAMMATIC ACTION 1C: Evaluate spawning gravel quality in areas used by chinook salmon in the Tuolumne River. If indicated, renovate or supplement gravel supplies to enhance substrate quality.

PROGRAMMATIC ACTION 1D: Evaluate spawning gravel quality in areas used by chinook salmon in the Merced River. If indicated, renovate or supplement gravel supplies to enhance substrate quality.

RATIONALE: *Gravel transport is the process whereby flows carry away finer sediments that fill gravel interstices (spaces between cobbles). Gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing, by flushing most fines and moving bedload, are important processes to maintain the amount and distribution of spawning habitat in the Sacramento-San Joaquin River basin. Human activities have greatly reduced or altered these processes. Opportunities to maintain and restore these processes include changing water flow, sediment supplies, and basin geomorphology (earth forming process); removing stressors; or manipulating channel features and stream vegetation directly.*

A feasibility study that emphasizes the hydrologic and fluvial geomorphologic aspects of the three watershed need to be conducted early in the program to provide guidance of the development and implementation of potential sediment augmentation programs. This will require the expertise and knowledge of trained experts. It may be that gravel deposits in streams of the East San

Joaquin Basin Ecological Management Zone are essential to maintain spawning and rearing habitats of fall-run chinook salmon, steelhead, and other native fish. Opportunities to maintain and restore gravel recruitment include manipulating natural processes and controlling or managing environmental stressors that adversely affect recruitment.

STREAM MEANDER

TARGET 1: Preserve and expand the stream-meander belts in the Stanislaus, Tuolumne, and Merced Rivers by adding a cumulative total of 1,000 acres of riparian lands in the meander zones (◆◆◆).

PROGRAMMATIC ACTION 1A: Acquire riparian and meander-zone lands by purchasing them directly or acquiring easements from willing sellers, or provide incentives for voluntary efforts to preserve and manage riparian areas on private land.

PROGRAMMATIC ACTION 1B: Build local support for maintaining active meander zones by establishing a mechanism through which property owners would be reimbursed for lands lost to natural meander processes.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to improve opportunities for natural meander by removing riprap and relocating other structures that impair stream meander.

TARGET 2: On the Merced River between the towns of Cressey and Snelling, isolate gravel pits, reconfigure (rearrange) dredge tailings, and restore a more natural channel configuration to 5 to 7 miles of disturbed stream channel. On the Tuolumne River, between river miles (RMs) 25 and 51, isolate 15 to 30 gravel pits, reconfigure dredge tailings, and restore a more natural stream channel to 6 to 9 miles of disturbed stream channel. On the Stanislaus River, restore a more natural stream channel to 2.5 to 5 miles of disturbed stream channel (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program, consistent with flood management, to restore more natural channel configurations to reduce salmonid predator habitat and improve migration corridors.

PROGRAMMATIC ACTION 2B: Work with permitting agencies to appropriately structure future gravel extraction permits. Coordinate the design and implementation of gravel pit isolation and stream channel configuration with the Corps, local water management agencies, and local governments.

PROGRAMMATIC ACTION 2C: Develop a cooperative program with the counties, local agencies, and aggregate (sand and gravel) resource industry to develop and implement gravel management programs for each of the three rivers.

PROGRAMMATIC ACTION 2D: Develop a cooperative program to implement a salmonid spawning and rearing habitat restoration program, including reconstructing channels at selected sites by isolating or filling in inchannel gravel extraction areas.

RATIONALE: *Stream meander, natural sediment supply, and floodplain and flood processes are closely linked and some of the programmatic actions under stream corridor would also be appropriate for natural sediment supply or floodplain processes. Between 1942 and 1993, approximately 6.8 to 13.6 million tons of bed material were mined from the active Merced River channel. The pits that resulted from this excavation occupy approximately 4 miles of the existing river channel between the towns of Cressey and Snelling (Kondolf et al. 1996). Restoration planning for the lower Tuolumne River has identified the need for channel reconstruction in approximately 8.5 total miles, or 42%, of the spawning reach (from RM 45.3 to RM 25.1), isolation of backwater areas at* *approximately 20 sites located from RM 50.3 to RM 30.1, and isolation of gravel pits from the active channel at approximately 10 locations from RM 50.0 to RM 30.5. Gravel mining was less extensive on the lower Stanislaus River, but channel improvements there are also needed.*

Stream channel restoration to isolate or reduce gravel extraction pits has been identified as an important component of a comprehensive spawning and rearing habitat improvement program in the basin (California Department of Fish and Game 1993, U.S. Fish and Wildlife Service 1995).

Additional research or technical advice is required to better understand and develop specific projects designed to improve stream channel meander, improve sediment supplies, and to increase the benefits of the interaction of streams with their floodplains.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Restore and improve opportunities for rivers to inundate (flood) their floodplain on a seasonal basis (◆).

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to construct setback levees in the Stanislaus, Tuolumne, and Merced River floodplains.

PROGRAMMATIC ACTION 1B: Restore, as needed, stream channel and overflow basin configurations within the floodplain.

PROGRAMMATIC ACTION 1C: Minimize effects of permanent structures, such as bridges and diversion dams, on floodplain processes.

PROGRAMMATIC ACTION 1D: Develop a floodplain management plan for the Stanislaus River.

PROGRAMMATIC ACTION 1E: Develop a floodplain management plan for the Tuolumne River.

PROGRAMMATIC ACTION 1F: Develop a floodplain management plan for the Merced River.

RATIONALE: *Setback levees will provide greater floodplain inundation, room for stream meander, and greater amounts of riparian forest and seasonal wetland habitats along the lower rivers. Channel configuration adjustments may be necessary to accelerate restoration of natural floodplain habitats and to restore and maintain configurations that may not occur naturally due to remaining constraints from new setback levees. Permanent structures, such as bridges and diversions dams can interrupt and impair natural floodplain processes and habitat development and succession, thus requiring removal of the structures, rebuilding, or some continuing maintenance or mitigative efforts to minimize their effects.*

The present channel capacity of the Tuolumne river is about 9,000 cfs which is not large enough to meet the needs of maintaining a healthy alluvial river ecosystem. The January 1997 flood on the lower Tuolumne River peaked at 60,000 cfs and provided a glimpse of the resiliency of the Tuolumne River. While the high flows damaged development in the floodplain, it also created alternate bars in the channel, recruited gravel from the banks as the river meandered, and placed large woody debris in the stream channel. As a result of the 1997 floods, the Governor's Flood Emergency Action Team Final Report (May 10, 1997) recommended that the U.S. Army Corps of Engineers conduct a study to increase the channel capacity in the Tuolumne river to convey flows up to 20,000 cfs. This would more than double the present 9,000 cfs capacity, mimic the seasonal peak to a greater degree, and provide additional ecological benefits while providing greater flexibility to manage floods. An expanded floodway on the Tuolumne river would also *address the implementation objectives related to natural sediment supply, stream meander, and stream temperatures.*

Other benefits of improving the quantity of floodplains include:

- *increased shading and food web support,*
- *re-establishment of stream meander, and*
- *potential conversion of agricultural land to floodplain and the reduced need for diversion.*

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain maximum surface water temperatures on the lower Merced, Tuolumne, and Stanislaus rivers to the downstream boundary of the salmon spawning area (as defined by Fish and Game Code section 1505) during summer, fall and winter and to the mouth of the river during the spring as follows (◆◆◆):

- June 1 through September 30, 60°F
- October 15 through February 15, 56°F, and
- April 1 through May 31, 65°F.

