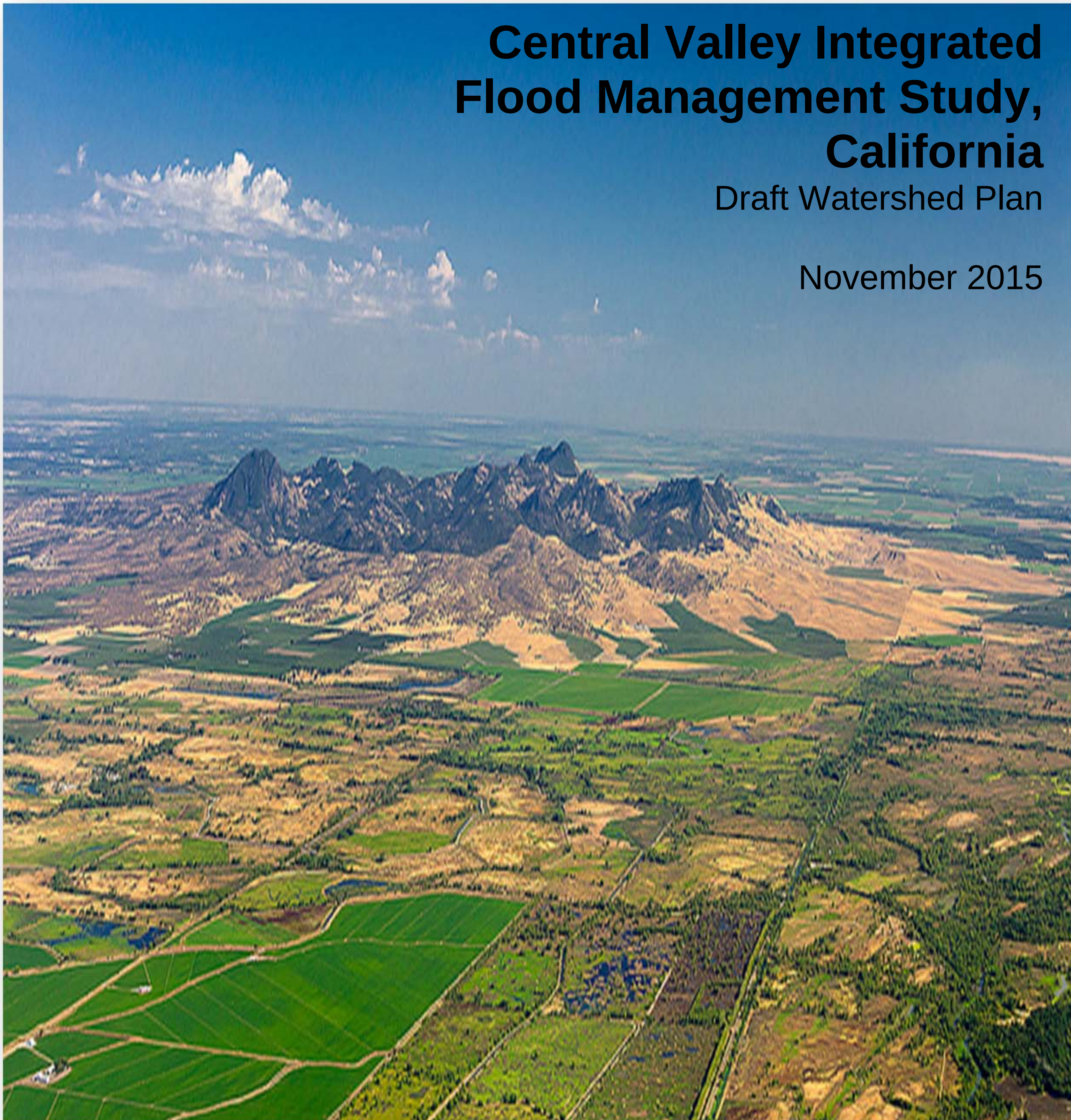
Central Valley Integrated Flood Management Study, California

Draft Watershed Plan

November 2015



US Army Corps of Engineers ®
Sacramento District

November 2015

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Acronyms

APE	area of potential effect (cultural resources)
ARCR	American River Common Features Project
BLM	Bureau of Land Management
CalEMA	California Emergency Management Agency
CALFED	A former multi-agency organization developed to coordinate activities in the Delta; replaced by the Delta Stewardship Council in 2009
CAP	U.S. Army Corps of Engineers Continuing Authorities Program
CCMP	(San Francisco Bay) Comprehensive Conservation and Management Plan
CDFW	California Department of Fish and Wildlife
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
Comp Study	Sacramento and San Joaquin River Basins Comprehensive Study
CS	Conservation Strategy
CSU Chico	California State University, Chico
CSU Sacramento	California State University, Sacramento
CVFED	Central Valley Floodplain Evaluation and Delineation Program
CVFPP	Central Valley Flood Protection Plan
CVFPB	Central Valley Flood Protection Board
CVHS	Central Valley Hydrology Study
CVIFMS	Central Valley Integrated Flood Management Watershed Study

CVP	Central Valley Project
The Delta	Sacramento-San Joaquin Delta
DPS	distinct population segment
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
E. coli	*Escherichia coli*
EAD	Expected Annual Damages
EPA	Environmental Protection Agency
ESU	evolutionarily significant unit
ER	Ecosystem Restoration
F-BO	Forecast-Based Operations
FCA	Flood Control Act
FCO	Forecast Coordinated Operations
FEMA	Federal Emergency Management Agency
FRM	Flood Risk Management
HCP	Habitat Conservation Plan
IIS	Inter-agency and International Support
in	inches
IWD	instream woody debris
LCAB	Lake County Air Basin
LDP	locally developed plan
MAF	million acre-feet
M&I	municipal and industrial
MCAB	Mountain Counties Air Basin
Mg/L	milligrams per liter

mm	millimeter
MUSR RFMP	Mid and Upper Sacramento River Regional Flood Management Plan
NCCP	Natural Community Conservation Plan
NGO	non-governmental organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRHP	National Register of Historic Places
NWS	National Weather Service
O&M	operations & maintenance
ppt	parts per thousand
Refuge	Sacramento River National Wildlife Refuge Complex
RFMP	Regional Flood Management Plan
RM	river mile
ROD	record of decision
Sac Bank	Sacramento River Bank Protection Project, Phase II, Post-Authorization Change
Sac BWFS	Sacramento Basin-wide Feasibility Study
SPFC	State Plan of Flood Control
SPK	Sacramento District, U.S. Army Corps of Engineers
SR	State Route
SRBPP	Sacramento River Bank Protection Project
SRCAF	Sacramento River Conservation Area Forum
SRFCP	Sacramento River Flood Control Project
SRS	system reoperation study
State	State of California

SVAB	Sacramento Valley Air Basin
SWP	State Water Project
TAF	thousand acre-feet
TCP	traditional cultural properties
TDS	total dissolved solids
TMDL	total maximum daily load
UC Davis	University of California, Davis
USACE	U.S. Army Corps of Engineers
USBR	United States Bureau of Reclamation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VELB	valley elderberry longhorn beetle
WRDA	Water Resources Development Act
WS	water supply

Executive Summary

PURPOSE OF THIS WATERSHED PLAN

The Federal and State governments share a vision for an integrated flood management system in the Central Valley to provide for safe, healthy and thriving communities while protecting and restoring the environment. The problem is so overwhelming that achievement of this shared vision can only be through pursuit of mutual priorities. The State's flood risk management priorities of public safety, environmental stewardship and economic stability align with the Federal administration's priorities of protecting the American people, restoring and protecting the environment and improving the nation's economy.

The Central Valley Integrated Flood Management Watershed Plan (Watershed Plan) is the companion document to the State of California's Central Valley Flood Protection Plan (CVFPP) and Draft Conservation Strategy, as well as to the State's Integrated Regional Water Management Plans. This Watershed Plan lays the foundation for future partnership between the State of California Department of Water Resources (DWR), the Central Valley Flood Protection Board (CVFPB), the State's regional water management/planning groups, local entities and other federal agencies on water resources studies that include flood risk management, ecosystem restoration and water supply in the Sacramento River Watershed.

SUMMARY OF WATERSHED ASSESSMENT

There are significant water resources challenges that need to be met over the near and midterm in the Sacramento River Watershed. The Sacramento River Flood Control Project, which was originally authorized by Congress in 1917, is now being asked to meet the multi-purpose needs and values of today's modern society, including an increased demand for flood risk management benefits to large and small communities as well as agricultural areas, an increased demand on water supply, a changing climate and an increased societal value on protecting and restoring the ecosystem. As such, it is necessary to reinvestigate the existing system to optimize its operation and functionality where possible, and to remove, repair, replace, rehabilitate or upgrade the facilities to reduce the risks and provide benefits to society, as needed. It is also necessary to revision the system to account for the demand and need for integrated water resources management to provide benefits to flood risk management, ecosystem restoration and water supply.

Recent flood risk management studies and projects in the watershed have dealt with localized, critical flood risk issues in areas such as the lower American River and Marysville as interim responses to various existing authorities, but the residual flood risks remaining in the watershed are still potentially catastrophic. At the same time, there are needs to improve habitat quality, quantity, connectivity and complexity for nationally significant habitats and species and to meet current and future demand for water supply. With California currently entering its fifth year of a severe drought, water supply for municipal, industrial, agricultural and ecosystem uses is an important issue. Many of the remaining opportunities are system benefits that can be accumulated over a wide area by addressing needs with multiple features located across broad areas within the watershed.

This watershed plan investigates the flood risk management, ecosystem restoration and water supply problems and opportunities in the Sacramento River Watershed.

The problems that have been identified by this watershed assessment process are:

- A high risk of flooding threatens public safety, as well as property and critical infrastructure throughout the study area,
- The consequences of flooding in the study area would be catastrophic,
- Systemwide residual flood risks will remain after implementation of current projects in high risk areas,
- The abundance, distribution and diversity of native species have been severely reduced by the degradation and loss of channel, riparian and floodplain habitats, including the loss of natural hydrologic and geomorphic processes,
- Access to salmonid habitats has been greatly reduced along the Sacramento River and its tributaries,
- Surface and groundwater supplies in many areas are exceeded by demands, resulting in a growing number of conflicts among users and uses, and
- Potential adverse effects of climate change on ecosystems, flooding and water supply in the watershed could cause further ecosystem degradation, increase flood risk and reduce water supply reliability and availability.

The planning objectives identified for this watershed plan include:

- Reduce risks to life safety in the Sacramento River Basin with a focus on improved flood risk system flexibility under a variety of climate change and land use development patterns,
- Reduce both societal consequences and economic damages associated with flood risk in the study area, with an emphasis on improving system resiliency and increasing the long term integrity of the flood system,
- In conjunction with flood risk management, increase geographic area, improve quality and functionality, augment connectivity and expand the diversity of significant native aquatic and related habitats in the Sacramento River ecosystem,

- In conjunction with flood risk management, improve the natural dynamic hydrologic and geomorphic processes in the Sacramento River and its tributaries,
- Expand fish access to spawning and rearing habitats in the Sacramento River watershed,
- Increase the reliability and availability of water supply, and
- Increase the adaptability and resiliency of the water supply, flood risk management, and ecological systems of the Sacramento River watershed in relation to climate change.

Conceptual alternatives to meet the purpose and need of the project were developed by dividing the watershed into 50 opportunity areas that are consistent with the State's planning areas; 49 of these areas are within the Sacramento River Valley, while the 50th area encompasses the remaining outer watershed area (Figure ES-1). Within each opportunity area, a comprehensive set of potential measures was identified to address the planning objectives established by previous studies and expert knowledge. The measures within each opportunity area were qualitatively evaluated for effectiveness in meeting the objectives, with consideration given to the magnitude of their costs. Measures with the lowest effectiveness relative to costs were screened from futher consideration. All retained measures were included in the final array of conceptual alternatives based upon the project purposes each measure would support. These remaining measures were assembled into seven conceptual alternatives as follows:

(0) No Action Alternative

(1) Non- Structural Flood Risk Management Alternative

(2) Ecosystem Restoration (ER) Alternative

(3) Structural Flood Risk Management (FRM)

(4) Combined ER and FRM Alternative

(4a) CVFPP and the Draft Conservation Strategy FRM and Water Supply (WS) Alternative

(5) Combined FRM, ER and WS Alternative

Based on a qualitative assessment of the relative benefits and costs of these alternatives, it was determined that there is a potential for Federal interest in future projects within any of these conceptual alternatives. In other words, they warrant future study.

RECOMMENDATIONS

EARLY OFF-SHOOT STUDY

The watershed analysis completed for this plan influenced the recently started Sacramento River General Reevaluation study. Based on recommendations from the watershed assessment, the Sacramento River General Reevaluation will re-vision the flood control system within the Lower Sacramento River and Sacramento-San Joaquin Delta-North area for improved flood risk management and ecosystem restoration.

POTENTIAL SPIN-OFF AND OFF-SHOOT STUDIES

Near-term recommended spin-off studies (under the same authority as this plan) and off-shoot studies (under other authorities) include:

- Climate Change Assessment under USACE Floodplain Management Services – The U.S. Army Corps of Engineers (USACE) should partner with the State of California (State), the Institute for Water Resources, other Water Districts in the region, and climate change experts to develop a standard approach for assessing the impact of inland climate change on decision criteria in future studies and projects in this region. The approach is likely to follow the cost-effective, interagency "bottom-up" stepwise process being piloted internationally and by other federal agencies.
- San Joaquin River Watershed Study (CVIFMS Part II) under General Investigations – The Sacramento River Watershed is only half of the Central Valley; the other half is the San Joaquin River Watershed. The two watersheds meet in the Sacramento-San Joaquin Delta. Originally, both of these watersheds were included in this study, but during a re-scoping of this effort, the San Joaquin River Watershed was recommended to be assessed in a separate Phase II. To come up with a comprehensive plan for water resources management in the Central Valley, it is necessary to complete a watershed assessment for the San Joaquin River Watershed to complement this plan, the Central Valley Flood Protection Plan (CVFPP) and the Draft Conservation Strategy.
- Central Valley Reoperation Study under General or Special Investigations – The reservoirs in the Sacramento and San Joaquin Watersheds work as and are operated as a collective system. A reoperation study would investigate what more could be done with the existing water infrastructure. The current focus of the State's Systemwide Reoperation Program is the Central Valley, as this region has the highest integration of water supply and flood management facilities. Additionally, the greatest potential for ecosystem restoration through infrastructure reoperation is found in the Central Valley because the existing infrastructure has had a profound effect on aquatic ecosystems. As a first step, it is important to determine what FRM, WS and ER benefits can be provided by the *existing* flood system before recommending construction of new features. This reoperation study would be a comprehensive investigation of existing reservoirs within both the Sacramento and San Joaquin River Basins (USACE, State, and U.S. Bureau of Reclamation [USBR]) to optimize operations for FRM, ER and

WS across the system of reservoirs, incorporating weather forecasts and climate change analysis. This is a logical and necessary next step to DWR's Phase I and II reoperation studies (http://www.water.ca.gov/system_reop/). System reoperation has the potential to produce benefits with little to no construction costs.

