CALFED Vision for the Sacramento River Ecological Zone

The CALFED vision for the Sacramento River Ecological Zone includes restoration of its important fish, wildlife, and plant communities to a condition of health, as defined by physical processes, ecological functions, and habitat and population parameters. Health will be attained when the status of these resources contributes measurably to the recovery of the Sacramento-San Joaquin Delta ecosystem. CALFED will realize this vision by protecting, restoring, or reactivating important physical and ecological processes and functions which create and maintain habitats for the plant, wildlife, and fish communities along and in the Sacramento River. CALFED's vision strongly focuses on restoration of the Sacramento River winter-run chinook salmon, protecting juveniles of the other chinook salmon stocks and steelhead as they rear and migrate downstream. CALFED's vision in protecting and increasing the survival of juvenile salmonids will emphasize the maintenance and restoration of a healthy riparian zone between Keswick Dam and Sacramento. This includes the preservation and restoration of functioning river ecosystems which will ensure ample shaded riverine aquatic habitats, woody debris, and biologically productive gravel beds for spawning and invertebrate production. It also includes the creation of complex aquatic habitats in the Sacramento River below Verona which will provide escape cover. The vision also anticipates reducing the input of heavy metals and other contaminants and the installation of positive barrier fish screens on water diversions.

CALFED envisions that municipal, agricultural, wildlife, fisheries, and riparian needs of the Sacramento River Ecological Zone will be reached and ecosystem health of the Sacramento River will be achieved when the following have been satisfactorily attained:

- Improved or unobstructed upstream and downstream passage at major water diversion structures near Redding and Red Bluff, and on tributaries of the Sacramento River
- Most of the water is diverted from the river (by volume) through positive barrier fish screens and irrigators screen all the largest diversions,
- Flow patterns are provided to restore ecological processes and functions which maintain habitats important to plant, fish and wildlife species,
- A plan is developed and carried out to preserve and restore riparian forest and valley oak woodland ecosystems and associated physical processes along the Sacramento River, including a channel meander belt and levee setbacks wherever possible,
- Natural sources of instream and off-stream gravel recruitment are protected and restored,
- Water temperature control in the Keswick Dam to Red Bluff Diversion Dam reach is improved for anadromous fish production,

Sacramento River Ecological Health

Natural Hydrograph	C
Stream Meander Belt	C
Gravel Recruitment	D
Water Management	B
Gravel Mining	B
Harvest of Fish and Wildlife	B
Predation and Competition	C
Artificial Production of Fish	C
Shaded Riverine Aquatic	C
Valley Oak Woodland	C
Perennial grassland	C
Agricultural wetland habitat	C
Agricultural upland habitat	C
Total Average Health Rating	**C**

- The discharge of heavy metals and other organic and inorganic pollutants into the Sacramento River is reduced to acceptable levels,

- Flow fluctuations below Keswick Dam to adjust the flashboards at the Anderson-Cottonwood Irrigation District's diversion dam on the main stem Sacramento River are reduced or eliminated,

- Sacramento River winter-run chinook salmon maintain a cohort replacement rate > 1.0 until the spawning population attains a level of 10,000 females per year and then maintain a replacement rate of ≥1.0, as recommended by the Sacramento River Winter-run Chinook Salmon Recovery Team,

- Fall-run, spring-run, and late-fall-run chinook salmon populations maintain a cohort replacement rates >1.0 during stock rebuilding and then maintain a replacement rate of ≥1.0,

- Steelhead populations maintain a cohort replacement rate of >1.0 during stock rebuilding and then maintain a replacement rate of ≥1.0, and

- Other native fish communities and populations maintain population growth rates of 1.0 or greater.

Background

The Sacramento River, more than 300 miles long from below Lake Shasta to Collinsville in the Delta where it joins the San Joaquin River, is a major western river and the largest and most important riverine ecosystem in the state of California. This magnificent river provides most of the water, nutrients, sediment, and anadromous fish entering the Bay-Delta ecosystem. The river corridor encompasses more than 250,000 acres of natural, agricultural, and urban lands upstream of Sacramento.

The Sacramento River Ecological Zone includes 242 miles of the main stem Sacramento River from Keswick Dam near Redding to the American River at Sacramento. (The remaining 60 miles of the lower river downstream of Sacramento is included in the North Delta Ecological Zone). The mainstem river planning area includes the river channel, gravel bars and vegetated terraces, the 100-year river floodplain, and the geologic-defined band of historic and potential river migration (i.e., the "meander belt"). In the artificially narrow leveed reach downstream of Colusa to Sacramento, an approximately one mile wide band of river alluvium and historic and potential forest land that borders the levees is also included in this ecological zone. The entire ecological zone is depicted in Figure 14-1.

Historically the riparian forest corridor along the river averaged 4-5 miles wide and encompassed a significantly large area, whereas today only 5 percent of the forests remain. Only 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 eliminates and degrades many habitats by increasing the depth and velocity of flow, and by reducing the hydraulic and substrate diversity associated with more

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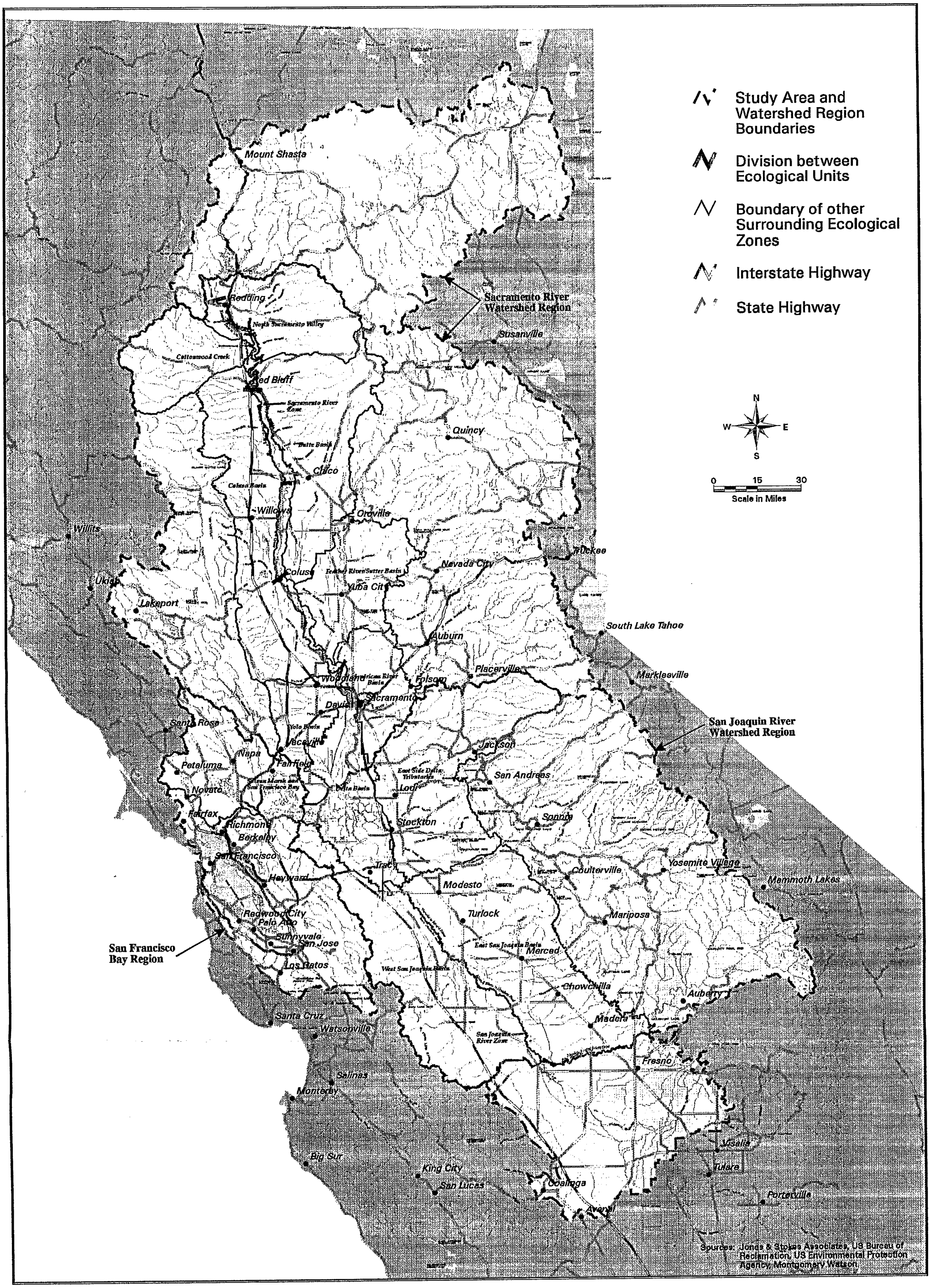