PROGRAMMATIC ACTION 1A: Cooperatively evaluate the use of temperature control devices/reservoir management options to reduce water temperatures during critical periods.

PROGRAMMATIC ACTION 1B: Evaluate the impact of irrigation returns on stream temperature.

RATIONALE: *Water temperatures in the lower rivers in fall and spring often exceed stressful or lethal levels for fall-run chinook salmon. High temperatures typically occur in drought periods, when storage levels in reservoirs have dropped sufficiently to allow warm surface waters to be included in storage releases to the lower river. Retaining water over the summer that may otherwise be released for downstream irrigation or other purpose may allow the cold water in the reservoirs to be retained through the early fall critical temperature period. Elevated temperatures are thought to delay migration and spawning (California Department of Fish and Game 1992), reduce egg survival, and increase mortality of rearing and outmigrating juveniles (California Department of Fish and Game 1993). The target temperature levels would maintain suitable habitat for chinook salmon for spawning, rearing, and outmigration throughout the lower rivers. These levels are identified in DFG (1993) and in USFWS (1995). Temperature models need to be developed and calibrated to determine the feasibility of providing the flows necessary to maintain 60° F in the designated salmon spawning areas from June 1 through September 30 to provide the necessary conditions for steelhead rearing.*

High water temperature below dams in summer is a critical stressor for steelhead throughout the Central Valley drainages (IEP Steelhead Project Workteam 1999). Because juvenile steelhead must rear for at least one year in fresh water, adequate temperatures must be maintained year-round. Providing the necessary cool temperatures in the reaches that contain rearing habitat will be necessary to achieve steelhead recovery in these streams.

HABITAT

GENERAL HABITAT RATIONALE

The primary focus of habitat restoration in the East San Joaquin Ecological Management Zone is directed at restoring riparian and riverine aquatic habitats. Many other habitat are important in providing for the diversity of fish, wildlife and plant species in this zone including seasonal wetlands, fresh emergent wetlands, and agricultural lands. Important areas that will provide these types of habitats include Merced National Wildlife Refuge and San Joaquin River National Wildlife Refuge which overlaps the East San Joaquin and San Joaquin River Ecological Management Zones. In addition, the Central Valley Habitat Joint Venture is implementing recommendations to improve seasonal wetlands *and agricultural lands through out the San Joaquin River and East San Joaquin Ecological Management Zones.*

Expansion of the San Joaquin River NWR will be an important component in providing the habitats required by waterfowl, shorebirds, and other neotropical migrant species. Congress has approved the 10,300 acre San Joaquin River NWR. Presently, the San Joaquin NWR encompasses about 800 acres of land along the east side of the San Joaquin River near the confluence of the Tuolumne River, and is working to acquire an additional 6,200 acres of fish and wildlife habitat on land adjacent to the existing refuge. Part of this expansion has recently been funded through the CALFED Category III habitat restoration program. This project will benefit Aleutian Canada geese, greater sandhill crane, western yellow-billed cuckoo, Swainson's hawk, riparian brush rabbit, riparian wood rat, valley elderberry longhorn beetle, splittail, waterfowl, shorebirds, herons, and neotropical migratory birds.

The Central Valley Habitat Joint Ventures goals for the San Joaquin Valley, including the East San Joaquin Ecological Management Zone, are to:

- *Protect 52,500 acres of existing wetland in perpetuity through fee acquisition or conservation easements,*
- *Restore and protect in perpetuity 20,000 acres of former wetlands,*
- *Enhance 120,300 acres of existing wetlands, and*
- *Enhance 15,290 acres of private agricultural lands to support nesting and wintering waterfowl.*

Some of these habitat improvement and restoration projects will occur in the East San Joaquin Ecological Management Zone.

RIPARIAN AND RIVERINE AQUATIC HABITAT

TARGET 1: Provide conditions for riparian vegetation growth along sections of rivers in the East San Joaquin Basin Ecological Management Zone (◆◆).

PROGRAMMATIC ACTION 1A: Purchase streambank conservation easements from willing sellers, or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Stanislaus River.

PROGRAMMATIC ACTION 1B: Evaluate the benefits of restoring aquatic and riparian habitats on the Stanislaus River, including creating side channels to serve as spawning and rearing habitats for salmonids.

PROGRAMMATIC ACTION 1C: Purchase streambank conservation easements from willing sellers, or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Tuolumne River.

PROGRAMMATIC ACTION 1D: Purchase streambank conservation easements from willing sellers, or establish voluntary incentive programs to improve salmonid habitat and instream cover along the Merced River.

RATIONALE: *Many wildlife species, including several species listed as threatened or endangered under the State and federal Endangered Species Acts (ESA) and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than all other habitat types in California. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

Improving low- to moderate-quality SRA habitat will benefit juvenile chinook salmon and steelhead by improving shade, cover, and food. Other wildlife in this Ecological Management Zone will also benefit from improved habitat. Protecting and improving SRA habitat may involve land use changes that will require the consensus of local landowners and local, State, and federal agencies. Limitations on land suitable or available for restoration will require establishing priorities, with efforts directed at acquiring high-priority, low-cost sites first.

Riparian habitat along the lower portions of the three rivers has been significantly reduced. Before the loss of habitats, riparian forests were an important component of the mosaic (mixture) of habitats in the San Joaquin Valley, providing habitat for many native wildlife species. The riparian community provides nutrient and woody debris input to the aquatic system, as well as shade and increased bank stability. To restore the riparian community along the lower rivers, further riparian vegetation removal should be restricted, improved land management and livestock grazing practices should be implemented, and a riparian restoration program should be developed and implemented. Restoration actions will need to be consistent with flood control requirements. The importance of riparian restoration was identified by DFG (1993) and USFWS (1995).

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for East San Joaquin Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater and essential fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the rivers in this ecological management zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce entrainment of fish and other aquatic organisms into diversions to a level that will not impair salmon and steelhead restoration by screening 50% of the water volume diverted in the basin (◆◆◆).

PROGRAMMATIC ACTION 1A: Improve existing diversion screens on the lower Merced River.

PROGRAMMATIC ACTION 1B: Evaluate the feasibility of installing state-of-the-art screens on small pump agricultural diversions along the three streams.

PROGRAMMATIC ACTION 1C: Provide alternative water sources to diverters who legally divert water from spawning and rearing areas of the three streams.