- Middle and Upper Sacramento River Basin Study under General Investigations – Multi-purpose ER, FRM and WS conservation study to restore impaired aquatic ecosystems, reduce flood risk to residential and commercial structures and to improve availability and reliability of water supply for ecosystem function, groundwater recharge and municipal and industrial uses. The study will consider sites located within the middle and upper Sacramento River Watershed for ER, FRM and WS. The Middle and Upper Sacramento River Basin Comprehensive Study would be a continuation of the Sacramento and San Joaquin River Basins, California Comprehensive Study (Comp Study). The study would complement the Middle and Upper Sacramento Regional Plan and provide an opportunity for partnernership between the State and regional agencies. The study area would include the Sacramento and Feather Rivers and their tributaries (The Lower Sacramento River-Delta North area is not included in this recommendation as it is being investigated under separate authorities in the Delta Islands and Levees Study and the recently initiated Sacramento River General Reevaluation Study).

Mid- to long-term spin-off and off-shoot studies include:

- Non-Structural Floodplain Management Services Studies – If near term efforts do not include non-structural floodplain management, local sponsors can approach the USACE for studies under the Floodplain Management Services authority. These studies can provide floodplain mapping, floodplain management plans, emergency plans and flood recovery plans. These non-structural actions could provide significant benefits to the affected areas for low costs and effort. Studies such as this may be critical for small communities, agricultural areas and tribal communities within the watershed where structural flood risk management projects may not be justified.
- Upper American River and Tributaries under General Investigations – Multi-purpose FRM, WS and ER study (USACE, DWR, USBR) to reduce flood risk to residential and commercial structures and to improve availability and reliability of water supply for ecosystem function, groundwater recharge and municipal and industrial uses. The study will consider sites along the American River and its tributaries (above Folsom Dam and Reservoir).
- Single-Purpose Ecosystem Restoration Projects under Continuing Authorities Program or General Investigations or Tribal Partnership Program – To restore ecosystems in more localized areas, including on tribal lands, smaller-scale projects could be pursued in areas such as Clear Lake/Upper Cache Creek, Elder Creek and Deer Creek, among others. These could complement restoration efforts addressed in the larger, near-term projects.

OTHER POTENTIAL PARTNERSHIPS

Aside from partnering with local sponsors on civil works feasibility studies, the USACE can also provide inter-agency support to sister federal agencies, like the USBR and Department of the Interior, as needed and requested, to assist with water resource projects for which the USACE has an expertise, but is not the appropriate lead agency. These support projects would be coordinated through the USACE Inter-agency and International Support (IIS) program.

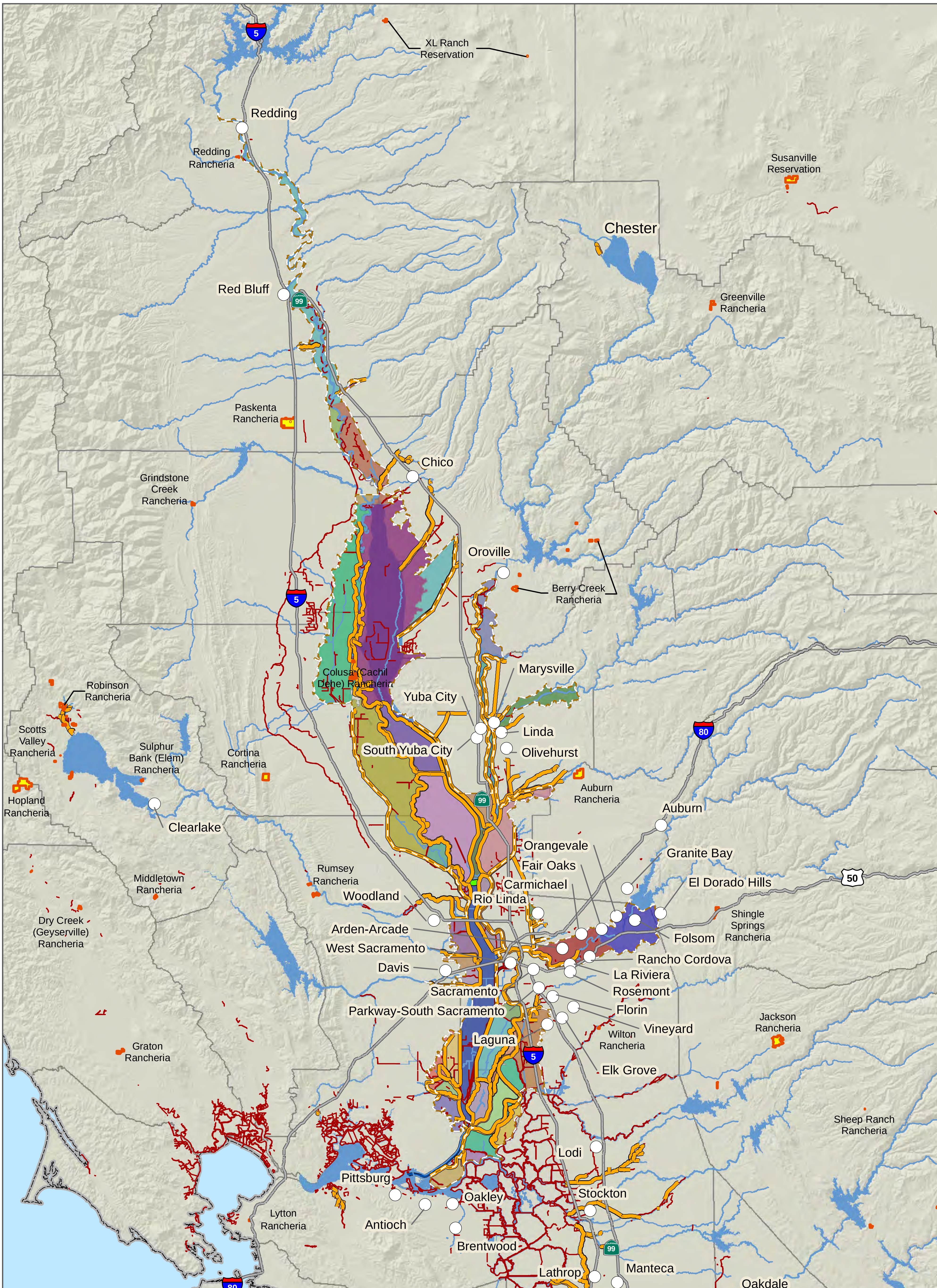
Under the Planning Assistance to States Authority provided by Section 22 of the Water Resources Development Act of 1974 (WRDA; PL 93-251), as amended, the USACE can provide states, local governments, other non-Federal entities and eligible tribes assistance in the preparation of comprehensive plans for the development, utilization and conservation of water and related land resources. Studies could include: water supply/demand, water conservation, water quality, ecosystem restoration and dam safety/failure.

The State's CVFPP, Draft Conservation Strategy, Regional Flood Management Plans and Integrated Regional Water Management Plans include many potential actions and projects that are outside of the USACE's primary missions, that may not have sufficient justification from a Federal perspective, or that do not meet other policies for USACE funding. DWR will continue to pursue such actions and projects using State funding and in conjunction with other Federal, State and local agencies, as appropriate.

OTHER PROJECTS AND CONSIDERATIONS

The Regional Plans developed as a component of the overall planning effort for the State's CVFPP contain a number of potential actions and projects that are outside the USACE's primary mission areas. However, there are some potential projects that could take advantage of the USACE Continuing Authorities Program (CAP) for study and implementation.

The USBR has a number of studies ongoing as part of their Biological Opinion on the Central Valley Project (CVP). The USACE has successfully partnered with USBR as part of one effortr – the Joint Federal Project at Folsom Dam. If additional alterations to the CVP are warranted outside the requirements of the Biological Opinion, there is some potential for the USACE to partner with the USBR in further actions within the system.



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CVIFMS Project Opportunity Areas

CVIFMS Opportunity Areas
Tribal Lands
Cities/Locations with more than 10,000 Residents
Federal Levees
Non Federal Levees
Weirs
SAC River System

Figure ES-1

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

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1.0 Study Information

The Central Valley Integrated Flood Management Watershed Study (CVIFMS or watershed study) is a companion document to California's Central Valley Flood Protection Plan (CVFPP) and Draft Conservation Strategy. The CVIFMS assesses the problems, needs, opportunities and potential solutions to flood risk management, ecosystem restoration and water supply in the watershed through analysis of existing information. This study has been developed in collaboration with the project sponsors, with consideration given to input received from key stakeholders and the public. This report presents the findings and recommendations for future efforts, including potential future projects and studies in which the U.S. Army Corps of Engineers (USACE) could partner with the State of California (State), sister Federal agencies and other non-Federal entities.

As part of the scoping phase of the study, it was determined by the USACE and the State to reduce the scope to the Sacramento River Basin with a subsequent watershed study to evaluate the San Joaquin River Basin. This watershed study evaluates only the Sacramento River Basin, with an emphasis on the existing flood protection system.

The watershed study is not a project implementation document. The level of detail in investigations is at a scale adequate for making watershed-level resource assessments and recommendations. If specific projects are identified for potential implementation under existing authorities of the USACE (for example, flood damage reduction or ecosystem restoration), separate interim reports will be required that will specific project features and include a detailed engineering appendix and appropriate NEPA documentation.

1.1 Study Area

The Sacramento River Basin (study area) occupies the northern portion of the Central Valley; it covers approximately 26,300 square miles above Rio Vista, is approximately 240 miles long and up to 150 miles wide (Figure 1-1) and includes the entire Sacramento River Watershed.

As a result of the re-scoping effort, the study area is now limited to the Sacramento River watershed, located in the north-central part of California. The Sacramento River is the largest river in California, with an average annual runoff of 950 billion cubic feet (ft^3). The Sacramento River Basin (referred to interchangeably as basin or watershed in this document) is located in the north central part of California (Figure 1-1). The upper Sacramento River flows are impounded by Shasta Dam (built in 1944). The basin is bounded by the Sierra Nevada on the east, the Coast Range on the west, the Cascade and Trinity Mountains on the north, and the Sacramento-San Joaquin Delta on the south. The Sacramento River drains into the largest estuary on the West Coast, the Sacramento San Joaquin Delta (the Delta).

Major tributaries to the Sacramento River include the Feather, Yuba, and American Rivers from the east; Cottonwood, Stony, Thomes, Clear, Spring, Cache, and Putah creeks from the west; and numerous other smaller creeks flowing into the Sacramento River from both the east and west. New Bullards Bar Reservoir on the Yuba River (built in 1969), Oroville Dam on the Feather River (built in 1967), and Folsom Dam on the American River (built in 1955) are in this basin.

The Sacramento Valley is the northern portion of the Central Valley of California. The Sacramento Valley has both the greatest population of the basin and also is the area of greatest water use. Major population centers include the cities of Sacramento, West Sacramento, Marysville, Yuba City, Woodland, Oroville, Chico, and Red Bluff.

The State Plan of Flood Control (SPFC) as defined in Section 8350 of the California Water Code, is the Federal-State flood protection system in the Sacramento River and San Joaquin River watersheds for which the Central Valley Flood Protection Board or California Department of Water Resources has provided assurances of cooperation to the Federal Government for operation and maintenance. The SPFC includes multiple Federal projects with separate authorizations. The SPFC protects a population of over one million people, as well as several major freeways, railroads, airports, water supply systems, utilities, and other infrastructure of statewide importance, over $70 billion in assets (includes structural and content value and estimated annual crop production values). Many of the more than 500 species of native plants and wildlife found in the Central Valley rely to some extent on habitat existing within SPFC lands. It is also important to note that portions of the State Plan of Flood Control also serve to convey water deliveries of State and Federal water supply. Those SPFC facilities that are within the Sacramento River Basin will be evaluated for potential modification, along with consideration of new facilities.

Figure 1-1 Sacramento River Basin

1.2 Study Authority

The CVIFMS is a continuation of the Sacramento and San Joaquin River Basins Comprehensive Study (commonly known and referred to herein as the Comp Study). The Comp Study is a comprehensive evaluation of the Sacramento River and San Joaquin River basins under an existing study authority: the Flood Control Act (FCA) of 1962 (Pub. L. 87-874, § 209, 76 Stat. 1180, 1197 (1962), Section 209.

Section 209, FCA 1962 states

> *"The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: . . . Sacramento River Basin and streams in northern California draining into the Pacific Ocean for the purposes of developing, where feasible, multiple-purpose water resource projects . . . "*

In addition, the Water Resources Development Act (WRDA) 2000 directed the Secretary of the Army to

> *" . . . integrate, to the maximum extent practicable, and in accordance with applicable laws, the activities of the USACE in the San Joaquin and Sacramento River Basins with the long-term goals of the CALFED Bay-Delta Program."*

CALFED was a multi-agency organization developed to coordinate activities in the Delta that was replaced by the Delta Stewardship Council in 2009. The mission of the Delta Stewardship Council is to achieve the coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem.

1.3 Local Sponsor Support

The SPFC facilities (Figure 1-2 below) were formally accepted by CVFPB and they have signed assurances of cooperation for the Operation and Maintenance of the system. For many of the annual tasks, they have additional assurance agreements with DWR as well as local sponsors. All oversight and management of encroachments on the system are performed by the CVFPB in cooperation with the USACE.

The local sponsors are the CVFPB and the DWR. Both local sponsors are supportive of the recommendations found in this report, as documented in Attachment F *Letters of Support*.

1.4 Watershed Problems, Planning Goals, Objectives and Constraints

1.4.1 Population and Land Use Changes

Development of land, no matter the purpose, has the effect of changing how water interacts with the land. Changes in amount and type of vegetative cover can impact the amount of water that infiltrates through the ground and the amount of water lost through evapotranspiration. Increases in impervious cover (e.g., pavement) can reduce the amount of water that infiltrates through the ground and increase water runoff to nearby streams. Flooding, erosion, and sedimentation are all processes that occur in nature with or without human influence. However, when the population of an area begins to grow and humans begin to change the land such that the impervious cover increases these natural processes of flooding, erosion, and sedimentation increase as well.