CALFED BAY-DELTA PROGRAM

Ecosystem Restoration Program Plan

Figure 1
ERPP Study Area and Ecological Zones

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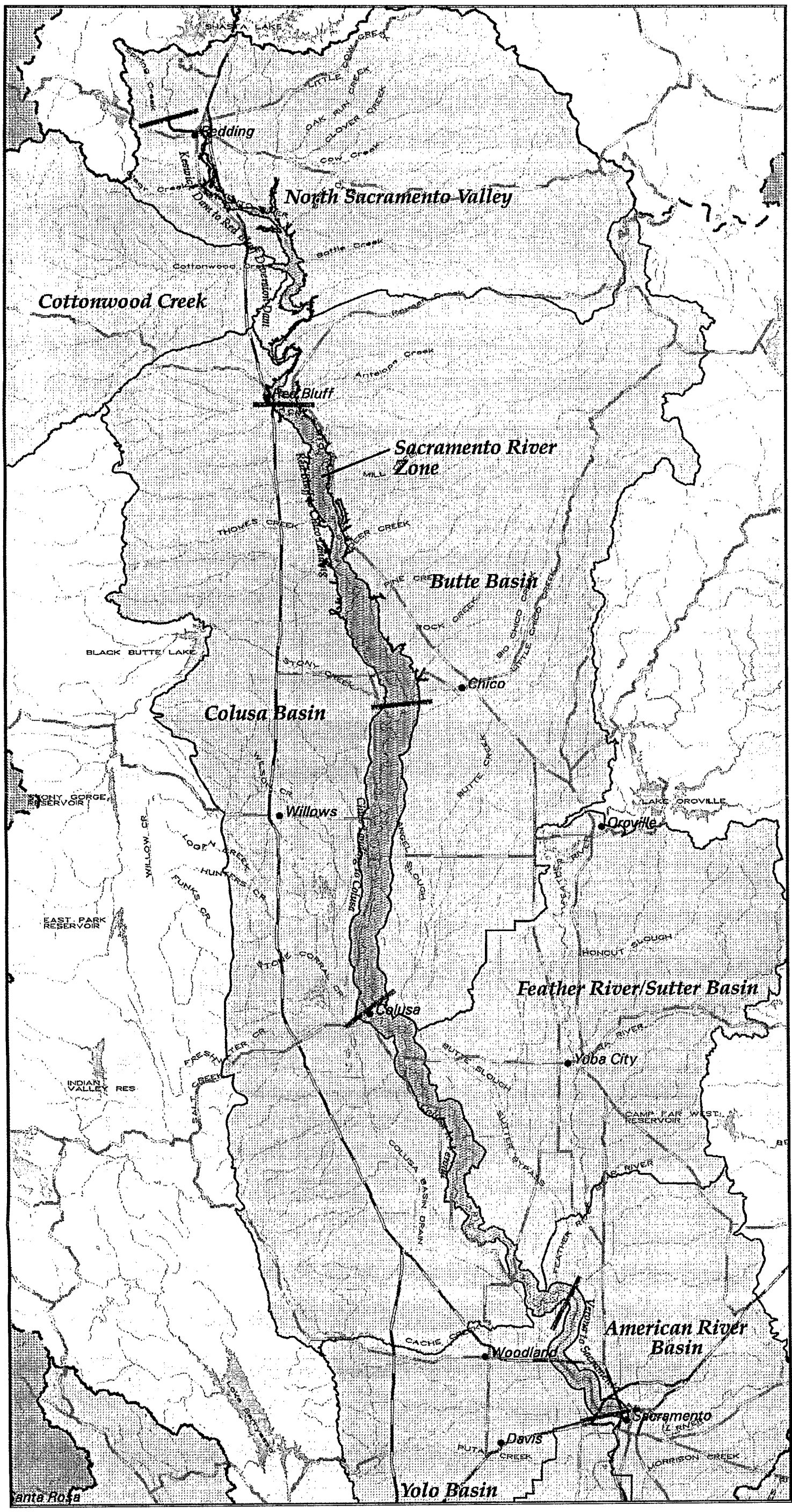

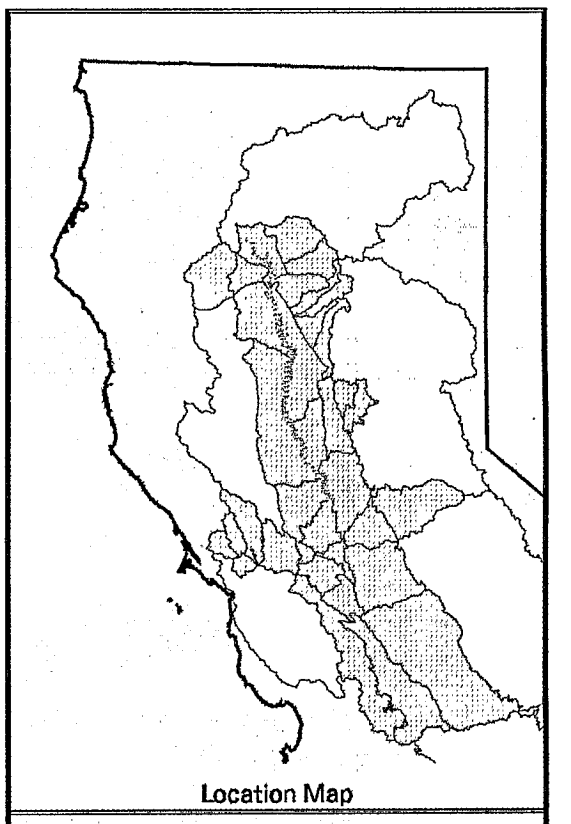

Location Map

Study Area and Watershed Region Boundaries

Ecological Zone

Division between Ecological Units

Boundary of other Surrounding Ecological Zones

Interstate Highway

State Highway

Length of ecological units in river miles:

1. Keswick Dam to Red Bluff Reach RM 302 - RM 243 (59 miles)
2. Red Bluff to Chico Landing Reach RM 243 - RM 194 (49 miles)
3. Chico Landing to Colusa Reach RM 194 - RM 143 (51 miles)
4. Colusa to Verona Reach RM 143 - RM 80 (63 miles)
5. Verona to Sacramento Reach RM 80 - RM 60 (20 miles)

Note: River Mile zero is located at Collinsville at the confluence of the Sacramento and San Joaquin rivers.

N W E S

0 5.5 11

Scale in Miles

Sources: Jones & Stokes Associates, US Bureau of Reclamation, US Environmental Protection Agency, Montgomery Watson.