PROGRAMMATIC ACTION 1D: Purchase water rights from willing sellers whose diversions entrain significant numbers of juvenile salmon or steelhead.

RATIONALE: *Five medium-sized gravity riparian diversions are located in the designated salmon spawning reach of the lower Merced River between Crocker-Huffman Dam and the State Route 59 bridge. Water-powered screens and* *nominal bypass systems were installed on two larger diversions in the mid-1980s. Gabion-type screens without bypass systems remain on the other three diversions. In addition, DFG surveys have identified numerous small pump diversions throughout the basin, none of which are adequately screened to prevent juvenile salmon entrainment. Entrainment losses at these pump diversions are unknown. Screening 50% of the diverted water volume at diversions with greatest risk to juvenile salmon and steelhead, as determined by monitoring, will help to define further screening needs.*

DAMS AND OTHER STRUCTURES

TARGET 1: Eliminate the loss of adult fall-run chinook salmon that stray into the San Joaquin River upstream of the Merced River confluence (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to eliminate blockage of upstream-migrating fall-run chinook salmon and steelhead at temporary irrigation diversion dams erected during the irrigation season.

PROGRAMMATIC ACTION 1B: Continue annual installation of a temporary weir on the San Joaquin River immediately upstream of the confluence with the Merced River to block adult salmon migration.

PROGRAMMATIC ACTION 1C: Evaluate the need to remove temporary diversion dams that block upstream salmon and steelhead passage into spawning grounds of three streams.

TARGET 2: Evaluate the feasibility of restoring steelhead access to historical habitats.

PROGRAMMATIC ACTION 2A: Investigate the feasibility of providing access to historical steelhead spawning and rearing habitat above the dams on at least one of the three tributaries.

RATIONALE: *In recent years, drainage practices in western Merced County have increased agricultural return flows from Salt and Mud Sloughs into the mainstem San Joaquin River. These flows attract significant numbers of adult salmon into the sloughs and, subsequently, into irrigation canals, where no suitable spawning habitat is available (California Department of Fish and Game 1993). In fall 1991, an estimated 31% of the San Joaquin basin run strayed into westside canals. In the late 1980s, DFG established an adult trapping station at Los Banos Wildlife Refuge, where eggs were taken and reared at MRH. In fall 1992, DFG installed a temporary electrical barrier across the mainstem San Joaquin River immediately upstream from the confluence with the Merced River, which was highly effective in blocking fish passage into the westside irrigation canals. Since that time, a temporary weir has been installed at the site annually, which has also been effective in blocking passage.*

Temporary diversion dams are sometimes constructed in the river channel during the irrigation season. Such structures may hinder upstream salmon migration in the fall and early winter.

Because of the magnitude of spawning and rearing habitat loss for steelhead, providing access to historical habitat that is currently inaccessible due to dams will be a key element in their recovery. The feasibility of providing a means to transport adults and juveniles around the large dams needs to be investigated in the San Joaquin River system.

PREDATION AND COMPETITION

TARGET 1: Reduce adverse effects of non-native fish species that have a significant effect on juvenile salmon production in the rivers (◆).

PROGRAMMATIC ACTION 1A: Eliminate gravel pits within or connected to the rivers.

RATIONALE: *Introduced warmwater fish, such as largemouth and smallmouth bass, prey on juvenile salmonids rearing in the lower Merced River. Predation has been identified as a major factor contributing to the poor survival of salmon smolts emigrating from the river. Large pit areas created by inchannel gravel mining are excellent habitat for warmwater fish. Implementing a predator control program has been identified as a salmonid restoration action by USFWS (1995). Habitat improvement actions described above should help to reduce predator populations of largemouth and smallmouth bass. Other species of possible concern include striped bass, American shad, and resident rainbow and brown trout. All potentially occur in the three rivers, and all are known to feed on juvenile salmon and possibly steelhead. If any of these species become a problem, steps will be taken to reduce their effects.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow the spawning population of wild, naturally produced fish to attain levels that fully use existing and restored habitat; focus harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest through increased enforcement.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet target.

PROGRAMMATIC ACTION 1C: Reduce the harvest of wild, naturally produced steelhead populations by continuing to mark all hatchery-reared fish and continuing to institute a selective fishery.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations, as well as striped bass and white and green sturgeon, to levels that fully take advantage of available habitat may require restrictions on harvest during and even after the recovery period. Stakeholder involvement should help to fairly balance available harvest allocation. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the wild fish harvest while hatchery fish are harvested to reduce their potential to disrupt the genetic integrity of wild populations. The Fish and Game Commission recently adopted DFG recommendations to establish a selective fishery for hatchery steelhead and to reduce incidental hooking of wild steelhead in the San Joaquin and other Central Valley streams.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead could stray into adjacent non-natal rivers and streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate the benefits of limiting stocking of MRH-reared salmon and steelhead to the Merced River.

TARGET 2: Employ methods to limit straying and loss of genetic integrity of wild and hatchery-supported stocks (◆◆◆).

PROGRAMMATIC ACTION 2A: Rear hatchery salmon and steelhead in hatcheries on natal streams to limit straying.

PROGRAMMATIC ACTION 2B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

RATIONALE: *In watersheds like the San Joaquin basin, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited so it does not inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead might directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds might also threaten the genetic integrity of wild stocks. Hatchery fish might also threaten the genetic makeup of stocks in natal rivers. Some general scientific information and theory from other river systems indicate that hatchery supplementation may limit the recovery and long-term maintenance of naturally producing salmon and steelhead populations. Further research and experimentation are necessary to determine how this issue is addressed. Long-term hatchery augmentation of healthy wild stocks may genetically undermine that stock and threaten the genetic integrity of other stocks.*

Adult straying into non-natal streams might result in interbreeding with a wild population specifically adapted to that watershed and thus lead to the loss of genetic integrity in the wild population. Releasing hatchery-reared fish into the San Joaquin River and its tributaries, other than the Merced River, could compromise the genetic integrity of wild salmon and steelhead populations.

REFERENCES USED TO DEVELOP THE VISION FOR THE EAST SAN JOAQUIN BASIN ECOLOGICAL MANAGEMENT ZONE

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-27.

California Dept. of Fish and Game. 1997. Letter from Jacqueline Schafer to Garth Griffen (NMFS) regarding CDFG comments on Proposed Rule to list steelhead under the Endangered Species Act, dated 1/6/97.

__________. 1996. Steelhead restoration and management plan for California. February 1996.

__________. 1993. Restoring Central Valley Streams: a plan for action. November. Sacramento, CA.

__________. 1992. Interim actions to reasonably protect San Joaquin fall-run chinook salmon. (WRINT-DFG Exhibit 25.) Sacramento, CA. Prepared for the Water Rights Phase of the State Water Resources Control Board Bay-Delta Hearing Proceedings. June.

Central Valley Habitat Joint Venture. 1990. Central Valley Habitat Joint Venture Implementation Plan, a component of the North American Waterfowl Management Plan. February 1990.