In many areas, development has outpaced the ability of flood managers to implement structural and nonstructural solutions needed to control flood damages. Among floodplain residents, flood risk is often poorly understood. Flood risk management tools such as flood insurance and disaster preparedness are often underused.

In the Watershed, the primary land use is rural, with the majority of the population in the in urban areas, particularly the Sacramento metropolitan area, which has about 40 percent of the watershed's population. By 2030, with increase in urbanization, the population of the watershed is expected to increase by about 2 percent.

1.4.2 Watershed Problems

This watershed study includes an examination of watershed-wide problems, primarily flooding, erosion, water quality, water supply and ecosystem degradation. Although some problems do not fall within the current mission areas of the CVIFMS and the broader Comp Study, the study includes discussion of these areas and makes recommendations for other appropriate agencies to address them.

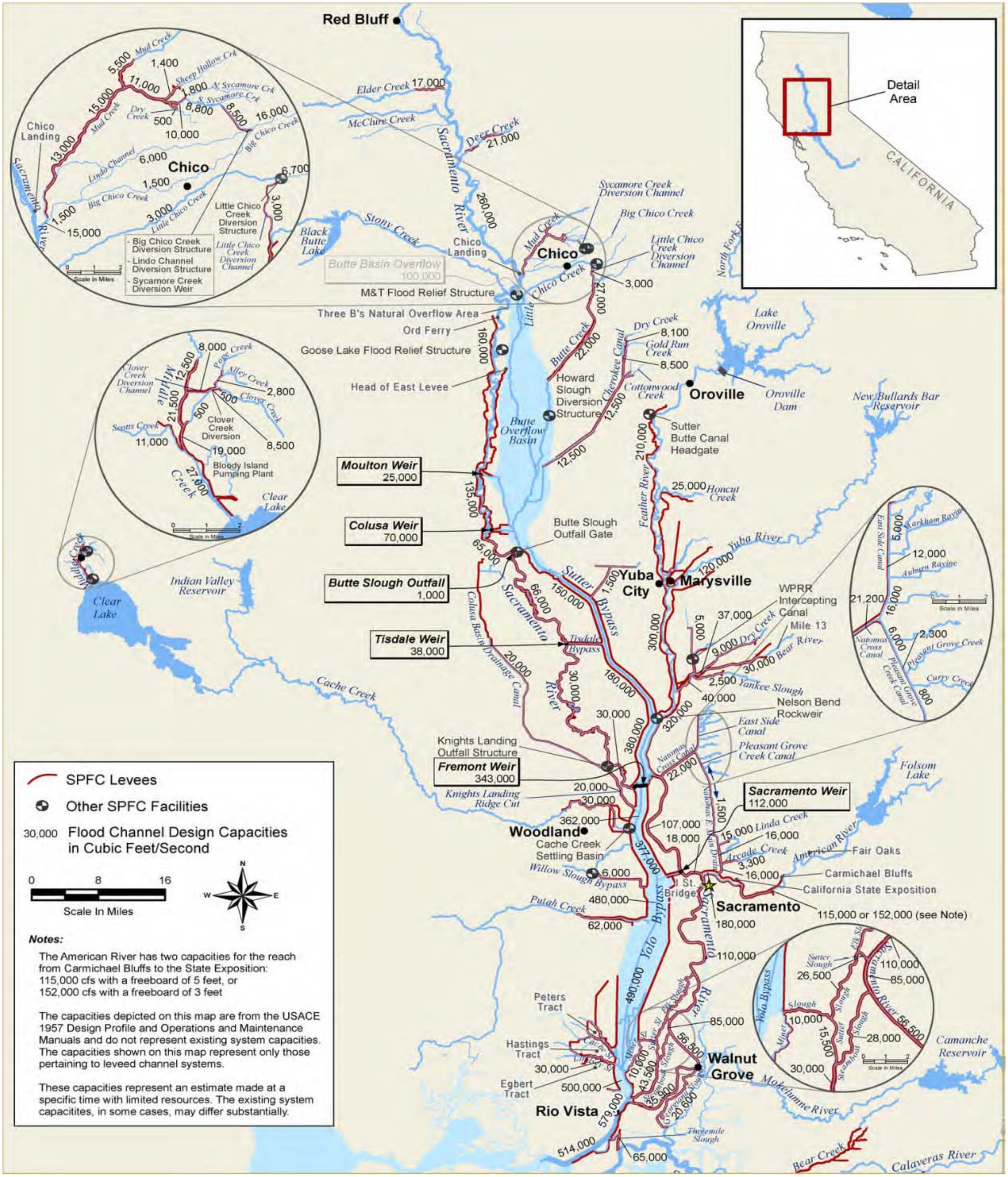

Figure 1-2 State Plan of Flood Control, Sacramento River Basin.

The USACE planning process follows the six-step process defined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implemention Studies*, also known as the Principles and Guidelines (P&G), issued by the Water Resources Council on March 10, 1983 (P&G, ER 1105-2-100). The planning process is a structured approach to problem solving which provides a rational framework for sound decision-making. The six-step process is used for all planning studies conducted by USACE. The first step in the process is the identification of problems and opportunities.

In a watershed study, identified problems focus on past extreme events, local needs, legislation that bears on local resources, local government interests, and the affected public. It is therefore critical that the study effort identifies problems and opportunities that reflect the priorities and preferences of the Federal government, the non-Federal sponsors, and other groups participating in the study process. Work products associated with the CVFPP and other State water resource programs have provided the basis for identifying problems and opportunities that can be addressed through water and related land resource management. The following seven key problems were identified during the first three phases of the watershed planning process by the study team and concerned stakeholders.

PROBLEM 1: A high risk of flooding threatens public safety, as well as property and critical infrastructure throughout the study area

Flooding in the Sacramento River Basin has historically caused substantial damage to structures, critical infrastructure and public facilities. Since the completion of the Sacramento River Flood Control Project (SRFCP) in the 1940's, nineteen significant flood events have occurred. These floods damaged millions of dollars of property and crop land. Nearly 50 people died as a result of flooding. In addition to the damage to private property, critical infrastructure such as interstate highways, railroads, state highways, and the flood management system itself were damaged. Public facilities including hospitals, nursing homes, fire stations and police stations suffered damage as well. Below is a brief history of the major historic flood events in the watershed.

History of Flooding

Following are text summaries of the major flooding events in the Sacramento Valley since 1950; Table 1-1 gives a broader view of historic flooding events that impacted the Sacramento Valley watershed beginning in the early 1800's. All estimates of monetary damages remain in flood year dollars (i.e., estimates made in same or following year as that flood event), and have not been inflated to 2015 values.

November-December 1950. A Yuba River levee breach produced flooding on 43,000 acres of suburban and developed lands south of Marysville, damaging homes in Olivehurst and closing U.S. Highway 99 East (within California, became California State Route [SR] 99 beginning in 1964). The American River flooded farms east of Sacramento, closed the Western Pacific Railroad, and joined the Sacramento River in flooding Del Paso Heights.

December 1955. This flood was characterized by extremely high flows, including record flows at some locations. Most damage was along unregulated streams, which then included the Feather River. A levee failed on the west side of the Feather River, inundating Yuba City and vicinity causing major damage. Portions of other towns and agricultural lands were also flooded; thirty-eight people died; total damages were estimated by the USACE at $63 million. Delta levees were breached and flooded Dead Horse Island, McCormack-Williamson Tract, New Hope Tract, Empire Tract, Quimby Island and an area east of McCormack-Williamson Tract and west of Galt—a total of about 7,700 acres. Figure 1-3 provides a view during the flooding event looking up a main section of downtown Yuba City.

Figure 1-3 Downtown Yuba City 1955

January-February 1958. The Sacramento River flooded surrounding areas causing bank erosion from Keswick to Butte City. Clear Lake rose, and its tributaries flooded, causing more than $1 million damage. Cache Creek overflowed and damaged property in locations from Rumsey to Yolo. In the Delta, levees protecting Prospect Island and Liberty Island overtopped and flooded. In February, the levee at Little Holland Tract overtopped, breached, and the area flooded. Total Delta flooding was about 7,300 acres.

January-February 1963. Flooding of Thomes, Mill, Cottonwood and Deer Creeks damaged levees and left debris deposits. Middle Creek and Clover Creek flooding damaged levees in Lake County. Extensive flood damage to public works occurred in Plumas County. Numerous communities were also flooded and damaged in the American and Yuba River Basins. Cold Stream overflowed, damaging Sierraville, SR 89, and property in the area. In the Delta, Prospect Island, Liberty Island, and Little Holland Tract were flooded—a total of about 7,300 acres.

December 1964-January 1965. Severe flooding occurred in the mountain communities of Chester, Downieville, and Coloma. Mountain highways, roads, bridges, public recreation areas, and cabins were extensively damaged. USACE estimated 383,500 acres in the region were flooded by stream overflows. The Southern Pacific Railroad suspended service over the Sierra Nevada due to flood damage to the tracks. Highway damage closed Interstate 5 (I-5) at the Oregon border and north of Redding. Daguerre Point Dam, a debris dam on the Yuba River, underwent a partial failure. Hell Hole Dam, under construction on the American River, collapsed. In the Delta, Prospect Island, Liberty Island, Little Holland Tract, Egbert Tract, and McCormack-Williamson Tract flooded—a total of about 14,100 acres. USACE estimated $39 million in flood damages in the Sacramento River Basin.

December 1969-January 1970. About 550,000 acres were flooded in the region, 82 percent was within the valley floor area and 50 percent was in dedicated floodways and natural overflow basins. The Pit River washed out bridges, flooded roads, and isolated Big Bend. The Sacramento River flooded parts of Anderson, Redding, Red Bluff, Hamilton City, and Tehama. Burney Creek overflowed and inundated Burney. Clear Lake rose and inundated shoreline property, particularly in Lakeport. High flows on Putah Creek above Lake Berryessa flooded resort areas and local roads in the region. USACE estimated more than $28 million in flood damage.

January 1974. From Mount Shasta City to Lakehead, the Sacramento River and tributaries caused extensive damage to infrastructure, homes, and a railroad. In Dunsmuir, homes, other structures, and infrastructure were destroyed or damaged. In Castella, flows from Castle and Little Castle Creeks damaged homes, a bridge, and a water service company. The Sacramento River overflow damaged the Southern Pacific Railroad for 30 miles from Shasta Lake to Dunsmuir. The Sacramento River overflowed, damaging properties from the Deschutes Bridge to Balls Ferry and north of Hamilton City, where a levee also breached and flooded homes. In the Delta, about 6,100 acres on Liberty Island and Little Holland Tract flooded when the levees overtopped and breached.

March-April 1974. Slides and washouts damaged the Southern Pacific Railroad and caused closures. There was extensive agricultural damage, including erosion, deposition, and breached local levees. Flooded farmlands amounted to 44,000 acres from Red Bluff to Colusa. In the Delta, Liberty Island and Little Holland Tract had been repaired following the January flooding, but the levees washed out again, reflooding about 6,100 acres.

January-March 1983. Stream overflows caused major flooding and road closures throughout Glenn County, damaged stores and homes in Oroville, and flooded homes and businesses along SR 20 at Colusa. A mudslide killed an equipment operator and crushed a bus in Shasta County. Prospect Island levees failed in the Delta, flooding 1,228 acres. During February, high outflow of Lake Berryessa damaged roads and parks. Stormwater inundated 80,000 acres of farmland in Butte County and commercial property in the north part of Sacramento, and overflowed drains in Rocklin and Loomis, flooding streets and closing four major roads. Figure 1-4 shows the levee breach that occurred at Cache Creek during flooding.

Figure 1-4 Levee Breach at Cache Creek, January 1983

February 1986: Known as the St. Valentine’s Day Storm, flooding from this storm caused extensive damage to the flood management system of the Sacramento Valley and led to a substantial reassessment of and repairs to flood management infrastructure. Record high tides and record Sacramento River inflow both occurred. The Yuba River levee at Linda failed (Figure 1-5), spreading floodwaters over 30 square miles, inundating Linda and Olivehurst, and causing an estimated $50 million in damage. Local stormwater flooding was widespread north and east of Sacramento because of high flows in American River tributaries. Stormwater flooded streets in Dixon, Vacaville, and Rio Vista. Levees protecting Tyler and Dead Horse Islands and the McCormack-Williamson Tract failed, inundating 11,802 acres in the Delta.

Figure 1-5 Levee Breach at Linda on Yuba River 1986

December 1996-January 1997. Extensive flooding and flood damage in the region (Figures 1-6 and 1-7) resulted from inundation at major rivers and creeks in the Sierra Nevada. The Sacramento River exceeded flood stage at Tehama Bridge, flooding Tehama, local roads, three mobile home parks, and orchards and fields in the area, leaving deep deposits of debris. In the Delta, McCormack-Williamson Tract and Dead Horse Island levees failed again, flooding 1,865 acres. The flooding caused five deaths in the region and damaged more than 587 homes. Widespread levee failures and damages that exceeded $301 million from this event highlighted the need for a concentrated effort to rehabilitate the flood management system.

Figure 1-6 Levee Breach on Cosumnes River near Wilton 1997

Figure 1-7 1997 Flooding at Sutter Buttes

A more detailed summary of events since early in the 19th century, including flood type (general reason flooding started), a brief description of the event, and counties impacted by resulting flooding are included in Attachment E.

Existing Facilities

The existing levee system was designed and built at the turn of the last century before modern construction methods were employed. These levees were constructed close to the river, using naturally occurring riverside deposits as their foundation, to increase flow velocities which would flush out hydraulic mining debris; at the time, mining debris deposition that causing widespread deposition was occurring across the valley floor and, causing disruption of economic uses of the river. This debris is essentially gone now but the high velocities associated with flood flows are have been eroding the levees since construction, compromising the existing flood risk management system.

Levee failures within the existing system can be caused by a variety of mechanisms, including:

- Seepage of floodwater through (through-seepage) and under (under-seepage) the levee,
- Continuing erosion of the levees and river banks,
- Lack of stability of the levees, and
- Overtopping of levees during events that exceed the facilities design, much of which was completed in the mid-1900s.

Evaluations conducted by the State and documented in the CVFPP and the Flood Control System Status Report (December 2011) indicate that approximately half of 300 miles of urban levees do not meet current design criteria for freeboard (height above the recorded high-water mark of a structure), stability or seepage. Approximately 60 percent of about 1,230 miles of nonurban levees have high potential of failure from under-seepage, through-seepage, structural instability or erosion (Figure 1-1). It is important to note that in non-USACE documents, level of protection (LOP) is often used to describe a level of performance but due to USACE regulations, is not used in USACE documents.