CALFED BAY-DELTA PROGRAM

Ecosystem Restoration Program Plan

Figure 14.1
Sacramento River Ecological Zone

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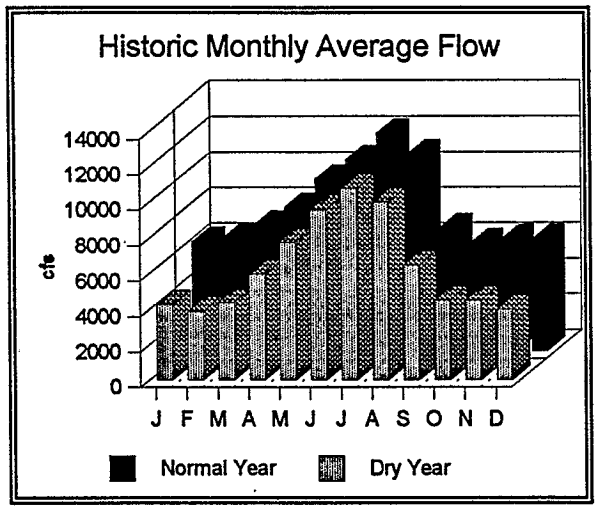
natural or undeveloped river systems. Bank protection also reduces the amount of fresh gravel and shaded riverine aquatic habitat available to the river through bank erosion. (Note that salmon spawning on gravel river beds of the Sacramento River occurs as far downstream as Princeton near Colusa.)

Over 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 percent of its banks are armored by riprap protecting 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 65-100 years to reach full maturity (climax succession to valley oak woodland). New sediment and gravel that sustains this process is supplied by a combination of eroding banks along the mainstem river and input from unregulated upstream tributaries. New fish habitat is created by the 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.

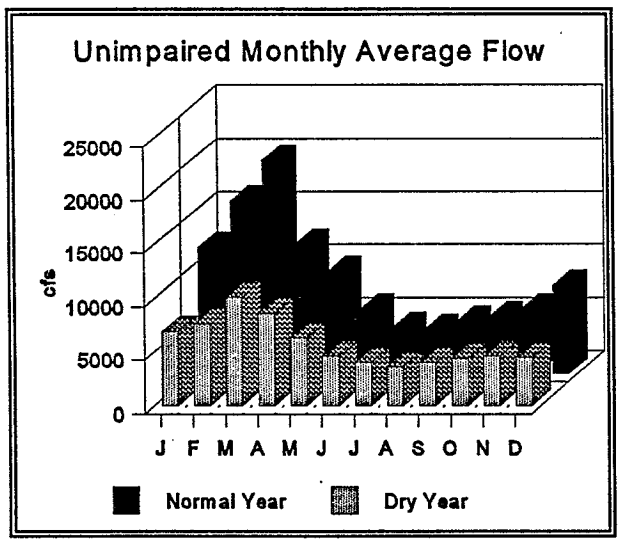
The Sacramento River Ecological Zone is dependent on virtually all its adjacent Ecological Zones which cumulatively contribute to the maintenance of important ecological processes and functions, particularly water, sediments, and nutrients. For the most part, the metamorphic rocks of the Klamath Mountains are resistant to erosion and do not produce much gravel. The Coast Ranges are also metamorphic rocks, but in contrast, produce large amounts of both suspended sediment and gravel. More recent sedimentary rocks of clay, silt, sand, and gravel (semi-consolidated deposits) are highly erodible and provide large quantities of sediments and gravel to the westside streams, and therefore, the Sacramento River. 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 the effects of instream gravel mining that depletes gravel sources in the channel for downstream transport.

Shasta Dam and diversion from the Trinity River controls Sacramento River flow through dam releases at Whiskeytown Lake, Spring Creek and Shasta Dam. Tributaries, including many with no major storage dam, provide a significant quantity of flow accretion, particularly through the winter and spring months. The Sutter and Yolo bypasses redirect a vast quantity of flow from the mainstem river during high flow periods and are integral components of the Sacramento River flood control project. The Sacramento River flows into the Central Valley via Shasta and Keswick Dams just north of Redding. Prior to the construction of Shasta Reservoir the river flows near Redding had a typical winter and spring high flow period and a summer low flow period. Peak dry year flows (represented by 20th percentile exceedance of the unimpaired flows 1972-1992) reached a peak near a monthly average of 10,000 cfs in March. In normal years (represented by the 50th percentile exceedance) peak flows reached near 20,000 cfs in March. Low summer flows averaged less than 5,000 cfs in dry and normal years.
Since construction of Shasta and Trinity Dams stream flows 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. March flows in normal years declined from an average of 20,000 cfs to near 7000 cfs. Likewise dry year flows declined from 10,000 cfs to 5,000

cfs. In contrast summer flows have increased sharply from about 4,000 cfs to 12,000 cfs in normal years and 3,000 cfs to near 10,000 cfs in dry years. In addition to irrigation releases, in recent years flows in excess of 10,000 cfs have been released in summer to protect winter-run salmon spawning in the upper river.



The CALFED vision is to try to restore some aspects of the natural hydrology of the upper Sacramento River. Anadromous Fish Restoration Plan (AFRP, U.S. Fish and Wildlife Service) targets of 3,250 to 5,500 cfs from October 1 to April 30 are similar to natural flows. In addition to the AFRP base flow minimums, CALFED proposes the pass through of 8,000-10,000 cfs and 15,000-20,000 cfs pulses in late winters of dry and normal years, respectively. Such pulsed flows would support natural processes in the upper river that depend on natural flow regimes.



Various cropland habitats occur on flat and gently rolling terrain adjacent to most of this zone and may not correspond to regional natural habitat stages. Irrigated crops grown are mostly orchards, rice, grains, and alfalfa. Most of this cropland is irrigated from water diverted from the Sacramento River or its tributaries. Croplands can provide numerous benefits to this zone with minimal changes to irrigation diversions identified in the targets below.

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 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 undamed tributary with natural hydrology and sediment characteristics. In the winter flood of 1986, over 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.

Other key components in the Sacramento River Ecological Zone include the many permanent and seasonal tributary stream mouths and oxbow lakes along the mainstem which are important backwater

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rearing areas for juvenile fish and provide major sources of nutrients, instream woody material, sediment, and gravel.

Reach 1 - 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, Battle, and Paynes creeks draining Mount Lassen, and Spring, Clear, and Cottonwood creeks drain the Coast Range and Klamath Mountains. Much of the river in this reach flows in confined canyons, although portions have a broader floodplain. About four 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 downstream of Reach 2.

Reach 2 - 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 Red Bank, Elder, and Thomes creeks. South of Red Bluff is a broad alluvial river system controlled by its own water discharge and sediment deposits. Here, 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 is relatively unchanged in nature, and includes a significant amount of riparian forest.

Reach 3 - 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 via three major flood relief outfalls at M&T Ranch, 3B's, and Parrot Ranch, and farther downstream via 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 1/4 to one mile apart.

In the Butte Basin overflow segment of Reach 3, more extensive bank revetment projects installed during the past 30 years by landowners and the Corps of Engineers 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 flood flow over three major weirs into Butte Basin, where flooding volumes poss 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, in spite of 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.

Reach 4 - The Colusa to Verona Reach (63 miles from RM 143 to RM 80) includes the mouth of the Butte Slough outfall gate, but no important tributary inflow until the Colusa Basin Drain enters the river near Knights Landing at RM 90. High flows leave the river via the Colusa and Tisdale Weirs, and farther downstream most flow from the Sutter Bypass/Butte Slough and Sacramento

River leaves the river again at the three-mile long Fremont Weir and flows down the Yolo Bypass to the Delta at Rio Vista. The levees in this reach are mostly built close to the main river channel, and little riparian forest or shaded riverine aquatic habitat remains. Leveed banks are steep with extensive riprap placement 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.

Reach 5 - The Verona to Sacramento Ecological Unit (20 miles from RM 80 to RM 60) includes important tributary inflow from the Feather River (and from Sutter Bypass and Butte Slough 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 Sacramento Weir. As with Reach 4, the levees in this reach are mostly built close to the main river channel, and little riparian forest or shaded riverine aquatic habitat remains.