Demko, D.B. and S.P. Cramer. 1997. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park site 1996. Final Report submitted to the U.S. Fish and Wildlife Service. 144 pp.

__________. 1998. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park site 1997. Final Report submitted to the U.S Fish and Wildlife Service. 102 pp.

EA Engineering, Science and Technology. 1992. Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, Fisheries Studies Report, appendix 8. Lafayette, CA. 6 pp.

Hubbs, C.L. and O.L. Wallis. 1948. The native fish fauna of Yosemite National Park and its preservation. Yosemite Nature Notes. XXVII(12)

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. *in* Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. App. VII-A-11

Kondolf, G. M., J. C. Vick, and T. M. Ramirez. 1996. Salmon spawning habitat rehabilitation in the Merced, Tuolumne, and Stanislaus Rivers, California: an evaluation of project planning and performance. (University of California Water Resources Center Report No. 90.) Centers for Water and Wildland Resources. University of California, Davis. Davis, CA.

Mayott, C.J. 1997. Operation of the Hills Ferry Salmon Barrier, 1996. CDFG-Region 4. Report. 5pp.

McBain & Trush. 1998. Draft Tuolumne River Corridor Restoration Plan, Stanislaus County, CA. Prepared for the Tuolumne River Technical Advisory Committee (Don Pedro Project, FERC License No. 2299). June 17, 1998.

Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.

National Marine Fisheries Service. 1997. Status review update for deferred and candidate ESUs of west coast steelhead. Prepared by NMFS West Coast Steelhead Biological Review Team.

__________. 1998. Draft proposed recommendations for amendment 14 to the Pacific Coast salmon plan for essential fish habitat. March 26, 1998.

Snyder, J. 1993. Did salmon reach Yosemite Valley or Hetch Hetchy? National Park Service - Yosemite Nat. Park memo from J.B. Snyder, Historian, to M. Finley, Superintendent.

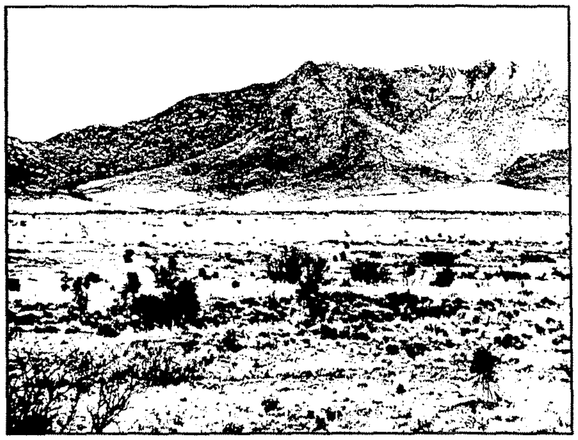
U.S. Fish and Wildlife Service. 1993. The relationship between instream flow and physical habitat availability for chinook salmon in the Stanislaus River, California. Region 1. Sacramento, CA.

__________. 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. May 9. Anadromous Fish Restoration Program Core Group. Stockton, CA.

__________. 1997. Revised draft restoration plan for the anadromous fish restoration program: a plan to increase natural production of anadromous fish in the Central Valley of California. May 30, 1997.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: Final report to Congress, vol. III. Centers for Water and Wildland Resources, Univ. Cal. Davis. pg. 309-361.

◆ WEST SAN JOAQUIN BASIN ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

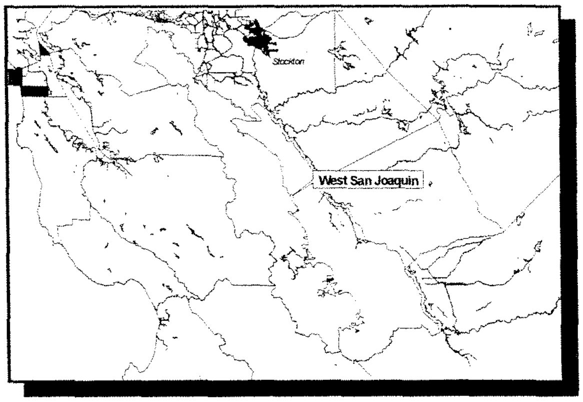
The West San Joaquin Basin Ecological Management Zone includes the eastern slope of the Coast Range and portions of the southwestern Central Valley. The zone is bounded on the north by the southern and western boundaries of the Sacramento-San Joaquin Delta Ecological Management Zone, on the east by the west bank of the San Joaquin River from the Stanislaus River to Mendota Pool, on the south by Panoche Creek, and on the west by the west slope of the Interior Coast Range. The West San Joaquin Basin Ecological Management Zone can indirectly contribute to the health of the Bay-Delta by providing much needed habitat for California red-legged frog, neotropical migrant birds, and waterfowl. Included in this Ecological Management Zone is the area between Orestimba Creek and Los Banos, a region which supports a number of federal and state-listed species, including the San Joaquin kit fox and blunt-nosed leopard lizard. About 33% of the remaining wetland acres in the Central Valley are clustered between Merced and Los Banos along the San Joaquin River. This is the largest contiguous block of remaining wetland habitat and associated upland communities.

The West San Joaquin Ecological Management Zone also contains several stands of Central California sycamore alluvial woodlands. The largest of these stands is located on Los Banos Creek, in Merced County. The principal environmental conditions necessary for the perpetuation of this community are intermittent flooding over broad floodplains and stable subterranean water table during dry summer months (California Department of Fish and Game 1997).

Although the overall vision for this Ecological Management Zone is directed by its ability to contribute to the ecological health of the Sacramento-San Joaquin Delta, there exist many opportunities to build upon the CALFED vision to provide many additional landscape ecological benefits in the region. For example, CALFED actions could contribute, in part, to a long-term goal of providing a continuous band of connective habitats (riparian, wetland, vernal pool, grassland, and other upland habitats) joining the Sierra (Yosemite National Park) with grassland and vernal pool complexes on the east side of the valley.

DESCRIPTION OF THE MANAGEMENT ZONE

The West San Joaquin Valley Ecological Management Zone has two distinct geomorphological (landform) areas: the hilly west-side arid watersheds and the valley floodplain on the eastern side adjacent to the San Joaquin River. The Delta-Mendota Canal of the Central Valley Project (CVP) and the California Aqueduct of the State Water Project (SWP) are dominant features of the zone from north to south, separating the hills from the valley. All watersheds in this zone flow east toward the San Joaquin River. Restoration efforts associated with the San Joaquin River corridor are addressed in the section on the San Joaquin River.