In addition to structural concerns, the early estimate is that approximately 500 miles of channels on SPFC lands have potentially inadequate capacities to convey the design flows. There is currently on-going work at DWR with additional modeling to determine the true amount.

The SPFC was designed to pass the known flood of record, which at the time of Congressional authorization was the 1909 flood. During construction of the system, a new flood of record occurred in 1927, which was incorporated into the overall system design. After completion of the Federal system in the 1950s, a new flood of record occurred in 1986, followed by the slightly smaller flood of January 1997. The floods of 1986 and 1997 delivered much more water to the leveed reaches than they were designed to carry, resulting in levee failures (see *History of Flooding* section). On the American River, the four biggest floods occurred after completion of Folsom Dam and the SRFCP. In general, throughout the Sacramento Valley, climatology following the completion of the Federal system has been much wetter with more precipitation than the period that the original design of the system was based upon, and more flow is being delivered to the levee system than it was intended to carry. This has resulted in large levee failures, resulting in significant loss of property and some loss of life. Table 1-1 shows the design capacities for various locations in the river system and computed flows for a 1 percent and a 0.5 percent Annual Chance of Exceedance (ACE) event for these same locations.

Table 1-1 Design Flows and Flood Flows at Select Locations in the Study Area

Location	SRFCP Design Capacity(ft^3/sec)	1 percent ACE (ft^3/sec)	0.5 percent ACE (ft^3/sec)
Sacramento River (upstream of Sacramento Bypass)	107,000	120,000	130,000
Sacramento River (downstream of American River Confluence)	110,000	122,000	134,000
Sacramento Bypass	112,000	115,000	149,000
American River (Folsom Dam release)	115,000	115,000	160,000

Notes:
ACE = Annual Chance of Exceedance
1 Assumes Folsom Dam improvements (JFP and dam raise) are completed and dam is operable.

Since the SRFCP was essentially completed in 1961, only localized improvements have been completed enhancing the function of the SRFCP in those locations. Most of the recent work has consisted of maintenance such as bank protection, and seepage and stability fixes to correct localized problems within specific reaches. Over this same period, many communities in the Delta have seen substantial urban development. This urbanization has dramatically increased the consequences of levee failure in these areas. Since levee improvements have not kept pace with the rate of urban development, overall flood risk has drastically increased since completion of the SRFCP system.

This report uses the term “annual chance of exceedance” (ACE) to describe the likelihood associated with individual storm and flood events. The ACE is the reciprocal in percentage terms of what is often referred to as the “return period”. The return period of an annual maximum flood event is X years if its magnitude is equaled or exceeded once, on the average, every X years. For example, a 100-year return period means that, on average, it is expected that a storm of that magnitude or greater would occur once every 100 years. The inclusion of the phrase “on average” means that it is possible to have more than one (or zero) 100-year events over any number of years—or even in the same year.

The return period descriptor has in recent years been supplanted by ACE because it is believed that describing the chance of occurrence in annual percentage terms is more precise and less prone to misinterpretation. In this report, what has previously been known as the “100 year” storm or flood event is described as having an ACE of 1 percent.

Table 1-2 provides conversions for other return periods to corresponding ACE percentages that will be used in this report; for readers familiar with ACE ratios rather than percentages, the table also provides corresponding ratios for reference.

Table 1-2 Annual Chance of Exceedance Conversion to Other Commonly Used Flood Occurrence Descriptors

ACE Percentage (%)	Return Period (in years)	ACE ratio
4	25	1/25
2	50	1/50
1	100	1/100
0.5	200	1/200
0.2	500	1/500

PROBLEM 2: The consequences of flooding in the study area would be catastrophic.

Population at Risk

If flooding should occur within the study area, the consequences would be catastrophic. Even with existing projects and ongoing studies assumed to be in place, an estimated $322 million in residual average annual damages would result from a major flood event occurring within the basin.

The Watershed is naturally prone to flooding. The flux of water associated with storm events in among the highest in the world. The construction of levees intensified flood risks in many areas, particularly due to structures' susceptibility to failure. The Watershed's largest population in the Sacramento metropolitan area is primarily centered in the downstream reaches of the Sacramento River, where a natural loss of channel capacity and inflows from major tributaries amplify flood risks. Due to the naturally extreme storm flows, deep flood depths, and fragility of the levees, most areas are subject to catastrophic flooding across a broad range of storm events. Thus, relatively minor reductions in the frequency of flooding can often lead to relatively large reductions in damages.

Health and Safety

Flooding in urban areas can cause serious health and safety problems for the affected population. In the study area, there are approximately 500,000 residents at risk. Census data (2010) indicates that another 100,000 people work in the Sacramento area but do not live there. Additionally, significant numbers of people traverse the area via I-5, I-80, SR 99 and U.S. Highway 50 (US 50) every day. Data obtained from the California Department of Transportation shows that 185,000 vehicles pass through the Sacramento area in the north-south direction in an average 24-hour period. The total number of vehicle occupants is estimated to be 270,000.

The most obvious threat to health and safety is the danger of drowning in flood waters. Swiftly flowing flood waters can easily overcome even good swimmers. If flooding occurs suddenly, people may become trapped in their homes and drown. Additionally, when people attempt to drive through flood waters, their vehicles can be swept away in as little as two feet of water.

In California's Central Valley, the risk of a large flood is seasonal. The majority of rainfall occurs in the October through March rainy season, making the area most vulnerable to winter floods. The ambient air temperature range in the rainy months is shown in Table 1-3.

Table 1-3 Average Ambient Air Temperature Range in the Rainy Season

Month	Low (°F)	High (°F)
November	42.8	63.7
December	37.7	53.9
January	38.8	53.8
February	41.9	60.5
March	44.2	64.7

Standing or working in water that is cooler than 75°F (24°C) will remove body heat more rapidly than it can be replaced, resulting in hypothermia (decreased body temperature) . Survival curves show that an adult dressed in average clothing may remain conscious for an hour in 40°F water and perhaps 2-3 hours in 50°F water. Physical activity such as swimming or other struggling in the water increases heat loss, reducing survival time to minutes. Without thermal protection, swimming is not possible and the victim, though conscious, is soon helpless. Without a life jacket, drowning is unavoidable.

Another risk during a flood is local water systems becoming contaminated, either through the loss of power to a public water supply or if private wells are flooded. Sources of contamination could include animal and human waste, dead and decaying animals, or chemicals accidentally released during flooding. Liquefied petroleum gas tanks and underground storage tanks can break away from their supports and float in flood waters, causing hazards from their released contents. Resulting water supply contamination can lead to a number of waterborne illnesses.

Buildings damaged by flooding can also become contaminated with mold and fungi if they do not dry out quickly enough. These molds and fungi can pose serious health risks. Additionally, food exposed to floodwaters or stored without refrigeration during extended losses of power during flooding could also lead to food-borne illnesses.

Wild animals and insects would likely become displaced from their natural habitats during flooding. Encounters with raccoons, opossums, and squirrels could result in bites that require medical attention or may lead to rabies. Dead animals can sometimes be found in homes after a flood, leading to odor and excessive flies and these carcasses can serve as reservoirs for disease-causing organisms. Bees, wasps, and hornets may have their nests disturbed by wind, rain, or flood waters. Under these conditions, these insects can become very aggressive. Snakes will also have their nests disturbed by flooding, and are prone to seek shelter in abandoned homes, vehicles, furniture, and equipment.

Floods can damage fire protection systems, delay response times of emergency responders, and disrupt water distribution systems. All of these factors, in turn, can lead to increased danger from fires.

Workers who respond to flooded areas are at the most risk of illness, injury, or death. These workers include utility workers, law enforcement, emergency medical personnel, firefighters, and military and government personnel. According to the Occupational Safety and Health Administration, some of the hazards associated with working in flooded or recently flooded areas include: electrical hazards, hypothermia, structural instability, exhaustion, hazards associated with heavy equipment operation, drowning, biohazards, fire, musculoskeletal hazards, burns from fires caused by energized line contact or equipment failure, carbon monoxide, falls from heights, hazardous materials, and dehydration.

After floodwaters have receded, debris cleanup would be a substantial undertaking. As an example, after the flooding in New Orleans resulting from Hurricane Katrina in 2005, debris removal included general household trash and personal belongings, construction and demolition debris, vegetative debris, household hazardous waste, white goods (household appliances), and electronic waste. Curbside debris in New Orleans was in excess of 51 million cubic yards. There were nearly 900,000 units of white goods and over 600,000 units of electronic goods. More than 350,000 cars were abandoned.

Emergency Costs
During and after a flood event, the public costs for emergency services, evacuation, securing infrastructure, and clean-up can be substantial. For example, considering the costs associated with evacuation, there are significant costs (and therefore, economic losses) related to temporary movement of a population away from a flood-impacted area. Evacuation and its associated costs can take place before, during, or after a flood event.

In order to simulate the financial impact of these emergency costs, a series of economic models were created. Thirteen distinct models were developed for thirteen individual categories of emergency costs. The basis for the data to be used in the models was gathered from experts. The thirteen categories of emergency costs are as follows:

- Evacuation
- Telecommunications
- Medical
- Wastewater utility
- Legislative
- Judicial
- Education
- Water supply utility
- Incarceration
- Debris
- Natural gas supply
- Police and fire
- Electrical utility

Critical Infrastructure
A significant amount of critical infrastructure is located within the study area. “Critical infrastructure” is a term used by governments to describe assets that are essential for the functioning of a society and its economy. Most commonly associated with this term are facilities for:

- Electricity generation, transmission and distribution
- Gas production, transport and distribution
- Oil and oil products production, transport and distribution
- Telecommunication
- Water supply and wastewater
- Agriculture, food production and distribution
- Heating
- Public health (hospitals, ambulances)
- Transportation systems (fuel supply, railway network, airports, harbors, inland shipping)

- Financial services (banking, clearing)
- Security services (police, military)

Impacts to critical infrastructure from a flood event would have significant local, regional, and statewide impacts because Sacramento is the capitol of the State of California. The capitol and many State office buildings are located in downtown Sacramento, which could be flooded by up to five feet of water during a flood event (http://www.safca.org/Images/Maps/AR_SR_FLOODDEPTHZONES.pdf). If critical elements of the State government were disabled due to a flood event, such as those related to emergency response systems, the Central Valley region and the State could be severely impacted. Impacts to State of California departments and agencies could become critical in nature for the entire state if the duration of flooding extends beyond a few days. State agencies provide payroll, retirement benefits, medical benefits, vehicle registration, criminal justice, and other activities that affect people throughout California. Flood recovery programs are run by State and local government agencies. Because these agencies could be located in areas impacted by flooding there is a potential for significant impacts on the distribution of disaster assistance. Although funding may be available, limited material and labor availability could slow implementation of needed repairs and recovery.

More generally, all businesses and government centers could be isolated from customers and employees. Significant numbers of people commute into downtown Sacramento to work at various Federal, State and local agencies and private businesses. The Sacramento District USACE offices are located in downtown Sacramento along with many other Federal and State facilities including the Secretary of State, California Department of Transportation, Water Resources Board, Attorney General's Office, Department of Consumer Affairs, and the Legislative Office Building. Local government facilities include police and sheriffs' offices, the City Library, and City and County of Sacramento administrative offices.

Another piece of critical infrastructure located in the Natomas Basin is the Sacramento International Airport, a major transportation hub for Sacramento and all of northern California. The airport can handle up to 29 flights per hour; in a typical month 800,000 passengers arrive or depart the airport. If a flood were to occur, passenger travel would be disrupted and those stranded at the airport would have to be evacuated to higher ground. Mail and freight transit through the airport would also be interrupted.

Flooding of transportation routes, utilities and public services will also likely occur throughout the region and impacts would be felt in areas far beyond the actual flooding.

Transportation facilities that could potentially be affected by flooding in the study areas include:

- Light rail lines in east and south Sacramento and downtown
- Regional transit bus routes and facilities throughout the City of Sacramento
- I-5
- I-80

- US 99
- US 50

PROBLEM 3: Systemwide residual flood risks will remain after implementation of current projects in high risk areas

Flood flows in the system are held in both the natural river channel, are spilled onto basins and flow over weirs into man-made bypasses. The system is designed to keep all flows from floods up to a certain magnitude within the river, and then to divert flow into the bypass network once this event is exceeded. Throughout the system, the frequency that flow starts to divert from the Sacramento River to the bypass network varies between a 3-year to 5-year flood event. Each component is carefully balanced to take pressure of flooding from urban areas, like Sacramento, and diverting those flows into agricultural areas where the damages will be less. Much like a waterwheel, the tipping of water from one component is critical to the next system element.

The history of flood management in the Sacramento River Basin since the completion of the SRFCP has been one of site-specific actions to address identified and localized flood problems. Often times, studies found that more system-wide solutions may be warranted, but the scope generally exceeded the current project-authorized study boundary despite the highly interconnected nature of the components. Now that many of the localized problems have been addressed, larger systematic fixes are needed to reduce the remaining residual risks.

Recently, the State has evaluated its water issues from a much broader and more strategic perspective by planning and implementing water management programs that combine flood management, ecosystem restoration, water supply, and other water management actions to deliver multiple benefits across watershed and jurisdictional boundaries. This approach, known as integrated water management, calls for pulling together multiple disciplines and interests to define problems and opportunities, and then working creatively and collaboratively to achieve practical, cost-effective, and sustainable multi-benefit solutions.

Existing flood risk management system

The Sacramento River Basin (study area) occupies the northern portion of the Central Valley; it covers approximately 26,300 square miles above Rio Vista, and is approximately 240 miles long and up to 150 miles wide (Figure 1-1 above).

The system is designed to keep all flows from floods up to a certain magnitude within the river, and then to divert flow into the bypass network once this event is exceeded. Throughout the system, the historic frequency that flows start to divert from the Sacramento River to the bypass network varies between a 3-year to 5-year flood event.

Historically, two approaches were considered and debated including channelization and bypass. The bypass system was selected after floods of 1907 and 1909 showed limiations of the channelization approach.