Identification, Status and Restoration Needs of Ecologically Important Processes, Resources, Habitats, and Stressors

The most important physical processes and ecological structures within the Sacramento River Ecological Zone are summarized below. The vision for this river zone is to maintain, reestablish, or augment these processes and structures wherever possible:

- frequent winter and spring storm flow peaks that inundate the vegetated river floodplain, transport and redeposit gravel and sediment, erode natural banks, and create new substrate for riparian forest to reseed and germinate in the spring,

- a one to five mile-wide meander belt and riparian corridor where the river is allowed to migrate within defined limits, and support a diverse age class structure of successional vegetation, clean gravel bars, and form backwater oxbow channels connected to the main river at low flow,

- an annual hydrograph that mimics pre-Shasta patterns, including adequate low water temperatures to support spawning, incubation, and juvenile rearing, and naturally lower flows during the growing season to prevent premature inundation and mortality of riparian seedlings,

- hydrologic and physical connectedness with major east and west side tributaries that supply unregulated peak flows, new gravel, organic matter, and sediment, and major rearing habitat and migration corridors to other watersheds, and

- in general, a reliance on integration of natural physical processes that create and sustain continuous habitats along the mainstem river with a minimum of artificial means needed to restore any one habitat type. This vision approach is most applicable from Keswick to Colusa, but new and enlarged nodes or stringers of riparian forest and shaded riverine aquatic

habitats can be created by tapping and unleashing physical processes downstream of Colusa as well.

Significant stressors of ecological functions, habitats, and species on the Sacramento River include bank protection (i.e., new riprap) and the artificial confinement of the river channel by the infrastructure of the Sacramento River Flood Control Project, adjacent land use (e.g., expansion of roads, subdivisions, orchards, and crops on flood terraces within the meander belt), reservoir management that reduces the magnitude, frequency, and duration of natural peak storm flows, absence of gravel and sediment supply downstream of the extensive system of flood control and water storage reservoirs, instream gravel mining that removes habitat on tributaries, inflow of water contaminants (especially Iron Mountain Mine and the Colusa Basin Drain), invasive riparian exotic shrubs (such as giant reed, tamarisk, ailanthus, and eucalyptus) competing for space and sunlight with new riparian stands, overharvest of fish and wildlife, and predation and competition with anadromous species from introduced and hatchery fish.

Habitats of the Sacramento River can only be created and maintained through the restoration and continuance of essential physical processes. Important habitats provided by the Sacramento River include shaded riverine and near-shore aquatic habitat, riparian forest, valley oak woodland, spawning gravel beds, shallow low-velocity nursery habitats and emigration cover for anadromous fish populations, and various cropland habitats including agricultural wetlands and uplands. Important resident and anadromous fish rearing habitats include oxbow lakes, backwater sloughs, tributary mouths, gravel bars and riffles, and permanent marsh or lake habitat associated with active floodplain basins along the river.

Various physical processes independently and synergistically maintain these important habitat types. For example, high flow eroding cut banks simultaneously recruits gravel for downstream spawning beds and scours deep water pools shaded by overhanging vegetation. High-energy peak flows are also essential to riparian forest succession which is necessary to regenerate the forest through cottonwood and willow seedling establishment on new gravel point bars. Occasionally overhanging vegetation eroded at the outside bank falls into the river, providing cover and refuge for fish of all sizes.

Important fish, wildlife, and plant species occupying the Sacramento River Ecological Zone and its habitats include winter-run chinook salmon, fall-run chinook salmon, late-fall-run chinook salmon, spring-run chinook salmon, steelhead, green sturgeon, white sturgeon, American shad, striped bass, waterfowl, neotropical migrant bird species dependent on high quality riparian habitats, valley oak woodland, and native riparian forest species. Bank swallow and other bank dwelling birds depend on vertical eroding banks for nesting sites, and bald eagle and osprey forage for fish in open water areas.

Vision for Ecological Units

Keswick Dam to Red Bluff Diversion Dam Vision (Reach 1): The CALFED vision for the Keswick Dam to Red Bluff Diversion Dam Ecological Unit highlights the restoration of ecological processes that naturally create and sustain habitats needed to support and restore the endangered

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Sacramento winter-run chinook salmon and species of special concern such as steelhead, spring-run chinook, fall-run chinook, and late-fall-run chinook. The vision includes maintaining a flow pattern that emulates the natural hydrologic regime to the extent possible given the high level of development of water and flood storage in the upper section. Important ecological functions of flow include maintaining and supplementing the natural stream meander and gravel recruitment processes; sediment transportation and deposition; protecting the limited riparian corridor in this section; and preventing potential catastrophic fish losses due to an uncontrolled spill of toxic materials from Iron Mountain Mine and Spring Creek Debris Dam overflow.

This ecological unit encompasses a significant portion of critical holding, spawning, and nursery area required by the endangered winter-run chinook salmon, and CALFED envisions that most of the water diversions in this reach will have positive barrier fish screens installed to protect all juvenile salmon and steelhead. A primary concern for Reach 1 is the protection and enhancement of instream gravel resources supplied to the mainstem river by the tributaries.

Intact physical processes create an optimum complexity of channel habitat structure and cover for juvenile fish. CALFED also envision that nursery areas for juvenile salmon would be improved through the restoration or enhancement of waterside emergent and riparian vegetation throughout this unit and particularly in areas immediately downstream of the mouths of some of the tributaries described above. This can be accomplished through a variety of measures including special riparian zone seasonal grazing management programs or fenced exclosures where landowners choose to participate.

Red Bluff Diversion Dam to Chico Landing Vision (Reach 2): The CALFED vision for the Red Bluff Diversion Dam to Chico Landing Ecological Unit emphasizes the quantity and quality of the riparian corridor and its associated riparian forest. The ecological processes needed to restore the riparian component are also extremely important for maintaining many important fish and wildlife resources that depend on habitats within the unit. Important elements needed to attain the CALFED vision for this unit include specific provisions for processes that maintain high quality habitat for winter-run chinook salmon and steelhead and other anadromous fish species.

Restoration of 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 and gravel recruitment, transport and deposition.

This ecological unit encompasses an important portion of critical nursery and emigration area required by the endangered winter-run chinook salmon, and CALFED envisions that most of the water diverted in the section will use positive barrier fish screens to protect juvenile fish.

In this unit CALFED envisions the restoration of broad riparian corridors that are connected and not subject to fragmentation. These corridors would connect larger blocks of riparian 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 greater that 100 meters wide and would support increased populations of neotropical migrants such as the yellow-billed cuckoo and unique furbearers such as the ring-tailed cat. Species such as the bank swallow will benefit from the restoration of the processes that create and maintain habitat within this unit.

CALFED also envisions that nursery areas for juvenile salmon would be improved through the restoration of waterside emergent and riparian vegetation throughout the unit and particularly downstream of the mouths of some of the tributaries described above.

In short, the CALFED vision for Reaches 2 and 3 combined could be summarized as the preservation, management, and restoration of a functioning ecosystem to ensure the sustainable maintenance of:

- a mosaic of varying age classes and canopy structure types of riparian forest,
- a diversity of habitat types including forest and willow scrub, cut banks and clean gravel bars, oxbow lake and backwater swales with emergent wetlands, and floodplain valley oak/sycamore woodlands with grassland understory,
- uninterrupted gravel transport, deposition, cleansing, and replenishment, and
- a complexity of shaded and near-shore aquatic substrate and habitats with well-distributed instream woody cover and organic debris.

Chico Landing to Colusa Vision (Reach 3): The CALFED vision for the Chico Landing to Colusa Ecological Unit provides improved habitat and increased survival of many important fish and wildlife resources. Important elements needed to attain the CALFED vision for this unit include specific processes that maintain high quality habitat for chinook salmon and steelhead, besides the other anadromous fish species. The continuance of the natural migration of the river within its meander zone is essential to create and maintain most of these habitats. A mix of solutions will be employed that 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 likely include strategic levee setbacks, expansion of flood basin outflow capacity, and new flood easements in basin lands that detain additional flood storage, thereby reducing river stage.