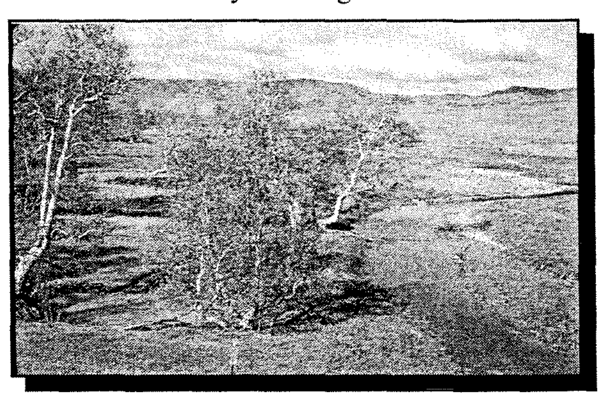


Location Map of the West San Joaquin Ecological Management Zone.

The zone has a Mediterranean climate. The northwestern portion of the zone is adjacent to the Delta, where the rain shadow effect and fog still have some influence. Within the rest of the zone, summers are hotter and longer winters are colder, and rainfall averages are lower. The southern and eastern portion of the zone is best described as an agricultural belt with large blocks of seasonally managed wetlands on both public and privately managed lands in the Grasslands Subarea. While some other habitats exist in the Grasslands Subarea, they are extremely narrow, fragmented, and widely scattered. Habitats that do remain include grasslands, seasonal wetlands, and riparian woodlands. The grasslands have been reduced to narrow strips within the rights-of-way along the California Aqueduct and Delta-Mendota Canal; other grasslands persist in scattered cattle ranches. Low quality seasonal wetlands can be found as small clumps of vegetation that persist in drainages and sumps associated with the Aqueduct and Canal. In addition, remnant riparian areas can be found along some drainages and tributaries associated with the Aqueduct and Canal.

The northern and western portions of the zone are best characterized as rolling hills of the coastal mountain range. The upper third is still within the influence of weather patterns associated with the Carquinez Strait. Fog and moisture from the rain shadow effect separates this area from the southern two-thirds of the unit, where the climate is more Mediterranean. While the northern area receives greater rainfall and moisture, the habitats found in the north and south are relatively similar. The dominant type is grassland, managed as cattle pastures. Savannas (grasslands with few trees) are common on the hills as the slopes stretch out of the Valley, while woodlands are prevalent along the creeks and their watersheds. Patches of seasonal wetlands can also be found along some creeks.

The Orestimba Creek and Los Banos Creek drainages are excellent examples of relatively undisturbed, natural, coast range watersheds. While the grasses have become predominately annuals (before European influence, these grasslands were dominated by perennial grass species), they still flourish and lead into wooded areas at the higher elevations and riparian woodlands along the creeks. There are two very significant stands of Sycamore Alluvial Woodlands that compose more than one-third of all remaining acreage of this habitat type within the Central Valley. Most of the landscape is rolling hills of the coastal range, with grasslands in the lower elevations and woodlands higher up. The geomorphology of these watersheds has remained relatively unchanged.



Orestimba Creek showing a sycamore alluvial woodland.

Biological resources in this area include the San Joaquin kit fox, San Joaquin antelope squirrel, kangaroo rats, neotropical migrant birds, California red-legged frog, foothill yellow-legged frog, waterfowl, upland game, western pond turtles, sycamore alluvial woodlands, vernal pools, as well as many other native plants and wildlife found in the several habitat types. Some unique animal and plant communities are found in some equally unique habitats, such as the vernal pool-hog wallow grassland found on the Flying M Ranch in Merced County.

Important ecological processes essential to maintaining and restoring a healthy West San Joaquin Basin Ecological Management Zone are floodplain, stream, and watershed processes, including streamflow, overbank flooding (which is particularly important for maintaining the remnant Central California sycamore alluvial woodlands), floodplain inundation, sedimentation and erosion, and fire. Fire is important for maintaining, or altering grassland and shrubland health through fuel reduction and plant succession and reproduction.

Streamflow in this arid zone, despite being intermittent and prone to flash flooding, is an essential determinant of habitat, as well as species distribution and abundance. Floodplain and stream channel processes are essential for dissipating the forces of flood flows and distributing sediments carried by them.

Though many of the streams along the west side of the San Joaquin Valley are naturally intermittent, maintaining natural winter and spring flows in the streams is important for maintaining floodplain processes, such as meander belts, and stream channel configurations, as well as riparian and wetland habitats. Streamflows have been modified by water diversions, subsidence (lowering) in groundwater tables, and watershed activities, such as grazing, road building, forest management, and agriculture.

In addition to changes in streamflow, floodplain processes have been altered by floodplain development, including flood control levees, gravel mining, and other land uses.

The West San Joaquin Basin Ecological Management Zone has many habitat types including:

- **AGRICULTURE:** the hills and lowlands of the valley that support crops,
- **WETLANDS:** the lowlands of the valley that are permanently or seasonally watered,
- **COASTAL SCRUB:** a low growing shrubby cover on the coastal hills,
- **CHAPARRAL:** dense shrubs found growing above the coastal scrub community,
- **OAK WOODLAND:** almost park-like sites with trees and shrubs in fairly open stands with a rich carpet of grass and other herbaceous growth,
- **OAK SAVANNA:** the transitional community between the woodlands of the hills and the grasslands of the broad valleys, where the trees are fewer in number and more widely spaced than those of the woodlands,
- **GRASSLAND:** areas that stand below the hillside wooded areas, and are green and littered with wildflowers in the spring followed by the gold of summer as the annual and perennial grasses go dormant during the dry season,
- **RIPARIAN FOREST:** a continuum of plant communities following the topographic line from the stream channel through the low and high terrace deposits of the floodplain; transition to nonriparian is usually abrupt, especially near agriculture;

- **SEASONAL WETLANDS:** areas within the grasslands and along the tributaries and drainages that remain inundated with water for varying periods after the rains and high flows have subsided; and

- **SYCAMORE ALLUVIAL WOODLANDS:** sycamore woodlands found along Los Banos and Orestimba creeks that require high soil moisture during the initial growth annual cycle followed by a significant reduction in the water table during the later part of the growing season.

These habitats are used by a wide variety of fish, wildlife, and plants, including many listed species (i.e., species identified by resource agencies as threatened or endangered). Coastal scrub and chaparral provide habitat for a variety of wildlife. Numerous rodents inhabit chaparral; deer and other herbivores often make extensive use of this habitat type, which provides critical summer range foraging areas, escape cover, and fawning habitat. Many birds, such as quail, fulfill a variety of their habitat needs in the chaparral, such as foraging needs (seeds, fruits, insects), protection from predators and climate, as well as singing, roosting, and nesting sites.

The oak woodland and savanna habitats are home to as many as 29 species of amphibians (salamanders) and reptiles, 79 bird species, and 22 mammal species. Seasonal wetlands provide habitat for many species, such as waterfowl, pond turtles, salamanders, as well as endemic (adapted to a particular locality) plants. Grassland habitat, as well as some of the special habitat features, such as cliffs, caves, and ponds found within grasslands, are used by many species, including tiger salamanders. Some of the more arid grassland species are listed as threatened or endangered. The riparian habitats provide food; water; migration and dispersal corridors; and escape, nesting, and thermal cover for wildlife. As many as 147 bird species, nesters, or winter visitants, as well as 55 species of mammals, are known to use this habitat type within this Ecological Management Zone.