Flood flows in the upper Sacramento River Basin below Shasta Dam are generally confined to their channels and their immediate overbank areas. After passing near Red Bluff, the Sacramento River flows onto a broad alluvial ridge flanked by lower flood basins. The ridge is the result of sediment deposition in the primary floodplain and subsidence in the Butte Basin and Colusa Trough areas. Consequently, most of the tributary flow to the east and south of Ord Ferry do not enter the Sacramento River directly, but instead flow southward for a considerable distance downstream through the Butte and Sutter Basins. The tributaries to the west enter Colusa Trough (Colusa Main Drain) before reaching the Sacramento River at Knights Landing. During high flow the Colusa Main Drain is diverted through the Knights Landing Ridge Cut south to the Yolo Bypass before entering the Sacramento River. Drainage areas west of the Yolo Bypass (Cache Creek, Willow Slough, and Putah Creek) enter that bypass before entering the Sacramento River.

When the Sacramento River is flooding, the Butte and Sutter Basins receive considerable overflow from the Sacramento River. The weirs were designed to begin operation in a particular order. Flood waters flow over the Tisdale Weir first, the Colusa Weir second, Fremont Weir third, Moulton Weir fourth, and the Sacramento Weir last. Colusa Weir and Moulton Weir overflows enter the Butte Basin and Butte Slough, which flow southward towards the Sutter Bypass. The Tisdale Weir discharges into the Sutter Bypass, which dumps its water into the Feather and Sacramento Rivers above Fremont Weir and Verona at the Sacramento and Feather River confluence. The weirs and bypasses were designed to mimic the natural flow of the Sacramento River system.

At this point, the flood waters either continue down the Sacramento River past Verona or flow over the Fremont Weir into the Yolo Bypass. The Yolo Bypass empties back into the Sacramento River above Rio Vista, and downstream the river empties into Suisun Bay and eventually into the San Francisco Bay. The Sacramento Weir lies between Verona and Sacramento on the Sacramento River. When stages are high at the J Street gage, the 48 gates of the Sacramento Weir are opened incrementally. Water then flows over the weir into the Sacramento Bypass, then into the Yolo Bypass. The American River discharges into the Sacramento River at the City of Sacramento. When high stages are occurring on the Sacramento and American Rivers, a portion of the flow in the American River will flow up the Sacramento River and spill over the Sacramento Weir. Remaining flow from the Sacramento and American Rivers which has not spilled over the Sacramento Weir continues south in the Sacramento River to Rio Vista. The system was not balanced to take pressure from urban areas and divert flows to agricultural areas.

Water within the watershed is managed by different agencies with different purposes. Since water is a scarce resource, a more efficient management system across all purposes is needed.

PROBLEM 4: The abundance, distribution and diversity of native species have been severely reduced by the degradation and loss of channel, riparian and floodplain habitats, including the loss of natural hydrologic and geomorphic processes.

Riverine habitats and ecosystem functions have been degraded over time through changes in land use, construction of dams and levees, water pollution, and other causes. The geographic extent, quality, and connectivity of native habitats along Central Valley rivers have all declined. Today, less than 4 percent of the historical riparian forests that lined valley streams remain, with a significant portion of this forest growing on, or close to, levees of the SPFC.

The most recent and detailed maps of this habitat type show it scattered in small and sometimes isloated pockets near SPFC facilities (CDFW, 2013). The Conservation Strategy indentified opportunities to increase riparian-lined banks (the vegetation attribute of shaded riverine aquatic cover) using the Fine-Scale Central Valley Riparian Vegetation Map GIS data layer and knowledge of existing plans. Along the Sacramento River, future multi-benefit flood management projects could have upwards of 4,800 acres of riparian habitat restored, and along the Feather River, up to 1,800 acres, but this would only partially fill the needs for species in the area.

Important ecosystem processes associated with riverine systems such as channel migration, meander cutoffs, and native wetland habitat establishment have been severely reduced by the existing flood management system. Near-channel levees, bank revetment, controlled channeling and water diversions have limited the extent to which these processes can occur. Major dams on the system regulate flows and hydrologic processes that also reduce natural geomorphic processes and limit the amount of materials in the channel for gravel and silt deposition. Consequently, valuable habitats continue to decline with no opportunity for the local or regional systems to recover.

For example, nearly two-thirds of floodplain that was historically inundated has been isolated from rivers by levees, and dams and diversions have substantially reduced the inundation of floodplain that remains connected to rivers (DWR, 2012a, 2012b)

As a result of the alterations in flow caused by dams and diversions, and the isolation of floodplains from rivers by levees, more than 90 percent of historical rearing habitat for Chinook salmon has been lost in the Sacramento and San Joaquin Valleys (Figure 1-8) (NewFields and Cramer Fish Sciences, 2014).

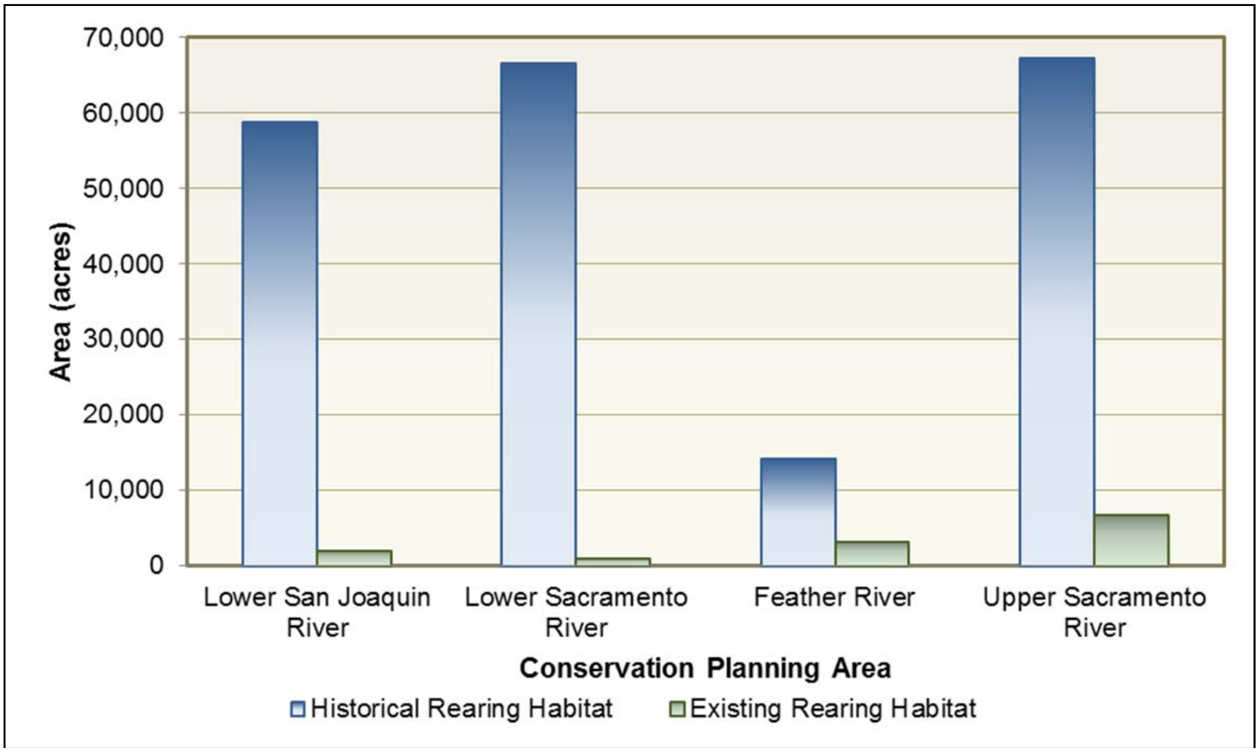

Figure 1-8 Historical and Existing Chinook Salmon Rearing Habitat

Source: NewFields and Cramer Fish Sciences 2014.

Two other important habitat components for salmonids, large woody material (LWM) in river channels and shaded riverine aquatic (SRA) cover along channels, have dramatically diminished in the past century, mainly because of the loss of natural riverbanks and riparian vegetation along the Sacramento and San Joaquin Rivers and their tributaries:

- LWM consists of logs, typically more than 4 inches in diameter and more than 6 feet long, lying in river or stream channels. This material provides valuable cover and resting habitat for fish. With the decreased extent of riparian forest connected to rivers, the supply of LWM in river channels has been substantially reduced. In recognition of its habitat value, removal of LWM has ceased, but the supply of LWM remains reduced because of the diminished extent of riparian forest.
- SRA cover is found at the interface between a river and adjacent woody riparian areas, where natural banks support overhanging vegetation and provide inputs of woody debris, falling insects, and other foods for aquatic species, and create variable velocities, depths, and flows. Federal, State, private levees and application of revetment has eliminated much of the high-value SRA cover on the Sacramento River system. Current data show that the amount of high-quality SRA cover along the banks of the Sacramento and San Joaquin Rivers represents a small fraction of what was present historically (DWR, 2012a).

Spawning habitat for salmonids also has been reduced. Spawning salmon need clean gravel with small to moderate pebble sizes in which they can build their redds. If not regularly replenished by high river flows acting on available sources of sediment, gravel beds degrade. Large gravel particles remain while small ones wash away. By limiting peak flood flows and preventing the recruitment of new gravel, dams and other instream structures have resulted in serious degradation of salmon spawning habitat in Central Valley rivers.

Reduced stream water depth and higher air temperatures will increase stream water temperatures to levels that are potentially unhealthy for coldwater fish Salmonids are temperature-sensitive and rely on cold water sources such as springs or seasonally cold precipitation and snow melt.. The projected changes in inland water temperatures with changing seasonal flows is projected to place additional stress on these species, contributing to the need for increased resources for monitoring, fish passage improvements, and restoration efforts.

Lindley et al. (2007) examined the effects of climate warming on the availability of spring-run Chinook salmon over-summer habitat. Their analysis suggests that a 2-degree-Celsius increase in water temperatures might eliminate summer holding habitat for Butte Creek, where one of three viable populations of spring-run Chinook salmon in the Central Valley remain. Given the possible conditions that may exist in Central Valley streams as the climate warms, many researchers and agencies have recognized the need to evaluate opportunities to provide Central Valley salmonid species access to currently inaccessible habitat (DWR, 2008; NMFS, 2009b; and California Natural Resources Agency, 2009). In addition, to recover Central Valley salmonids, some populations will need to be established in areas now blocked by dams (Lindley et al. 2007). As temperatures increase, providing fish passage to areas upstream from reservoirs could eliminate or reduce the need for cold water releases and give water managers additional flexibility in meeting downstream water supply and flood protection needs.

PROBLEM 5: Access to salmonid habitats has been greatly reduced along the Sacramento River and tributaries.

The system contains a number of features such as dams, weirs, and water diversions for agricultural, industrial, and municipal water uses. These features represent barriers to fish passage that limit fish migration and have eliminated significant amounts of historic fish habitat. The impact of disconnected historic habitat is exacerbated under conditions of climate change including reduced snow pack, warming water temperatures, and severe drought conditions. Of additional concern is fish mortality associated with unscreened water diversions. A fish ladder at the Fremont Weir is shown in Figure 1-9. Figure 1-10 shows known and potential barriers to fish passage.

Figure 1-9 Fremont Weir Fish Ladder

Source: DWR
(Ref: AFRP & CalFish Database) Website:
http://www.calfish.org/ProgramsData/HabitatandBarriers/CaliforniaFishPassageAssessmentDatabase.aspx

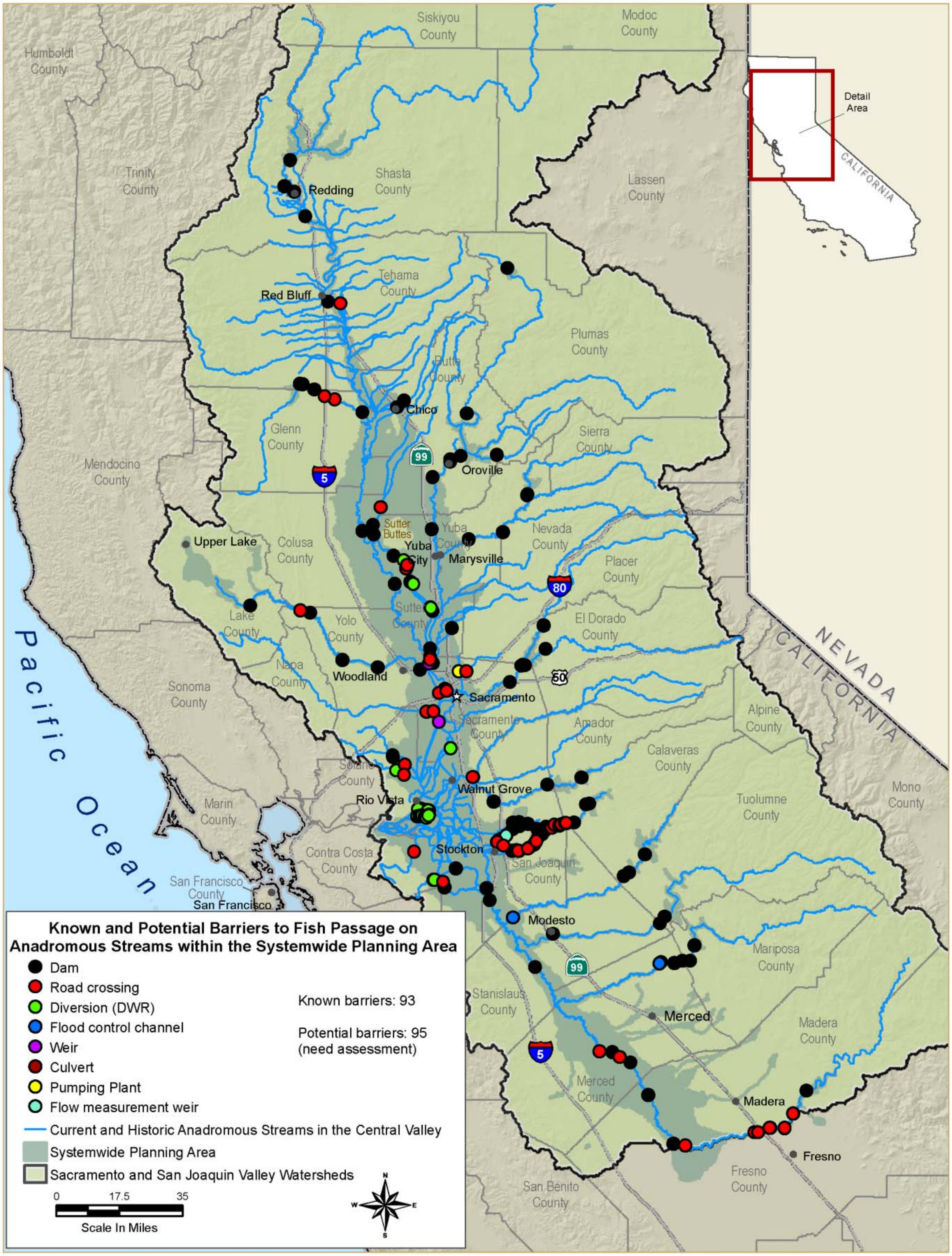

Figure 1-10 Known and Potential Barriers, Including DWR-Owned Diversions, in the Systemwide Planning Area

PROBLEM 6: Surface and groundwater supplies in many areas are exceeded by demands, resulting in a growing number of conflicts among users and uses.
Water is an increasingly scarce resource in California, given population growth and competing economic and ecological demands, as well as changing social values. There are high demands on both surface and ground water originating in the Sacramento Basin to supply water for municipal, agricultural and industrial uses in Central and Southern California. Specifically, the Sacramento River Basin water is a key resource for two-thirds of the residences throughout all of California (including San Francisco and Los Angeles), comprising about 23 million people. This is exacerbated by aging and inadequate infrastructure, growing environmental constraints, the potential for effects of climate change and lack of groundwater regulations.