Restoration of 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 development of water in the upper section. Important considerations include flows needed to maintain natural stream meander processes and gravel recruitment, transport and deposition, maintenance of the limited riparian corridor in this section.

Closure of gaps in the shoreline riparian vegetation and near shore aquatic habitat will be accomplished through natural colonization of expanded floodplain along channels, by a reduction of

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vegetation management by local reclamation districts, and enhancement of channel banks through the modification of levees and berms that incorporates habitat structures such as "fish groins" and low waterside berms supporting natural growth and woody debris.

This ecological unit encompasses a significant portion of the critical migration habitat required by the endangered winter-run chinook salmon, and CALFED envisions that most of the water diverted in the section will use positive barrier fish screens to protect juvenile fish.

In this unit, CALFED envisions the restoration of broad riparian corridors interconnected with narrower corridors that are not subject to fragmentation. These corridors would connect larger blocks of riparian typically greater than 50 acres. These blocks would be large enough to support the natural evaporative cooling of the river by convection currents of air flowing from the cool, humid forests and across the river water. The wider riparian corridors would generally be greater that 100 meters wide and would support increased populations of 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 the restoration of the processes that create and maintain habitat within this unit. The narrower corridors would range between 10 and 25 meters wide.

CALFED also envisions that nursery areas for juvenile salmon would be improved through the restoration of waterside emergent and riparian vegetation throughout this unit and particularly in areas immediately downstream of the mouth of the Feather River.

Colusa to Verona Vision (Reach 4): The CALFED vision for the Colusa to Verona Ecological Unit provides improved habitat and increased survival of many important fish and wildlife resources. Important elements needed to attain the CALFED vision for this unit include specific processes that allow the recovery of riparian forest and near-shore aquatic habitats, and maintains high quality habitat for chinook salmon and steelhead and other anadromous fish species. This reach is an important seasonal component of the critical migration habitat required by the endangered winter-run chinook salmon, and CALFED envisions that much of the water diverted in the section will use positive barrier fish screens to protect juvenile fish.

The January floods of 1995 and 1997 provided stark evidence that the Sacramento River possesses inadequate capacity within its levees to safely pass major flood flows downstream of Colusa. The lack of channel capacity and proximity of levees to the river in Reaches 4 and 5 is the primary reason 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 of an undersized flood control system. Ecosystem recovery requires a fundamental reevaluation of the flood control project in this part of the valley, and potential major alterations in infrastructure and floodplain management must be evaluated concurrent with ecosystem planning. Major additional capacity of the system is needed to prevent a repeat of the catastrophic flooding of 1997 and previous years, to make room for the ecological recovery of the degraded river in this 85 mile stretch, and to connect the Delta to a functional river system.

Verona to Sacramento Vision (Reach 5): The CALFED vision for the Verona to Sacramento Ecological Unit provides for many important fish and wildlife resources that depend on partially

operational ecological processes and functions. Important elements needed to attain the CALFED vision for this unit include specific processes and conditions that maintain high quality nursery and migration habitat for adult and juvenile winter-run chinook salmon and steelhead, and other anadromous fish species.

Restoration of 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. Important considerations include flows to maintain natural stream meander processes and gravel recruitment, transport and deposition, maintaining a limited but continuous riparian corridor, and reducing potential fish losses due to toxic residues from agricultural tailwater. This ecological unit encompasses a significant portion of critical nursery area required by the endangered winter-run chinook salmon, and CALFED envisions that most of the water diverted in the section will use positive barrier fish screens to protect juvenile fish.

Closure of gaps in the shoreline riparian vegetation and near shore aquatic habitat will be accomplished through a reduction of vegetation management by local reclamation districts, and enhancement of channel banks through the modification of levees and berms that incorporate habitat structures (such as "fish groins" and low waterside berms) supporting natural growth and woody debris. CALFED also envisions that nursery areas for juvenile salmon would be improved through the restoration of waterside emergent and riparian vegetation throughout this unit and particularly in areas immediately downstream of the mouth of the American River.

In this unit, CALFED envisions the restoration of narrower riparian corridors that are connected and not subject to fragmentation. These corridors would connect larger blocks of riparian 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 meters wide and would support cavity nesting species such as the wood duck and would 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 flood flow can be reduced, or where levees can be setback several hundred feet wide at constricted bends to create expanded floodplain "nodes" within the levees.

Pathways to Vision

Overall, CALFED anticipates that its vision for the Sacramento River Ecological Zone will nurture and augment other important ongoing and future restoration efforts for the zone. In particular, the CALFED vision will greatly supplement the National Marine Fisheries Service's needs for restoration of the endangered winter-run chinook salmon and other potential salmon and steelhead stocks presently under status review for inclusion in the list of endangered species. CALFED's vision for the Sacramento River Ecological Zone will also improve the benefits from the U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan which strives to double the natural production of anadromous fish in the system over the average production during 1967-1991. Likewise, the CALFED vision will help the Department of Fish and Game as it progresses toward doubling the number of anadromous fish over the number present in 1988.

CALFED will foster the cooperation of all state and federal agencies responsible for flood control and natural river resources to jointly evaluate the system capacity, and to collaborate with local jurisdictions, landowners, and river conservation organizations to seek system-wide solutions not previously contemplated. In particular, CALFED will cooperate with the US Army Corps of Engineers to develop a physical model of the river system and its floodplain (similar to the Butte Basin study, but on a larger scale) in order to test hypotheses for complex rerouting, detention, and bypassing of floodwaters. 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.

Finally, the CALFED vision for this important ecological zone will help the Upper Sacramento River Advisory Council's Riparian Habitat Committee (a.k.a. SB1086 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.

Linkage to Other Ecological Zones

Restoration and maintenance of ecological processes and functions in the Sacramento River Ecological Zone are highly dependent on actions and conditions in adjacent zones. For example, the maintenance of the riparian forests and stream meander quality of the Sacramento River above Chico Landing is highly dependent on input of largely unregulated flow and sediments from Cottonwood Creek and several undamed tributaries draining Mount Lassen and the northern Sierra Nevada. Therefore, maintaining and restoring important ecological processes in Cottonwood Creek and other unregulated tributaries is essential to maintain the ecosystem health of the Sacramento River.

Likewise, some fish species depend exclusively on the Sacramento River for migration, spawning, and nursery habitat, while some species that use other ecological zones for spawning use the Sacramento River as primary migration, nursery and emigration habitat. Other important ecological zones dependent on the resources of the Sacramento River include the Sacramento-San Joaquin Delta Ecological Zone and the Suisun Marsh/San Francisco Bay Ecological Zone. These zones in turn provide essential food web 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 zones. For example, ocean recreational and commercial salmon fisheries remove a large portion of the potential adult spawners 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 loadings present.

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Technical Appendix 14. CALFED Ecosystem Quality Objectives -Sacramento River Ecological Zone

Zone Number: 14

Zone Description: The linear extent of the Sacramento River Ecological Zone includes the mainstem of the Sacramento River from Keswick Dam (river mile 302) near Redding to the "I" Street bridge (river mile 60) in Sacramento. The width of the ecological zone extends to the margin of the active floodplain (approximately 1 to 4 miles).

Ecological Subunits:

- Keswick Dam to the Red Bluff Diversion Dam.
- Red Bluff Diversion Dam to Chico Landing.
- Chico Landing to Colusa.
- Colusa to Verona.
- Verona to Sacramento.

Summary of Targets For The Sacramento River Ecological Zone:

Table 1 summarizes ecosystem restoration targets by resource element and corresponding CALFED Objectives and Subobjectives addressed by each target established for the Sacramento River Ecological Zone.