Sloughs and ponds within and adjacent to wetlands in the San Joaquin Valley are important habitat for waterfowl, as well as many plant and wildlife species. They include many rare or declining species that have special status, such as being listed under the State or federal Endangered Species Acts (ESA).

Marshes, once the most widespread habitat in the San Joaquin Valley floodplain, are now restricted to remnant patches. There have been extensive fresh emergent wetland habitat losses to agricultural development. Most of the remaining wetlands lack adjacent upland transition habitat and other attributes of fully functioning wetlands because of agricultural practices. Emergent wetland habitat provides important habitat for many species of plants, waterfowl, and wildlife. In addition, wetlands contribute important plant detritus and nutrient recycling to the aquatic foodweb of the San Joaquin River and Bay-Delta estuary, as well as important habitat to some species of fish and aquatic invertebrates.

Seasonal wetlands include portions of the floodplain that seasonally flood, usually in winter and spring, especially in high flow years. Most of this habitat is located in the valley floor adjacent to the San Joaquin River and nearby perennial wetlands. Such habitats were once very abundant during the winter rainy season or after seasonal flooding. With reclamation (draining wetlands for other uses), flooding occurs primarily from accumulation of rainwater behind levees, directed overflow of flood waters to bypasses, or flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and other wildlife.

Upland habitats are found on the outer edges of valley wetlands and consist primarily of grasslands and remnant oak woodland and oak savanna. Of these, perennial grasslands are an important transition habitat for many wildlife species. They act as buffers to protect wetland and riparian habitats. Much of the grassland habitat associated with wetland and riparian habitat has been lost to agriculture (e.g., pasture, grain, vineyards, and orchards) and development (e.g., home construction, golf courses). Grasslands provide habitat for many plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees and along stream channels of the zone. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide shaded riverine aquatic (SRA) habitat on which many important fish and wildlife species depend during some portion of their life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse habitat structure with low diversity. Riparian habitat along intermittent streams is lost to excessive erosion and livestock grazing. Riparian habitat is used by more wildlife than any other habitat type. From about 1850 to the turn of the century, most of the riparian forests in the Central Valley were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, along stream channels, and along the margins of marshes. Riparian habitats and their adjacent SRA habitat benefit fish and wildlife species.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors (soaring birds of prey). Nonflooded fields and pastures are also habitat for pheasants, quail, and doves. The marshes along the Valley floor support a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields, which support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations. The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Central Valley.

Stressors to ecological processes, habitats, and species within this zone include land uses, such as urban and industrial development; water diversions; land reclamation; water conveyance structures; livestock grazing; exotic (non-native) species; gravel mining; contaminants; wildfire, levees; bank protection; stream channelization; irrigation canals; and agricultural practices. These stressors have contributed to a change in native plant communities, fragmentation of riparian habitats, and interrupted migration corridors for species, such as the State and federally listed San Joaquin kit fox. Streamflows patterns and natural stream meandering have been altered by many of these stressors.

There are increased amounts and concentrations of contaminants in the San Joaquin River. Agricultural drainage and associated contaminants that originate in the West San Joaquin Basin Ecological Management Zone, or are transported to this Ecological Management Zone from agricultural lands to the south in the Westlands Subarea, are a significant source of contaminants reaching the Bay-Delta.

Other stressors include dams, reservoirs, and other structures. They have further contributed to habitat fragmentation and are barriers to wildlife movement and dispersal.

Water diversions from streams and adjacent marshes divert streamflow that is important to habitat and species of the zone. Diverted water is used primarily locally.

Toxins continue to enter the streams and adjacent marshes in large amounts from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of waterfowl, fish, and wildlife.

The riparian zones of west San Joaquin Valley streams are typical habitat of the California red-legged frog. Loss of riparian and adjacent upland habitats have led to declining frog populations in this zone and elsewhere in the Central Valley. Non-native predatory fish, such as largemouth bass in Central Valley ponds have also contributed to the decline of the frog.

Neotropical migratory birds depend on the riparian corridors of the creeks and wetlands of the San Joaquin Valley. Conversions of vegetative cover by agricultural practices and loss of riparian habitats, along with competition and predation by non-native species, have reduced populations of these migrants.

The San Joaquin Valley, with its wetland complexes, is an important waterfowl area. Large numbers of ducks, geese, and swans winter in the Valley, depending on the high-quality foraging habitat of the wetlands and adjacent riparian, upland, and agricultural habitats to replenish their energy reserves.

List of Species to Benefit from Restoration Actions in the West San Joaquin Basin Ecological Management Zone

- native resident fishes
- neotropical migrant birds
- California red-legged frogs and other native anuran amphibians,
- native resident fishes,
- upland game,
- plant community groups, and
- waterfowl.

Vision for the Ecological Management Zone

The vision for the West San Joaquin Basin Ecological Management Zone includes improved water quantity and quality from the basin to wetlands and the San Joaquin River. The vision also includes a range of sustainable aquatic, wetland, riparian, and upland habitats that support abundant natural production of resident fish and wildlife, as well as waterfowl and other migrant birds that use the Pacific Flyway each winter. The vision includes enlarging remaining native habitats and connecting those areas.

The vision focuses on improving watershed, stream channel, and floodplain processes. The result would be increased seasonal flows of quality water to the San Joaquin River and area wetlands and reduced input of agricultural waste runoff and associated contaminants into zone watersheds and wetlands and the San Joaquin River. Improved quality and quantity of water for publicly and privately managed wetlands will reduce stresses on waterfowl populations. Improved water quality and quantity in the San Joaquin River will directly benefit fish and wildlife of the San Joaquin River and the Bay-Delta.

The ERPP will focus on habitat restoration and water quality improvements in the southern and eastern portions of this zone. A particular focus is agricultural drainage that contains extremely high selenium concentrations. Selenium is present in such high concentrations in some areas that there are potential human and wildlife health problems. Seasonal wetlands for migratory species, such as waterfowl and shore birds, should be expanded and improved. Present restoration efforts can be expanded by providing adequate high quality water to the seasonal wetlands. Water supplies can be improved by reducing or eliminating diversions in streams and sloughs that flow into agricultural lands. Restoring natural watershed, stream, and floodplain processes on west side tributaries to the San Joaquin River, including Mud and Salt Sloughs, Orestimbe Creek, and Los Banos Creek, will promote natural habitat restoration. Emphasis should also be placed on connecting habitats and providing unbroken habitat corridors necessary for species such as the San Joaquin kit fox, kangaroo rats, waterfowl, and neotropical birds.