PROBLEM 7: Potential adverse effects of climate change on ecosystems, flooding and water supply in the watershed could cause further ecosystem degradation, increase flood risk and reduce water supply reliability and availability.
Uncertainty exists with respect to the impact of climate change on precipitation, surface water flows and groundwater. Climate change is predicted to lead to a greater fraction of seasonal precipitation occurring as rain rather than snow and to lead to rising sea levels. Climate change could result in larger and more frequent flood events resulting in increased flood damages. These trends appear to be already established and, if they continue as expected, will put increasing stress on California. In addition, as the moderating effects of snowpack on runoff decrease, there will be a need for more water supply storage, putting greater pressure on California's multipurpose reservoirs to meet conflicting needs.

Climate change could have profound effects of fish and other species in the watershed. As a result of a decrease in snow pack and earlier snowmelt, stream flows are experiencing lower and warmer flows during the summer months extending into the fall and even winter seasons. It is common for adult fish migrating to spawning grounds to encounter obstacles that require high flow conditions in order to pass. If climate change results in reduced stream flows this could impede or halt their progress. A delay in the arrival to spawning grounds decreases reproductive success and increase fish mortality (California Natural Resources Agency, 2009). This decrease in summer flows will further limit access to the very limited available cold water habitat that only exists below major dams that salmonids require, particularly as temperatures in many stream, rivers and reservoirs increase (Moyle et al., 2008). For example, lower flows in the summer will affect winter-run and spring-run Chinook salmon by reducing the size and frequency of deep, cold water pools used for holding, leading to crowding and increased mortality. (Safeguarding California Implementation Action Plans:http://resources.ca.gov/docs/climate/Safeguarding%20California_Implementation%20Action%20Plans%202015%20(CNRA).pdf)

1.4.3 Watershed Planning Goals

The watershed planning goals for this study are to:

- Reduce the risk to public safety from flooding in the Sacramento River Basin,

- Reduce the risk of damages from flooding to residential, agricultural, and commercial/industrial areas, and to roads and other critical infrastructure,
- Restore aquatic habitat in the Sacramento River ecosystem, and
- Restore natural stream processes in the Sacramento River.

This plan investigates an integrated approach to evaluate system functions from water supply to flood management to ecosystem restoration and protection and Climate Change adaptation.

The specific goal of this study documentation is to assist in developing a comprehensive basin-wide management plan that will:

- Incorporate public input and involvement,
- Assess existing and determine aspired watershed characteristics and conditions,
- Identify watershed issues and concerns,
- Develop, evaluate and prioritize conceptual plans including both structural and non-structural measures, in support of determined watershed goals and objectives,
- Identify potential “spin-off” and “off-shoot” projects that may fall under appropriate Federal, State and/or local authorities, and
- Identify potential regionally- or locally-funded projects.

1.4.4 Watershed Planning Objectives

Planning objectives for the Federal and non-Federal sponsors in this watershed plan, given a 50-year planning horizon (2015-2065), have been determined to include:

- Reduce risks to life safety in the Sacramento River Basin with a focus on improved flood risk system flexibility under a variety of climate change and development patterns,
- Reduce both societal consequences and economic damages associated with flood risk in the study area, with an emphasis on improving system resiliency and increasing the long term integrity of the flood system,
- In conjunction with flood risk management, increase area, improve quality, augment connectivity and expand the diversity of significant native aquatic and related habitats in the Sacramento River ecosystem,
- In conjunction with flood risk management, increase the natural dynamic hydrologic and geomorphic processes in the Sacramento River and its tributaries,

- Improve fish access to spawning and rearing habitats in the Sacramento River watershed,
- Increase the reliability and availability of water supply.

1.4.5 Watershed Planning Constraints

In the development of the multipurpose conceptual alternatives, the following constraints were identified to direct plan formulation efforts so that beneficial effects would be maximized and adverse effects would be minimized:

- Solutions must be compatible with the CVFPP,
- Designs will comply with all applicable Federal and State laws, regulations, and policies,

1.5 Prior Studies

CVFIMS is informed by several prior and current studies. These efforts are interrelated as they each address components of the larger flood management system, and therefore completion of these studies and implementation of study recommendations will be required to fully realize the common vision for flood management in the Central Valley.

1.5.1 Sacramento-San Joaquin River Basins Comprehensive Study

The Comp Study (USACE, 2002), was a joint effort by the California Reclamation Board (now Central Valley Flood Protection Board) and USACE, in coordination with State, Federal, and local agencies, groups, organizations, and the public. The Comp Study focused on balancing and integrating multiple objectives on a local, regional, and systemwide basis by facilitating regional coordination and interaction with other programs. Numerous technical analyses were conducted during the Comp Study to inventory resource conditions in the Planning Area and to analyze problems and opportunities for flood management and ecosystem restoration. The findings of the Comp Study were documented and highlighted planning principles used to guide implementation of individual flood management projects and actions in the Central Valley. Technical information and tools developed for the Comp Study have been used by numerous subsequent studies and analyses.

1.5.2 Central Valley Flood Protection Plan

In 2012 DWR prepared, and the Central Valley Flood Protection Board subsequently adopted, the CVFPP. The 2012 CVFPP presented a vision for future improvements to flood management in the Central Valley; this vision was represented through the State Systemwide Investment Approach (SSIA). The 2012 CVFPP considered and evaluated three preliminary approaches to flood management for the areas protected by the SPFC facilities. Assessment of these three approaches resulted in formulation of the SSIA. The SSIA is an assembly of the most promising, affordable, reasonable, and balanced elements of the three preliminary approaches. The SSIA includes two types of physical improvements: (1) regional improvements, which address local and regional flood management needs; and (2) system improvements, which are long-term SPFC improvements that provide cross-regional benefits and improve overall flood system performance, flexibility, and resiliency. System improvements include actions such as new bypasses and existing bypass expansion, flood storage reoperations, and systemwide ecosystem actions, and are intended to provide benefits above and beyond the levels of flood protection achieved through regional improvements.

To refine the SSIA for both the Sacramento and San Joaquin river basins, two studies–one in the Sacramento River Basin and one in the San Joaquin River Basin–were conducted. These Basinwide Feasibilities Studies (BWFS) inform long-term financing and implementation strategies for the SSIA and the 2017 update to the CVFPP.

The BWFS focus on refining system elements identified in the SSIA in consideration of new technical analyses and recommendations and objectives from the State's Draft Conservation Strategy and regional planning efforts.

The primary purposes of the BWFS include:

- Refine the scale and/or location of flood system improvements and integrate environmental conservation and restoration opportunities with flood system improvements.
- Evaluate systemwide hydraulic and economic benefits and impacts, and ecosystem restoration opportunities
- Inform the 2017 CVFPP Update and Investment Strategy.

1.5.3 Regional Flood Management Plans

RFMPs are the regional follow-on to the 2012 CVFPP. Phase I was completed in 2014 at the local and regional level with funding provided by DWR. Phase II began in 2015 to support continued regional planning activity through the 2017 CVFPP update.The RFMPs established the regional flood management vision and identified a prioritized list of regional actions including improvements to existing flood management facilities. DWR is considering these regional improvements in their BWFS, assessing their consistency with refined system improvements and other aspects of the SSIA. Three of the six RFMPs are located in the Sacramento Basin including:

- Upper Sacramento River/Mid-Sacramento River
- Feather River
- Lower Sacramento/Delta North

Additional information on the RSMPs can be found in chapter 4.

1.5.4 Draft Conservation Strategy

The Central Valley Flood System Draft Conservation Strategy (Draft Conservation Strategy) describes DWR's approach for implementing the three environmental objectives of the Central Valley Flood Protection Act of 2008 (DWR, 2015):

1. Promote natural dynamic, hydrologic, and geomorphic processes.
2. Increase and improve habitat quantity, diversity, and connectivity.
3. Promote the recovery and stability of native species populations.

Building on the Conservation Framework included as Attachment 2 to the 2012 CVFPP (DWR, 2012), the Draft Conservation Strategy provides the systemwide context for improving environmental conditions and trends as part of the 2017 CVFPP Update.

By integrating the Draft Conservation Strategy with the BWFS, DWR intends to proactively improve environmental conditions throughout the flood system, thereby reducing compensatory mitigation needs for individual projects. DWR developed the Draft Conservation Strategy in close coordination with regulatory agencies and stakeholders. The Final Conservation Strategy will be included as part of the 2017 CVFPP Update.

1.5.5 Statewide Flood Management Plan

The Statewide Flood Management Planning (SFMP) program is led by the DWR in collaboration with local, State, and Federal agencies and tribal entities throughout California to make recommendations to guide flood management policies and investments in the coming decades by:

- Promoting a clear understanding of flood risks in California
- Garnering active support for partnerships at the local, State, and Federal levels
- Coordinating with other California Department of Water Resources (DWR) planning efforts
- Identifying strategies and feasible next steps to better incorporate flood management into integrated water management (IWM)
- Promoting an IWM approach for flood management solutions

As part of the SFMP program DWR partnered with USACE to develop the document, California's Flood Future: Recommendations for Managing the State's Flood Risk (DWR, 2013), which provides the first look at statewide exposure to flood risk, and identifies and addresses the barriers to improved flood management. California's Flood Future provides information intended to inform decisions about policies and financial investments to improve public safety, foster environmental stewardship, and support economic stability. Research used to develop California's Flood Future included gathering information from local, State and Federal agencies throughout California. More than 140 public agencies responsible for flood management provided information used to describe the problem and develop recommended solutions. DWR is currently working on the California Water Management Investment Strategy to describe the State investment priorities and finance options necessary to support the programs and projects that help improve water supply, water quality, flood management, and ecosystem management throughout the State.

1.5.6 Bay Delta Conservation Plan (BDCP)

In 2007, Federal and state water and wildlife agencies, in cooperation with the public water districts that depend upon water delivered from the Delta, launched the Bay Delta Conservation Plan (BDCP). This effort had the duel goals to:

- Enhance, protect and restore the Delta ecosystem and;
- Improve the reliability of water supplies for California.

In April 2015, following the thousands of public comments on DWR and Reclamation a change in their strategy to achieve the duel goals. They have chosen to study additional alternatives to modernize the Delta's water conveyance system through implementation of the North Delta intakes and associated conveyance facilities, including the tunnels. DWR identified Alternative 4A (California WaterFix), as its proposed project.

At the same time, the State and Federal governments are pursuing at least 30,000 acres of habitat restoration through the California EcoRestore initiative. This effort is unassociated with the habitat mitigation responsibilities of California WaterFix, and represents a continued commitment to restoring the Delta's ecosystem.

1.5.7 System Reoperation Program

DWR is conducting a system reoperation study (SRS) in cooperation with USBR, to identify potential strategies for reoperation of the statewide flood protection and water supply systems in the northern Central Valley. Legislation mandated DWR to conduct planning and feasibility studies to identify potential options for the reoperation of the State's flood protection and water supply systems that will optimize the use of existing facilities and groundwater storage capacity. The main objectives of the SRS include assessing existing facilities operations to improve broad public benefits. Specifically:

- The studies shall incorporate appropriate climate change scenarios and be designed to determine the potential to achieve the following objectives:
- Integration of flood protection and water supply systems to increase water supply reliability and flood protection, improve water quality, and provide for ecosystem protection and restoration.
- Reoperation of existing reservoirs, flood facilities, and other water facilities in conjunction with groundwater storage to improve water supply reliability, flood protection, and ecosystem protection and to reduce groundwater overdraft.

- Promotion of more effective groundwater management and protection and greater integration of groundwater and surface water resource uses.
- Improvement of existing water conveyance systems to increase water supply reliability, improve water quality, expand flood protection, and protect and restore ecosystems.

In support of the legislative objectives, DWR developed the SRS to identify viable reoperation strategies and understand how integrated management can:

- Improve the reliability of municipal and irrigation water supply
- Reduce flood hazards
- Restore and protect ecosystem function and habitat conditions
- Buffer the hydrologic variations expected from climate change
- Improve water quality

California's water supply and flood management infrastructure is physically interconnected to the extent that it is technically feasible to move water around the system from Trinity County in the north to Imperial County in the south. However, the management of the water system is not as well integrated as it could be. The underlying logic of the SRS is that California can do much more with its existing water infrastructure by taking advantage of the physical interconnections (and enhancing them) while also operating the system in a coordinated manner to optimize the benefits.

The current focus of the SRS is the Central Valley because this region has the highest integration of water supply and flood management facilities. Additionally, the greatest potential for ecosystem restoration through infrastructure reoperation is found in the Central Valley because the existing infrastructure has had a profound effect on aquatic ecosystems.

An example of system reoperation is integrating management of groundwater and surface water by utilizing dewatered aquifer space for storage in conjunction with reservoir reoperation. For some Sacramento Valley reservoirs, this could include increased reservoir space for flood risk management.

Development of the SRS is a multi-phased effort that includes:

- Phase 1 – Plan of Study (Completed in 2011)
- Phase 2 – Strategy Formulation and Refinement (Completed in 2014)
- Phase 3 – Preliminary Assessments of Strategies (Completed in 2015)
- Phase 4 – Reconnaissance Level Assessments of Strategies (To be Completed in 2016)

1.5.8 Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is a joint effort between DWR and U.S. Bureau of Reclamation (Reclamation) for compliance with the National Oceanic and Atmospheric Administration Fisheries Biological and Conference Opinion for the Central Valley Project and State Water Project (NMFS, 2009). Action 1.6.1 of the biological and conference opinion is aimed at providing floodplain habitat in the lower Sacramento Valley, and Action 1.7 is aimed at providing fish passage in the Yolo Bypass.