Ecosystem Health Rating for Applicable Resource Elements

Table 1 summarizes the relative ecosystem health for each important resource element for the entire Sacramento River ecological zone and each of the ecological subunits. The scale used to rate resource elements ranges from F (indicating the poorest ecosystem health rating attainable for the resource element) to A (indicating the highest attainable ecosystem health rating attainable for the resource element).

TABLE 1. Resource Element Health Ratings for the Sacramento River Ecological Zone by Ecological Subunit.

Resource Element	Ecological Subunits					Total Average Health Rating
	Keswick to RBDD	RBDD to Chico Landing	Chico Landing to Colusa	Colusa to Verona	Verona to Sacramento	
Natural Hydrograph	C	C	C	C	C	C
Stream Meander Belt	NA	B	D	NA	NA	C
Gravel Recruitment	F	D	D	NA	NA	D
Water Management	B	B	B	B	B	B
Gravel Mining	B	B	B	NA	NA	B
Harvest of Fish and Wildlife	B	B	B	B	B	B
Predation and Competition	C	C	C	C	C	C
Artificial Production of Fish	C	C	C	C	C	C
Shaded Riverine Aquatic	B	B	C	D	D	C
Valley Oak Woodland	B	C	D	D	D	C
Perennial Grassland	B	B	C	D	D	C
Agricultural Wetland Habitat	C	C	C	D	D	C
Agricultural Upland Habitat	C	C	C	D	D	C
Total Average Health Rating	**B**	**B**	**C**	**C**	**C**	**C**

*NA = Not applicable.

CALFED IMPLEMENTATION OBJECTIVES, TARGETS, AND ACTIONS

Primary Physical Process Resource Element: ***Stream Flow***

Implementation Objective: Restore basic features of the hydrograph in order to reactivate and maintain ecological processes and functions which create and maintain habitat required to sustain healthy fish, wildlife, and plant populations.

Target: More closely emulate the natural seasonal streamflow patterns in dry and normal year types by allowing a late winter or early spring pulse of flow of approximately 5,000-

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10,000 cfs in dry years and 15,000-20,000 cfs in normal water years to pass through Lake Shasta.

Rationale: *Late-winter or early-spring pulse flow 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 that in some years may not occur under the present level of project development and operation. Implementation of the target level of the pulse flow must necessarily be on a conservative basis because of the potential cost to water supply, because it cannot be determined that reaching the target will meet the prescribed objectives, and because there is lack of sufficient consensus on the potential effectiveness of these target flows among stakeholders.*

Applicable Ecological Subunits: *All.*

Action: Provide a pulsed flow by supplementing normal operating flows from Shasta and Keswick dams with releases from Lake Shasta (and Trinity Lake) in March of years when no pulse flow has occurred during the winter or is expected to occur. Pulsed flows would only be provided when sufficient inflow to Lake Shasta is available to sustain the prescribed releases. Refinement of this action can be made by evaluating its indirect costs and the overall effectiveness of achieving objectives.

Rationale: *If a pulse flow of equal or greater magnitude has not occurred between Keswick Dam and Red Bluff by March, then supplementing base flows or augmenting small natural pulses or reservoir spills with additional reservoir releases is the only means to provide pulsed flows. Such releases would only be allowed 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 pulses occurred historically in dry and normal years, and because opportunities for such flow to occur "naturally" as a function of normal project operation would by then have been exhausted. Water forecasts as to the water year type (dry or normal) would also be available by February and March. The pulse flow in March would be expected to proceed unimpaired downstream to and the Delta, because little or no diversions from the Sacramento River occur during the month of March. (Note that additional pulsed flows 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 pulse could also help satisfy Delta outflow requirements.*

Target: Maintain base flows in fall between 6,000 to 8,000 cfs.

Rationale: *Maintenance of natural base flows will help promote natural channel forming, riparian vegetation, and food web functions. Base flows also serve to attract steelhead and fall and late-fall chinook salmon. Unimpaired baseflows in fall are approximately 4,000 cfs and 6,000 cfs in dry years, and up to 8,000 cfs in wetter years. Natural base flows are only prescribed for the 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. The need for such base flows is well established based on experience in past when flows were below these base levels. These flows are generally being met under existing operating regimes in dry and normal years.

Applicable Ecological Subunits: *All subunits.*

Action: Provide flow releases from Shasta Lake and Keswick Dam when necessary to provide the target natural base flows. Releases would only be made when inflows equal or exceed prescribed releases.

Rationale: *Increasing releases from Shasta Reservoir is the only means of maintaining base flows in the upper river. Sufficient foundation has been established and sufficient water supplies are available to provide this action.*

Secondary Ecosystem Process and Function Resource Element:	***Stream Meander Belts***

Implementation Objective: Maintain, improve, or restore natural stream meander processes in order to allow the natural recruitment of sediments, creation of habitats, and promote natural riparian succession processes.

Target: 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 8-12,000 acres of riparian lands in the meander zone.

Rationale: *Preservation and improvement of the existing 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 food web), 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. There is sufficient justification, scientific basis, and stakeholder support to accept this target for immediate implementation.*

Applicable Ecological Subunits: *Red Bluff downstream to Chico Landing*

Action: Remove rip-rap from banks and reduce effects of other structures such as bridges that inhibit meander process.

Action: Reimburse property owners for land lost to meander process.

Implementation Objective: Maintain, improve, restore, or supplement gravel recruitment processes in riverine systems of the Sacramento-San Joaquin basin in order to provide spawning substrate for anadromous fish, promote riparian succession, maintain stream channel gradient, and dissipate stream energy to prevent deep scour.

Target: Increase gravel recruitment in the upper Sacramento River between Keswick Dam and the Red Bluff Diversion Dam by 10-20,000 cubic yards annually in order 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 annually captured by Shasta Dam.

Rationale: *Replenishment of 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. Replenishment of gravels to maintain channel forming processes and stream meanders in the upper Sacramento River will help maintain fish and wildlife habitats, aquatic algae and invertebrate production, and streamside vegetation. There is adequate regulatory foundation, sufficient scientific basis, and stakeholder and agency support for immediate implementation of this target. A pre-development level of gravel recruitment should be adequate to restore the natural ecological processes supported by gravel recruitment, but may require experimentation, monitoring, and experience to determine the exact amount of gravel supplies necessary to meet the objective.*

Applicable Ecological Subunits: *Keswick Dam downstream to Red Bluff, and Red Bluff downstream to Chico Landing.*

Action: Stockpile gravel at strategic locations along the Sacramento River below Keswick Dam where river flow 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.

Action: Reactivate gravel recruitment to the river by exposing existing sources of river gravel on islands, bars, and banks that have become armored to river flows. This action should be implemented on a conservative basis because the availability of such in-channel gravel, costs of activating the gravel, indirect impacts, and potential effectiveness have not been determined.

Implementation Objective: Reduce entrainment of juvenile fish into water diversions by screening or consolidating diversions or by altering diversion timing in order to increase survival and cohort replacement levels.

Target: Reduce entrainment of juvenile salmon and steelhead into water diversions to minimal levels. Emphasis should be on the upper river from Keswick Dam downstream to Chico Landing.

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 from predation 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 through fall irrigation season. This is a immediate target because there is consensus among agencies and stakeholders that entrainment should be minimized in order to restore salmon and steelhead populations.*

Applicable Ecological Subunits: *All subunits.*

Action: Screen one- to two-thirds of all unscreened diversions and all diversions greater than 250 cfs. This programmatic level-of-action should be sufficient to provide the data necessary to modify this target through adaptive management. Determination of which diversions need be screened will be determined upon 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. Priorities will be given to screening diversions that pose the most threat and where screening has been determined to be cost effective.

Action: 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.

Action: Reduce diversions during periods when and locations 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, with decisions made with agency and stakeholder involvement, and with consideration given to appropriate alternatives.

Stressor Resource Element:	***Gravel Mining***

Implementation Objective: Reduce the adverse effects of gravel mining in order to improve and restore the natural recruitment of gravel and other sediments to the Sacramento River.