Throughout much of the northern portion of the zone are numerous intermittent creeks and streams. Restored, they would provide higher quality water and improved habitats. Excluding cattle along the streams and creeks, removing gravel mining, and reducing diversions would improve stream channels and riparian corridors. Reforestation of sycamores has not been possible, because cattle range through the creek bottoms and landowners are continuously moving the rock beds around to pool water for the cattle during the summer months, when surface flows are minimal.

The narrow strips of grasslands along the California Aqueduct and Delta-Mendota Canal are managed intensively to suppress wildfires and erosion. The adjacent tributaries or drainages are also managed for vegetation control to increase the runoff into the conveyance systems. Practices should be modified to benefit species such as the San Joaquin kit fox, kangaroo rats, California red-legged frog, and native plants, such as perennial grasses. Alternatives to pesticides should be developed, or pesticides eliminated. This would encourage natural recovery of predator species like the kit fox, which help keep pest species in balance, while reducing contaminants entering the system. Vegetation control practices should also be modified to support the recovery of native plants, such as perennial grasses and wetland species in the local watersheds.

Extensive wetland areas in the eastern portions of the zone adjacent to the San Joaquin River should be protected and expanded. Stream flow into the wetland-slough complexes should be improved. Water quality should also be improved. Natural floodplain processes should be enhanced through setback levees, stream meanders, and seasonal flood overflow basins, which should reduce peak flood flows to the San Joaquin River.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Where possible, natural streamflows will be protected, enhanced, and restored to support riparian habitat and important species.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Where possible, natural floodplain processes will be preserved by allowing winter-spring flows to overflow into riparian and wetland habitats. Natural stream meanders will be encouraged by removing, where possible, constraints on meander belts, such as levees and bank protection. Natural floodplain overflow will help to collect floodwaters and sediment and dissipate the erosive forces of flood waters.

VISIONS FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: Riparian habitat, both forest and shrub, will be protected and expanded along zone streams and wetlands. Remnant patches of high-quality riparian habitat will be protected. Disturbed habitat will be restored, where possible. Agricultural and grazing practices will be modified in riparian zones to encourage riparian and SRA habitat recovery along streams. Improvements in stream flows will also benefit riparian zones.

NONTIDAL PERENNIAL AQUATIC HABITAT: Existing sloughs and ponds within and adjacent to wetlands in the San Joaquin Valley will be protected and new aquatic habitat created.

EMERGENT WETLAND HABITAT: Remnant patches of marshlands will be expanded and connected, where possible. New wetlands will be created.

SEASONAL WETLAND HABITAT: Existing seasonal flooding areas will be protected and sources of water maintained or expanded to promote higher quality wetlands, especially in drier years. Areas where seasonal flooding develops, seasonal wetlands will be expanded.

PERENNIAL GRASSLANDS: Upland habitats around the outer edges of wetlands will be protected and expanded. Grasslands and remnant oak woodland and oak savanna will be restored, where possible.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native fish species. The streams in the West San Joaquin Basin Ecological Management Zone are typical California roach streams that are small, mid-elevation stream that typically contain deep pools in canyons and are often intermittent in flow by late summer (Moyle and Ellison 1991).

AGRICULTURAL LANDS: Agricultural practices that provide valuable wildlife habitat will be encouraged. Riparian and upland habitats will be protected and expansion encouraged.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions along valley streams and adjacent marshes will be reduced, where possible and needed, to protect and enhance riparian and wetland habitats. Greater streamflows, especially in drier years, will provide for expanded riparian habitat.

CONTAMINANTS: Reduced input of toxins to valley streams and wetlands will improve health, survival, and reproduction of many important waterfowl and other wildlife. Reduced toxins also will reduce contaminant effects on fish and wildlife in the San Joaquin River and the Bay-Delta. Levels of toxins in the fish tissues should be reduced.

VISIONS FOR SPECIES

RESIDENT NATIVE FISH SPECIES: Many native fish species will benefit from improved aquatic habitats and stream channel/floodplain processes. Population abundance indices should remain stable or increase and population sizes should be large enough to fully recover from natural and human-induced disasters. The distribution of native resident fishes should increase with widespread habitat restoration.

NEOTROPICAL MIGRANT BIRDS: Protection, restoration, and enhancement of large, contiguous areas of riparian and wetland habitats that contain a great diversity in composition, density, and make-up will benefit the recovery of listed neotropical migrants such as yellow-billed cuckoo as well as aid in the prevention of future listing of additional bird species.

CALIFORNIA RED-LEGGED FROG: Protection, restoration, and enhancement of the zone streams and associated riparian and upland habitats will benefit the recovery of the red-legged frog. Efforts to manage invasive species such as the bullfrog will also be carried out, where necessary, to benefit the recovery as well.

WATERFOWL: Protection, restoration, and enhancement of wetland complexes and beneficial agricultural habitats with adjacent upland habitats will improve waterfowl use.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

Integration with Other Restoration Programs

Much of the vision for the West San Joaquin Valley can be accomplished through cooperative efforts of landowners, agencies, and other stakeholders. Watershed conservancy organizations should be established to structure such cooperative efforts. Funding and technical support should be provided to these conservancies to oversee and conduct much of the restoration work.

Some lands marginal for agriculture because of poor drainage can be purchased from willing sellers for conversion to wildlife habitat. Incentive plans should be developed to allow land owners to maintain their lands and habitats consistent with the vision. Agricultural management plans that are more friendly to wildlife, because studies have shown that soil productivity can be increased by leaving land out of production for extended periods. Such practices, programs, and efforts can restoring blocks of wildlife habitat for relatively long periods of time while enhancing crop production and lessening the need for fertilizers and chemicals. Incentives should be developed to encourage landowners maintain at least 10% of their land as fallow or non-agriculture. Additional incentives should be offered to land owners to permanently convert portions of their lands to natural habitats. This would effectively reduce the stress of land use practices and the use of contaminants and improve wildlife habitat. An additional incentive program might entail livestock exclosures to protect stream banks and allow sycamores and opportunity to regenerate.

Much of the vision can be accomplished through established restoration programs on federal and State lands, as well as on private lands. The Southern San Joaquin Valley Ecosystems Protection Program was initiated in 1986 to provide a foundation for planning now to protect future ecosystems and sensitive species in the Southern San Joaquin Valley. This program identifies opportunities to protect and to restore the connectivity of the remaining natural habitat. The San Joaquin Drainage Implementation Program is similar.

Nongame Migratory Bird Habitat Conservation Plan

The U.S. Bureau of Land Management administers a habitat conservation plan for nongame migratory birds. Recommendations are provided; however, no funding is presently available.

Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture is a component of the North American Waterfowl Management Plan of the USFWS with funding and cooperative projects of federal, State, and private agencies. New sources of funding including CALFED restoration funds are being sought to implement the joint venture. The joint venture has adopted an implementation plan that includes the west side of the San Joaquin Valley. Objectives include protection of wetlands through acquisition of in-fee title or conservation easements, and enhancement of waterfowl habitat in wetlands and agricultural lands. The objectives and targets of the joint venture have been adopted by the ERPP.

Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley

This plan is a framework for reducing impacts of contamination by agricultural drainage water. The plan was prepared by the California Resources Agency, DWR, Reclamation, USFWS, and USGS.

San Joaquin River Management Plan

State Assembly Bill 3606 authorizes the San Joaquin River Management Plan to identify factors adversely affecting the San Joaquin River and its tributaries. Problems being considered are flood protection, water supply, water quality, recreation, and fish and wildlife. Emphasis is on a plan to restore and manage riparian corridors, floodways, non-native vegetation removal, wetland restoration, and basin water quality. The plan was developed by DWR and is administered by the San Joaquin River Parkway and Conservation Trust.

Linkage to Other Ecological Management Zones

Many of the habitats, processes, and stressors found within this Ecological Management Zone are similar to those found in the Fresno Slough/Mendota Basin Subregion, and East San Joaquin Ecological Management Zone. Efforts within one Ecological Management Zone should be similar to those in adjacent zones providing connectivity where needed and cumulative benefits to the system.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: Provide flows of suitable quality water that more closely emulate (imitate) natural annual and seasonal streamflow patterns in West San Joaquin tributary watersheds. Provide a total watershed flow of 250 to 500 cfs to the San Joaquin River in dry and normal years for a 10-day period in late April to early May (approximately 5,000 to 10,000 af) (◆).

Programmatic Action 1a: Enter into agreements with water districts and wetland managers to provide return flows of high quality water from irrigated agriculture and seasonal wetlands to the San Joaquin River.

Programmatic Action 1b: Enter into agreements with landowners and water districts to limit diversions of natural flows from streams to improve streamflows.

Programmatic Action 1c: Make seasonal releases from the California Aqueduct or Delta-Mendota Canal into streams and wetlands.

Programmatic Action 1d: Limit capture of natural stream flows from westside tributaries into irrigation canals and ditches and State and federal aqueducts.

Rationale: *Natural streamflow patterns are important in maintaining geomorphology of watersheds, as well as riparian and floodplain vegetation along stream banks. Streamflow is also essential for the well being of valley wetlands and contributes to the flow of the San Joaquin River and to Delta inflow.*

Natural Floodplain and Flood Processes

Target 1: Restore 10 to 25 miles of stream channel, stream meander belts, and floodplain processes along westside tributaries of the San Joaquin River (◆◆).

Programmatic Action 1a: Enter into agreements with willing landowners and irrigation districts to set back levees and allow floodplain processes such as stream meander belts.

Programmatic Action 1b: Expand existing floodplain overflow basins by obtaining easements of titles from willing sellers of floodplain lands.

PROGRAMMATIC ACTION 1C: Reduce or eliminate gravel mining and stream bed altering from active stream channels.

RATIONALE: *Restoring natural stream channel and floodplain processes will help restore natural habitat and vegetation.*

HABITATS

NONTIDAL PERENNIAL AQUATIC HABITAT

TARGET 1: Evaluate the feasibility of restoring 1,000 acres of perennial aquatic habitat within and adjacent to existing wetlands (◆◆).

PROGRAMMATIC ACTION 1A: Manage existing wetlands so that they maintain 40 percent open water and 60 percent vegetation.

RATIONALE: *Aquatic habitats provide valuable foraging and resting habitats for waterfowl.*

FRESH EMERGENT WETLAND HABITAT

TARGET 1: Evaluate the feasibility of restoring or creating fresh emergent wetland habitat (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to acquire, in-fee title or through a conservation easement, the land needed for tidal restoration, and complete the needed steps to restore the wetlands to tidal action.

RATIONALE: *Aquatic habitats provide valuable foraging and resting habitat for waterfowl and habitat for a variety of special status species.*

PERENNIAL GRASSLAND HABITAT

TARGET 1: Evaluate the feasibility of preserving and restoring perennial grassland habitats.

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore perennial grasslands by acquiring conservation easements or purchasing land from willing sellers.

RATIONALE: *Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this Ecological Management Zone. Eliminating fragmentation and restoring connectivity will enhance habitat conditions for special-status species.*

SEASONAL WETLAND HABITAT

TARGET 1: Evaluate the feasibility of creating or improving seasonal wetland habitats.

PROGRAMMATIC ACTION 1A: Acquire lands adjacent to existing seasonal wetlands from willing sellers or conservation easements.

TARGET 2: Provide 150,000 af of water to existing wetlands to improve waterfowl habitat (◆).

PROGRAMMATIC ACTION 2A: Provide water to wetlands on a seasonal basis from the California Aqueduct, Delta-Mendota Canal, or other source.

RATIONALE: *Improved seasonal wetland habitat will provide additional seasonal habitat for waterfowl.*

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Restore 5 miles of riparian habitat totaling 500 to 1,000 acres (◆◆).

PROGRAMMATIC ACTION 1A: Restore riparian forest habitat on lands purchased from willing sellers or obtained via conservation easements.

RATIONALE: *Additional riparian forest habitat would improve habitat for many special status plant and animal species.*

FRESHWATER FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat is evaluated in terms of its quality and quantity. Actions described for West San Joaquin Basin Ecological Management Zone ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the rivers in this ecological management zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Restore and maintain migration corridors of native plants of more than one mile in width (◆).

PROGRAMMATIC ACTION 1A: Purchase land or conservation easements on which to restore wildlife habitat to connect existing grassland or agricultural wildlife habitat.

RATIONALE: *Corridors of habitat are necessary between larger habitat areas to ensure potential recovery of kit fox populations in the San Joaquin Valley.*

STRESSORS

CONTAMINANTS

TARGET 1: Evaluate the feasibility of reducing the application of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife on 20,000 acres of agricultural lands that have the greatest risk to fish and wildlife populations (◆).

PROGRAMMATIC ACTION 1A: Acquire land from willing sellers in areas with demonstrated subsurface agricultural drainage problems and elevated levels of selenium and return those lands to native alkaline scrub habitat.

PROGRAMMATIC ACTION 1B: Enter into conservation easements with willing landowners to modify agricultural practices in ways to reduce loads and concentrations of contaminants.

PROGRAMMATIC ACTION 1C: Provide incentives to landowners to modify agricultural or other land use practices that contribute to the input of contaminants into waterways.

RATIONALE: *Reducing the inputs of contaminants into waterways from the lands with the greatest inputs would provide significant improvement in water quality in streams and wetlands, as well as in the San Joaquin River and Bay-Delta.*

REFERENCES USED TO DEVELOP THE VISION FOR THE WEST SAN JOAQUIN ECOLOGICAL MANAGEMENT ZONE

California Department of Fish and Game. 1997. The definition and location of Central California Sycamore Alluvial Woodland.

Prepared by Natural Heritage Division, Bay-Delta and Special Water Projects Division. May 1997. 111 pp + appendices.

Moyle, P.B., and J.P. Ellison. 1991. A conservation oriented classification system for the inland waters of California. California Fish and Game 77(4): 161-180.