Pursuant to the California Environmental Quality Act, a Notice of Preparation of an Environmental Impact Statement/Environmental Impact Report on the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project was circulated for an extended public comment period in 2013.

1.5.9 California Water Plan Update

For almost 60 years, the California Water Plan (Water Plan) has served as the long-term strategic plan for informing and guiding the sound management and development of water resources in California. With updates every five years, the Water Plan reaffirms the State's commitment to integrated water management.

The 2013 update of the Water Plan proposes the use of sustainability indicators to evaluate progress and return on State investments. It also promotes analytical tools to (1) better integrate and align with other planning activities, (2) seek consensus on information needed to make good decisions, (3) build a common understanding of the water management system, and (4) improve transparency of Water Plan information. The Water Plan uses the collaborative approach to evaluate several resource management strategies that increase resilience in Central Valley water management.

1.5.10 Integrated Regional Water Management Planning Program

IRWM is the application of integrated water management (IWM) principles on a regional scale. IWM is a comprehensive and collaborative approach for managing water to concurrently achieve social, environmental, and economic objectives. IRWM was officially embraced by the State of California in 2002 with the passage of the Integrated Regional Water Management Planning Act (SB 1672).

There are 48 IRWM regions across the State, which collectively cover about 87 percent of the State's geographic area and 99 percent of the State's population. As of December 2014, 45 of those regions had adopted IRWM plans that identify regional water management issues; establish water management goals, objectives, and performance measures; define regional governance for IRWM; describe the stakeholder participation processes; and identify projects that provide, or work toward, regional water management solutions.

A corresponding grant funding program has helped local groups with their planning and resulting implementation projects. Through funding from Proposition 50 and 84, DWR has funded 700 implementation projects since 2002.

1.6 Current Studies and Projects

In addition to the prior studies, there are also several related State and Federal Projects in various stages of completion. These projects are located in the Sacramento Region and are related to State Plan of Flood Control Facilities. A brief description of these related projects is presented here:

- Sacramento River Bank Protection Project – The Sacramento River Bank Protection Project (Sac Bank) has provided erosion protection to maintain the integrity of the levees and other facilities of the Sacramento River Flood Control Project (SRFCP) since its congressional authorization in 1960. This original authorization (Phase I) provided for construction of 435,000 linear feet (LF) which was completed in 1974. An additional 405,000 LF of construction was authorized by Congress in 1974 as Sac Bank Phase II. WRDA 2007 added an additional 80,000 LF. A Post Authorization Change Report (PACR) identified federal interest in Sac Bank utilizing current federal guidance for the 80,000 LF. Following approval of the PACR it is anticipated that a new construction agreement for the 80,000 LF will be signed at the end of 2015.
- American River Common Features Project – The focus of this project is reducing flood risk for the City of Sacramento. Levee improvements to address seepage and stability authorized by WRDA 1996 and WRDA 1999 along the American River have been constructed. Recommendations from the Natomas PAC report for levee improvements to 42 miles of levees surrounding the Natomas Basin, were authorized by WRRDA 2014 and are now in design (PED). Additional levee improvements to address seepage, stability, erosion and levee height for the remaining study area are the focus of the American River Common Features GRR which is now in the study phase.
- Folsom Dam Raise Project – This project, which is under design, will be a 3 ½ foot raise of the dam, dikes, and gates on the main and auxiliary spillways. This will enhance the use of the dam's flood surcharge storage space as well as increase the temporary water storage space that can be used during flood events.
- Folsom Dam Joint Federal Project – This project, which is under construction, includes major dam safety measures to Folsom Dam, including the construction of an additional spillway and gates to allow Folsom Dam to release controlled flood flows more efficiently. The Bureau of Reclamation is responsible for the dam safety work.
- Marysville Ring Levee Project – This four-phase project, which is under construction, will upgrade the levee that surrounds Marysville. The primary purpose of the project is to strengthen the existing levee by implementing additional measures to reduce the likelihood of through- and under-seepage. This project is part of the larger USACE Yuba River Basin Project authority.
- South Sacramento County Streams Project – This project increased the capacity of urban streams in south Sacramento County to lower flood risk in this area. In

addition a ring levee around the Sacramento Regional Wastewater Treatment Plant was raised. This project is complete and is in the O&M phase.

- Sutter Basin Project – This project was recently authorized by WRDA 2014. The project's purpose is flood risk management. Sutter Basin is in Sutter County and is bounded by the Sacramento, Feather, and Bear Rivers. The project would strengthen existing levees to protect Yuba City, the smaller communities of Biggs, Gridley, and Live Oak, and surrounding agricultural land.
- Levee Safety Program – Coordinating with the USACE under this program, DWR conducts levee inspections in the Central Valley sponsored by the Central Valley Flood Protection Board twice a year, with the USACE conducting routine inspections of 10 percent of those levees for quality assurance. The results of USACE levee inspections help determine continued eligibility for the Levee Safety Program's Rehabilitation and Inspection Program, the Corps' authority to provide Federal aid in repairing levees damaged by floods or storms. The inspections also provide a better picture of levee conditions; an important step in USACE's shared efforts with State and local authorities to communicate flood risk and make informed decisions to reduce it.
- Sacramento River Flood Control Project General Reevaluation Report (GRR) – As a follow-on to the Sac Bank, USACE has begun working on the Sacramento River Flood Control Project GRR. The GRR will evaluate feasible flood risk reduction alternatives and ecosystem restoration benefits within the SRFCP, and recommend the most cost-effective, implementable solutions to provide flood protection and ecosystem benefits in the Sacramento Basin.
- Yuba River Basin GRR – This is a general reevaluation of flood protection for Reclamation District 784 and the City of Marysville. The Three Rivers Levee Improvement Authority has, as advance construction, set back and strengthened many of the levees along the Feather and Bear Rivers to protect District lands. The GRR authority includes strengthening and installing under-seepage barriers to the ring levee that protects Marysville
- Lower Cache Creek, Woodland Feasibility Study – The objective of this study is to recommend a plan to reduce potential flood risk within the City of Woodland and the unincorporated areas of Yolo County.
- West Sacramento GRR – The City of West Sacramento is dependent on levees for protection from high flows in the Sacramento River, and Sacramento and Yolo Bypasses. Since 2009, the Corps of Engineers has been conducting a General Reevaluation Report in cooperation with project sponsors to evaluate the levee system and determine the Federal interest in reducing the City's flood risk. In July 2014, USACE released a draft GRR, which outlined the tentatively selected plan for more improvements for the full levee system surrounding the City.
- Folsom Dam Water Control Manual Update – In addition to accounting for the new spillway, the water control manual update will develop new operational rules for dam safety and flood risk management, and ensure compliance with Federal authorizations to reduce creditable space allocation from the current operating

range of 400,000–670,000 acre-feet to 400,000–600,000 acre-feet. To put it simply, the existing dam infrastructure could not release water fast enough so the current water control manual had to plan for scenarios in which the reservoir would have up to 670,000 acre feet of water. With the spillway and the increased capability to release water not only in larger amounts, but sooner based on forecasting, operators are anticipated to typically manage releases at lower reservoir levels.

1.7 Public Involvement

The non-Federal sponsors (DWR and the CVFPB) have organized and continue to conduct extensive public outreach and coordination for the CVFPP, the Draft Conservation Strategy and CVIFMS. Representatives from the sponsors regularly participate in local and regional meetings where they solicit input from the public and present updates of the various on-going efforts.

USACE Sacramento District (SPK) has conducted public outreach and provided multiple opportunities for public involvement during the CVIFMS watershed analysis. The CVIFMS project website was launched in January, 2015 and initial stakeholder and tribal outreach letters were sent in February, 2015. After advertising the study via emails, the project website and several newspaper announcements, two public meetings were held in March of 2015, one in the city of Colusa and one in West Sacramento. At these meetings, the sponsors informed the public of the goals and objectives of the CVIFMS watershed study and solicited their input.

Specific meetings were conducted with tribal communities who requested briefings about the project, including the United Auburn Indian Community and the Yocha De He Wintun Nation.

With input from stakeholders, the sponsors developed a full list of potential flood risk management, ecosystem restoration and water supply measures and developed potential designs by applying those measures to specific sites within the watershed, given site-specific problems and opportunities. During the formulation, evaluation and screening of conceptual alternatives, a public workshop was held on 24th and 25th August, 2015 in Sacramento. All those who signed up to be invited to the stakeholder workshops, either in-person at one of the public meetings or by contacting the sponsors through the project website and email, were invited to that event. At the workshop, a facilitator from the Institute for Water Resources with assistance from the Lead Planner for the project, facilitated a discussion of the plan formulation process, and sought input on the features, a qualitative assessment of the features, formulation of conceptual alternatives, and scoring and evaluation of those conceptual alternatives.

At the August, 2015 public workshop, the following objectives were accomplished:

- Established a shared understanding of the watershed study purposes, problems, opportunities, and goals and objectives,

- Developed metrics with specific impact scales to use in evaluating the performance of defined measures and alternatives,
- Gathered public insight on the definitions for proposed design measures and on how to determine the relative effectiveness in achieving watershed objectives, as well as proposed scoring and evaluation criteria,
- Evaluated the proposed scoring scales for all design features,
- Obtained ideas about ways to combine measures into cohesive, conceptual alternatives, and integrated varying perspectives on how to strategically group measures; used information to combine proposed features into conceptual alternatives, and
- Enabled a “trade-offs discussion” demonstrating that despite individual value preferences, combined alternatives that included flood risk management, ecosystem restoration and water supply components ranked the highest for all perspectives represented at the workshop.

The final public meeting is scheduled to be held in December, 2015 during the informal 30-day public review period for the draft watershed plan. During this public review period and in-person at the public meeting, public comments will be accepted via the project website, email, written letter, and personal communication with sponsors on the draft watershed plan.

Stakeholder viewpoints are discussed in more detail in Attachment B *Stakeholder Viewpoints*.

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2.0 Existing and Future Without-Project Conditions

The existing condition provides a snapshot of the current status of various aspects of the Watershed. The existing conditions described in this report are important for providing an environmental assessment baseline. The future without-project condition is the most likely condition expected to occur in the future in the absence of proposed actions included in this watershed study. The future without-project condition defines the benchmark against which the alternative plans have been evaluated. A few critical assumptions that affect the plan formulation and the without-project condition are discussed in their corresponding resource area in Sections 2.1 through 2.12.

For the future without-project condition, projects in the study area that are assumed to be in place and accruing economic and environmental benefits include:

- American River, Common Features
- West Sacramento
- Sutter Basin
- Yuba Basin
- South Sacramento Co. Streams
- Folsom Joint Federal Project
- Marysville

The first two listed studies have identified recommend plans; however, they have not been authorized for construction at this time. They are schedule to have their Civil Works Review Boards in December, 2015.

Residual flood risk in the study area following completion of the above seven projects has been identified and is addressed in this watershed study.

The following sections documents the watershed resources of concern and provide the existing and future without-project conditions.

2.1 Socioecomonics

The Sacramento River Watershed falls within portions, or the entirety of Butte, Colusa, El Dorado, Glenn, Lake, Lassen, Modoc, Nevada, Placer, Sacramento, Shasta, Solano, Sutter, Tehama, Yolo, and Yuba Counties, encompassing over 27,000 square miles. Population within the watershed is largely located in cities and towns along the major highway corridors of I-5, I-80, and SR 99, with the largest being the City of Sacramento. The watershed borders the San Joaquin River Watershed to the south and the San Francisco Watershed to the west.

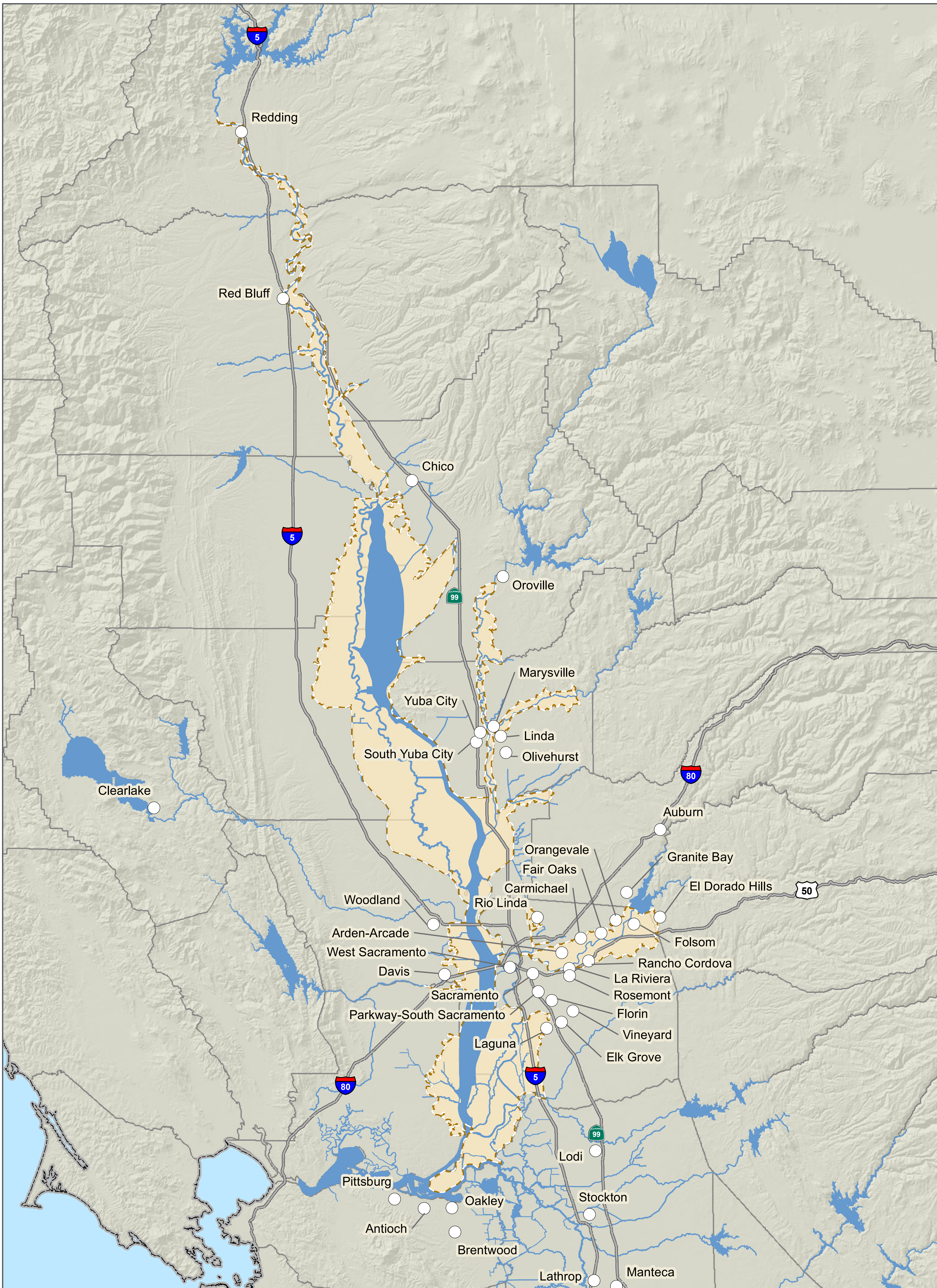
2.1.1 Population and Employment

The populations of the counties within the watershed are provided below in Table 2-1. In the 2000 and 2010 censuses, Sacramento County was the most populous of the counties located within the watershed. By 2030, Sacramento County is projected to remain the most populous county in the area (Department of Finance, 2010a). Between 2000 and 2010, the population of the watershed increased by 1.61 percent and is predicted to grow an additional 1.83 percent by 2030 (Department of Finance, 2007, 2010a). The expected population growth provides a major challenge to the State's flood management system and existing infrastructure as it could significantly increase risk to life-safety. A map showing the locations of major population centers (greater than 10,000 people) is shown in Figure 2-1. Almost all of these population centers experienced population growth between 2000 and 2010.