Target: Protect, enhance, and restore natural gravel recruitment in all areas of active and inactive gravel mining.

Rationale: *Natural gravel recruitment is limited in the upper Sacramento River by Shasta, Keswick, and smaller diversion dams, as well as shoreline protection and controlled flow regimes. There is general consensus among agencies and stakeholders that gravels may be inadequate for fully restored salmon and steelhead population levels, but not necessarily for existing population levels. The full restoration target will be evaluated to determine cost effectiveness and a level that can be substantiated with adequate scientific foundation and agency and stakeholder agreement.*

Applicable Ecological Subunits: *Keswick Dam downstream to Red Bluff, and Red Bluff downstream to Chico Landing.*

Action: Reduce the mining of gravels in the Sacramento River and its tributaries by providing alternative gravel supplies outside the active stream channels in order to contribute directly to maintaining the supply of gravel in and to the river. This action will be taken on a case by case basis upon determination of impacts of existing operations and cost effectiveness of eliminating gravel operations or providing adequate mitigation.

Action: Where past gravel mining has reduced gravel recruitment to the river, restore the natural features and supplies of gravel that contributed to recruitment of gravel to the river. This action will be undertaken based on evaluation of the cost effectiveness of actions on a case-by-case basis, determination that pilot experiments prove such actions meet objectives, and that actions are necessary to meet objectives.

Stressor Resource Element:	***Harvest of Fish and Wildlife***

Implementation Objective: Reduce the level of illegal harvest of fish and wildlife in order to promote sustainable populations and other legal consumptive and non-consumptive uses.

Target: Reduce illegal harvest of fish species to a minimum in order to maintain or increase populations by increasing enforcement efforts 50 to 100%.

Rationale: Some populations of salmon and steelhead in the Sacramento River are at such depressed levels that drastic reductions in whatever factors contribute to mortality are necessary. Illegal harvest occurs at unknown levels along the Sacramento River. There is general agreement among agencies and stakeholders on this issue.

Applicable Ecological Subunits: *All subunits.*

Action: Provide increased enforcement efforts.

Action: Educate public on the threats to populations from illegal harvest. Various actions include ad campaigns, signs along streams, and various types of out-reach programs to schools and groups.

Action: Provide funding for a poaching hotline and rewards for arrest and convictions of poachers.

Action: Provide for greater penalties for illegal take of chinook salmon, steelhead, and green and white sturgeon.

Implementation Objective: Annually or biannually adjust the level of legal harvest of fish in order to sustain healthy populations and promote stock rebuilding.

Target: Manage the legal harvest of chinook salmon, steelhead, and sturgeon by shifting harvest from natural stocks to hatchery stocks where possible or reducing harvest of wild stocks until the naturally produced populations recover.

Rationale: Some populations of salmon and steelhead, and the population of green sturgeon in the Sacramento River are at such depressed levels that drastic reductions in whatever factors contribute to mortality are necessary. This target will be subject to adaptive management because there is lack of scientific information and agency and stakeholder consensus that existing harvest levels are detrimental to naturally produced populations.

Applicable Ecological Subunits: *All subunits.*

Action: Mark all hatchery salmon and steelhead, thereby 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 it meets its objective and is cost effective. There is presently a lack of certainty as to the need and potential cost effectiveness of this action.

Action: 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 short term. Long-term restrictions would depend on response of populations and effectiveness of restrictions, and the degree of effectiveness of the action.

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Stressor Resource Element:	*Predation and Competition*

Implementation Objective: Reduce the loss of juvenile anadromous and resident fish and other aquatic organisms due to predation in order to maintain sustainable populations.

Target: Reduce the adverse effects of predatory fish by identifying and eliminating human-made instream structures or operational conditions that allow unnatural rates of predation.

Rationale: *Reducing the number of predatory fish in the Sacramento River may help in short-term in the recovery of salmon and steelhead populations. This is a conservative target because there is a lack certainty as to the potential effectiveness and technical feasibility of such a measure.*

Applicable Ecological Subunits: *All subunits.*

Action: Selectively evaluate areas and make physical changes to structures in the Sacramento River such as bridge abutments, diversion dams, and water intakes that currently may attract predators and provide them with additional advantages in preying upon juvenile salmon and steelhead. The need for and potential effectiveness and cost of such actions are unknown, thus the need for pilot studies and evaluations to determine the types of changes required and the potential degree of implementation.

Stressor Resource Element:	*Artificial Production of Fish*

Implementation Objective: Protect and restore the genetic diversity of naturally producing populations of salmon and steelhead in the Sacramento River in order to sustain long-term viability of the populations.

Target: Minimize the likelihood that hatchery reared salmon and steelhead in the upper Sacramento River will stray into non-natal streams in order to protect naturally produced salmon and steelhead.

Rationale: *In watersheds like 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. There is presently a lack of consensus among agencies and stakeholders as to the scientific foundation and the effects of stocking hatchery reared fish on wild populations. There is some general scientific information and theory from other*

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river systems that indicates 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.

Applicable Ecological Subunits: *Keswick to Red Bluff and Red Bluff to Chico Landing.*

Action: Limit stocking of hatchery reared salmon and steelhead in upper Sacramento River. Stocking may be reduced in years when natural production is high in selected populations. 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 conducted on a short-term and experimental basis with subsequent efforts dependent on results and effectiveness.

Target: Limit hatchery stocking to populations that cannot be sustained through natural production.

Rationale: *Long-term hatchery augmentation of healthy wild stocks may genetically undermine that stock and threaten the genetic integrity of other stocks. Augmenting production of fall run chinook salmon, the only healthy population in the upper Sacramento River, may be necessary despite its healthy state, because spawning and rearing habitat are limited, and because adverse conditions may occur in drought or flood years that would undermine the population without additional hatchery production. Because there is a lack of consensus on this issue, the specific target is conservative, and the degree to which hatchery stocking is to be employed in the future will depend on further research and experience, and a consensus of agencies and stakeholders.*

Applicable Ecological Subunits: *Keswick to Red Bluff and Red Bluff to Chico Landing.*

Action: 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: Employ methods to limit straying and loss of genetic integrity of wild and hatchery supported stocks.

Rationale: *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.*

Applicable Ecological Subunits: *Keswick to Red Bluff and Red Bluff to Chico Landing.*

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Action: Rear hatchery 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.

Action: 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: Minimize further threats of hatchery fish contaminating "wild" stocks of salmon and steelhead.

Rationale: *Release of hatchery reared fish into the upper Sacramento River and its tributaries could lead to a loss in the genetic integrity of wild salmon and steelhead populations. Though some irreversible contamination has occurred in salmon and steelhead populations, further measures are necessary to minimize further deterioration of contaminated populations and to protect population that are not contaminated.*

Applicable Ecological Subunits: *Keswick to Red Bluff and Red Bluff to Chico Landing.*

Action: 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 spawners for the hatchery.

Action: Select adult spawners 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 spawners selected for hatcheries, this action will necessarily be of an experimental nature. 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.

Habitat Resource Element:	***Shaded Riverine Aquatic***

Implementation Objective: Increase the length of stream channels bordered by riparian vegetation and reduce fragmentation of riparian corridors in order to provide habitat complexity and contribute to the long-term sustainability of fish and wildlife populations.

Target: Provide conditions for growth of riparian vegetation along channelized portions of the Sacramento River.

Rationale: *Rip-rapped 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, provide spawning substrate for other fish such as Sacramento splittail, and provide refuge for*

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juvenile fish during periods of high water. This target is conservative because the technical feasibility, indirect effects (potential reduction of levee integrity), and cost effectiveness of such activities are uncertain. There is also a lack of agency and stakeholder consensus on this issue.

Applicable Ecological Subunits: *Chico Landing downstream to Sacramento.*

Action: Plant vegetation on un-vegetated rip-rapped banks. Because the technical feasibility and cost-effectiveness of such actions will need to be determined, pilot projects will be conducted as experiments. Further implementation will be subject to adaptive management and depend on results of these experiments.

Action: Setback levees may be constructed on leveed reaches of the river to provide a wider flood plain and greater development of SRA habitat. Because of the potential indirect impacts to landuse and uncertainty as to cost and technical feasibility of setback levees, such development will experimental and conservative, and dependent on adaptive management.

Implementation Objective: Preserve existing and enhance degraded shaded riverine aquatic habitat areas in order to locally reduce temperature, increase the input of terrestrial food, and provide for habitat diversity and complexity.

Target: Increase the ecological value of low- to moderate-quality shaded riverine aquatic habitat through land use and land management changes.

Rationale: *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. Protection and improvement of existing SRA habitat may involve changes in landuse that will require consensus of agencies and stakeholders. Limited available funds may require priority setting with high-priority, low cost sites developed initially. For sites where consensus exists, immediate action can be undertaken on an experimental basis.*

Applicable Ecological Subunits: *All subunits.*

Action: Purchase property or easements and allow habitat to improve naturally. Properties to be considered should be developed through priority process based on quality and importance of habitat, technical feasibility and cost of purchase and improvement, and consensus of stakeholders.

Action: Provide incentives and technical support for private landowners to protect and improve existing SRA habitat.

Target: Maintain existing streamside riparian vegetation.

Rationale: *Because of the importance and limited distribution and abundance of SRA habitat, all existing quality habitat should be protected. Target is conservative because the*

extent of exising habitat in need of protection is not known, the technical feasibility of preservation and cost of maintenance are not known, and because there is lack of consensus among agencies and stakeholders as to means and extent such habitat should be maintained..

Applicable Ecological Subunits: *All subunits.*

Action: 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 subject to adaptive management.

Habitat Resource Element: ***Valley Oak Woodland***

Implementation Objective: Protect, improve, and restore valley-oak woodlands in order to provide habitat diversity needed to sustain wildlife species.

Target: Improve 500 acres of existing degraded oak woodlands and restore 500 acres of valley oak woodlands along the Sacramento River.

Rationale: *Valley Oak Woodlands are an important part of the SRA habitat as they provide shade, cover, and food for aquatic organisms, and they are important habitat for wildlife living in the flood plain of the river. Present acreage is not adequate to support ecological functions for fish and wildlife associated with the river, and 1000 acres of quality woodlands represents a reasonable start toward restoration of valley oak woodland habitat along the Sacramento River. The target is short-term given that the potential for restoration and costs are unknown. Initial efforts should be implemented as experiments in order to determine technical feasibility and cost of such efforts.*

Applicable Ecological Subunits: *All subunits.*

Action: Plant oaks on available public lands adjacent to the river. The action will be conducted as experiments to determine the technical feasibility and cost of such actions.

Action: Plant oaks on private lands acquired through conservation easements or purchase, or through voluntary participation of landowners. Such actions are conservative as they will depend on results of initial experiments on public lands and consensus of agencies and stakeholders as to benefits, mitigation of indirect effects, and cost-effective of measure.

Target: Expand the area of existing preserves adjacent to the Sacramento River to include all existing significant valley-oak woodlands.

Rationale: *Because limited woodlands remain, all remaining woodlands adjacent to the river should be preserved.*

Applicable Ecological Subunits: *All subunits.*

Action: Preserve and protect oak woodlands on public lands adjacent to the river.

Action: Preserve oaks on private lands by acquiring land through purchase or conservation easements from landowners, or provide incentives for landowners to preserve oak woodlands. Such action will be undertaken only with the cooperation and participation of landowners.

Habitat Resource Element: ***Perennial grassland.***

Implementation Objective: Increase the area of perennial grassland.

Target: Restore 500 acres of perennial grasslands along the Sacramento River in conjunction with restoration of riparian and valley oak habitats.

Rationale: *500 acres represents a reasonable start toward restoration of perennial grasslands along the Sacramento River.*

Applicable Ecological Subunits: *All subunits.*

Action: Protect existing grasslands and where feasible restore perennial grasslands on public lands adjacent to the river.

Action: Protect existing grasslands and restore where feasible perennial grasslands on private lands by acquiring land through purchase or conservation easements, or by providing incentives to landowners.

Habitat Resource Element: ***Agricultural wetland habitat.***

Implementation Objective: Co-manage agricultural wetlands to provide high wildlife values for associated species and maintain or increase the economic viability of agricultural lands.

Target: Improve management on 10,000 acres of rice fields along the river to increase the wildlife forage and resting area habitat values for wintering and migrating waterfowl and shorebirds, and other wildlife.

Rationale: *10,000 acres represents a reasonable amount of the approximately one-half million acres of rice fields along the Sacramento River to improve forage and resting habitat. This target is conservative because the technical feasibility, indirect effects (potential reduction of rice yield or cost of production), and cost effectiveness of such*

activities are uncertain. There is also a lack of agency and stakeholder consensus on this issue.

Applicable Ecological Subunits: *From Red Bluff downstream to Sacramento.*

Action: Provide incentives to landowners to manage rice fields to improve habitat values for wintering and migrating waterfowl and shorebirds. The extent of such actions will depend on technical feasibility and willingness of landowners to participate in such action.

Target: Flood 500 acres of pasture along the river during the winter and spring to provide high quality foraging habitat for wintering and migrating waterfowl and shorebirds, and other wildlife.

Rationale: *500 acres represents a reasonable short-term target from which logistics, cost, technical feasibility, and overall cost effectiveness of such a program can be determined..*

Applicable Ecological Subunits: *All subunits.*

Action: Provide incentives to landowners to flood pasture in winter and spring to improve habitat values for wintering and migrating waterfowl and shorebirds.

Target: Create 50 ponds each with a minimum size of 0.5 acre in farmed areas adjacent to the river that lack suitable waterfowl nesting or brooding habitat to increase resident dabbling duck production.

Rationale: *50 ponds represents a reasonable amount of ponds to be constructed along the Sacramento River to determine the effectiveness of ponds for improving nesting and brooding habitat for dabbling ducks associated with the river.*

Applicable Ecological Subunits: *All subunits.*

Action: Provide incentives to landowners to create permanent or semi-permanent ponds on lands along the river.

Habitat Resource Element: ***Agricultural upland habitat.***

Implementation Objective: Co-manage agricultural uplands to provide high wildlife values for associated species and maintain or increase the economic viability of agricultural lands.

Target: Increase the acreage farmed for wheat and other crop types that provide suitable nesting habitat for waterfowl and other ground nesting species by 5% in farmlands along the river.

Rationale: A 5% increase in acreage represents a reasonable increase in grain production for waterfowl along the Sacramento River. The target is conservative in that there is no consensus among agencies and stakeholders.

Applicable Ecological Subunits: *All subunits.*

Action: Provide incentives to landowners to increase acreage of grains on lands adjacent to the river.

Target: Convert 5% of agricultural lands along the river that are farmed from crop types of relatively low forage value for wintering waterfowl, wintering sandhill cranes, and other wildlife to production of crop types that provide greater forage value.

Rationale: 5% of the acreage producing poor forage value is a reasonable amount along the Sacramento River to improve forage habitat. The target is conservative in that there is no consensus among agencies and stakeholders.

Applicable Ecological Subunits: *All subunits.*

Action: Provide incentives to landowners to convert crop type from poor forage value to types of higher forage value for waterfowl and wildlife.

Target: Defer fall tillage on 10 % of cornfields along the river to increase the available forage for wintering waterfowl, wintering sandhill cranes, and associated wildlife.

Rationale: Deferring tillage on 10 % of cornfields along the river would measurably improve forage for waterfowl and wildlife along the river. This target is conservative because there is also a lack of agency and stakeholder consensus on this issue.

Applicable Ecological Subunits: *All subunits.*

Action: Provide incentives to landowners to defer tillage of corn fields on lands along the river.