Table 2-1 County Population

County	Population			Annual Growth Rates	
	2000	2010	2030 (Projected)	2000-2010	2010-2030 (projected)
Butte	204,065	221,768	334,842	0.87%	2.55%
Colusa	19,027	22,206	34,488	1.67%	2.77%
El Dorado	158,621	182,019	247,570	1.48%	1.80%
Glenn	26,764	29,434	45,181	1.00%	2.67%
Lake	58,724	64,053	87,066	0.91%	1.80%
Lassen	34,108	35,889	47,240	0.52%	1.58%
Modoc	9,628	9,777	16,250	0.15%	3.31%
Nevada	92,532	98,680	123,940	0.66%	1.28%
Placer	252,223	347,102	512,509	3.76%	2.38%
Plumas	20,868	20,428	24,530	-0.21%	1.00%
Sacramento	1,233,575	1,445,327	1,803,872	1.72%	1.24%
Shasta	164,794	184,247	260,179	1.18%	2.06%
Solano	396,995	427,837	590,166	0.78%	1.90%
Sutter	79,632	99,154	182,401	2.45%	4.20%
Tehama	56,130	63,100	93,477	1.24%	2.41%
Yolo	170,190	202,953	275,360	1.93%	1.78%
Yuba	60,598	73,380	137,322	2.11%	4.36%
Totals:	**3,038,474**	**3,527,354**	**4,816,393**	**1.61%**	**1.83%**

Data Source: DOF 2007, 2010a



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Sacramento District

Urban Areas

CVIFMS Opportunity Areas

Cities/Locations with more than 10,000 Residents

Figure 2-1

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983
CA State Plane II Feet

PATH: F:\PROJECTS\028_233549_CH2MHILLDWR_CVFPP_TO_14_09\MAP_DOCS\MXD\REPORT\FIGURE_3.16-2_PROTECTEDURBANAREA_11X17.MXD - USER: AARNOLD - DATE: 11/9/2015

Source: 2012 CVFPP

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Employment data from the State's Employment Development Department for the counties within the watershed are detailed below in Table 2-2, which shows a combined unemployment rate for Sacramento Valley counties of 6.71 percent for March 2015. According to the data, Placer County has the lowest unemployment rate of 5.08 percent with a total employed population of 168,200 people. Colusa County has the highest unemployment rate at 20.57 percent with an employed population of 8,620. Sacramento County, the largest by population in the watershed, has the most employed with 642,600 people at an unemployment rate of 6.04 percent.

Table 2-2 March 2015 Employment Data

County	Employment Data			
	Labor Force	Employed	Unemployed	Unemployment Rate
Butte	101,700	94,000	7,600	7.47%
Colusa	10,840	8,620	2,230	20.57%
El Dorado	89,100	83,900	5,200	5.84%
Glenn	12,640	11,440	1,200	9.49%
Lake	30,000	27,670	2,330	7.77%
Lassen	10,530	9,650	880	8.36%
Modoc	3,180	2,850	330	10.38%
Nevada	47,850	44,700	3,150	6.58%
Placer	177,200	168,200	9,000	5.08%
Plumas	7,680	6,670	1,010	13.15%
Sacramento	683,900	642,600	41,300	6.04%
Shasta	74,200	67,900	6,300	8.49%
Solano	203,500	190,800	12,700	6.24%
Sutter	44,100	38,500	5,600	12.70%
Tehama	24,970	22,860	2,110	8.45%
Yolo	102,100	95,000	7,100	6.95%
Yuba	27,900	25,100	2,800	10.04%
Totals:	**1,651,390**	**1,540,460**	**110,840**	**6.71%**

Data Source: http://www.calmis.ca.gov/file/lfmonth/countyur-400c.pdf

2.1.2 Tribal Communities

There are as many as 22 Federally recognized tribes in the watershed, as listed in Table 2-3 (California Water Plan, 2013). Tribes have a unique government-to-government relationship with the United States government through Federal case law and executive orders. Tribal governments are responsible for providing for the health, safety, and welfare of all citizens within their territory, and also have roles in flood management. Tribes maintain, operate, and have responsibility for flood management facilities in coordination with counties, the State, and the United States government.

Table 2-3 Federally Recognized Tribes in the Sacramento River Watershed

Name of Tribe	Cultural Affiliation
Alturas Indian Rancheria	Anchomawi
Berry Creek Rancheria of Maidu Indians	Tyme Maidu
Big Valley Band of Pomo Indians	Pomo
Cachil DeHe Band of Wintun Indians of the Colusa Indian Community	Wintun
Cedarville Rancheria	Northern Paiute
Cortina Indian Rancheria of Wintun Indians	Wintun
Elem Indian Colony of Pomo Indians	Pomo
Enterprise Rancheria of Maidu Indians	Maidu
Fort Bidwell Indian Community of the Fort Bidwell Reservation of California	Northern Paiute
Greenville Indian Rancheria of Maidu Indians	Maidu
Grindstone Indian Rancheria of Wintun-Wailaki Indians of California	Wintun, Wailaki
Habernatolel Pomo of Upper Lake	Pomo
Koi National – Lower Lake Rancheria	Pomo
Mechoopda Indian Tribe of Chico	Maidu
Middletown Rancheria of Pomo Indians	Pomo, Lake Miwok
Mooretown Rancheria of Maidu Indians	Maidu
Paskenta Band of Nomlaki Indians	Nomlaki
Pit River Tribe (includes XL Ranch, Big Bend, Likely, Lookout, Montgomery Creek and Roaching Creek Rancherias)	Anchomawi (Achumawi, Ajumawi), Aporidge, Astariwawi (Astarawi), Atsuge (Astugewi), Atwasmsini
Redding Rancheria	Wintu, Yana, Pit River
Robinson Rancheria of Pomo Indians	Pomo
Scotts Valley Band of Pomo Indians	Pomo
United Auburn Indian Community of the Auburn Rancheria	Miwok, Maidu

2.1.3 Future Without-Project Conditions

The population of the Sacramento River Basin was about 2.6 million in 2000, but this is expected to increase to more than 4.5 million by 2030 (DWR, 2005b). The southern portion of this river basin is experiencing the most rapid population growth and urbanization. While the State experienced a statewide population growth approaching

15 percent from 1990 to 2000, growth rates in the Sacramento Metropolitan Area have exceeded this trend. Similarly, adjoining urban areas in Placer, Yolo, and Sutter counties are also experiencing rapid growth and urban expansion. The conversion of agricultural lands to other uses is expected to continue as urban areas grow and prospective homeowners move farther away from urban centers in search of lower housing costs and a more rural lifestyle (USACE, 2001). Much of this urbanization is expected to take place within floodplains protected by SPFC facilities (USACE, 2001). Increases in population will increase demands for water, which can put added pressure on the basin's rivers and channels to reliably convey water for a variety of purposes, including water supply, flood, and environmental management.

2.2 Climate and Precipitation

The climate of the study area is characterized by cool, wet winters and hot, dry summers. Annual precipitation occurs almost entirely during the winter storm season (November to April). Air temperatures are high in summer and moderate in winter.

A dominating factor in the weather of California is the semipermanent high-pressure area of the northern Pacific Ocean. This pressure moves northward during the summer creating warmer temperatures and preventing the watershed from receiving much precipitation during the summer months. During the fall and winter months, the pressure typically moves back southward, allowing for cooler weather and storms to provide a moderate amount of rainfall throughout the watershed. Average annual temperatures in the study area are shown in Table 2-4.

Table 2-4 Average Annual Sacramento River Watershed Temperature

County	Annual Average Temperature (in degrees Fahrenheit)
Butte	60.1
Colusa	60.4
El Dorado	56.4
Glenn	60.8
Lake	58.6
Lassen	48.4
Modoc	47.8
Nevada	55.3
Placer	54.1
Plumas	48.3
Sacramento	62.2
Shasta	55.5
Solano	60.4
Sutter	61.5
Tehama	60.9

County	Annual Average Temperature (in degrees Fahrenheit)
Yolo	60.9
Yuba	60.1

Data Source: www.usa.com

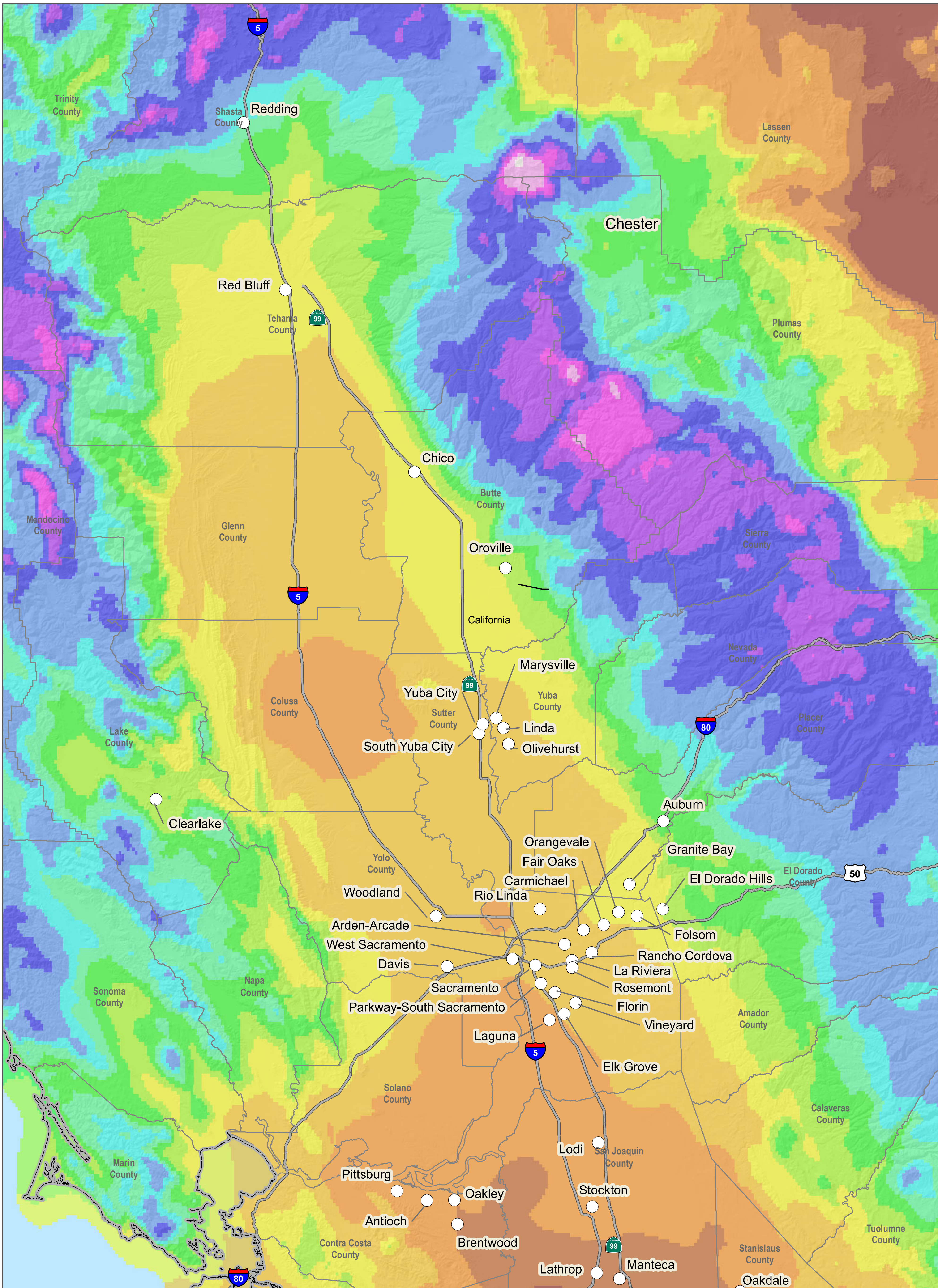
In the northern portion of the Sacramento River Basin, total annual precipitation averages between 60 and 70 inches and is as high as 95 inches in the Sierra Nevada and the Cascade Range. Other mountainous areas bordering the valley reach elevations higher than 5,000 feet and receive an average of 42 inches of precipitation per year, with snow prevalent at higher elevations. (CVFPP, 2012).

Table 2-5 below shows average annual precipitation by select Cities in the basin. Figure 2-2 shows the annual precipitation of the watershed.

Table 2-5 Average Annual Precipitation

City / Location	County	Gage Number	Description	Average Annual Precipitation (in inches)
Redding	Shasta	47296	Redding Fire Station 2, California	39.2
Red Bluff	Tehama	47292	Red Bluff Muni AP, California	23.2
Oroville	Butte	46523	Oroville 7 SE, California	28.9
Chico	Butte	41715	Chico University Farm, California	25.7
Bullards Bar	Yuba	41180	Bullards Bar PH, California	66.9
Nevada City	Nevada	46136	Nevada City, California	54.3
Truckee	Placer	49043	Truckee RS, California	30.2
Auburn	Placer	40383	Auburn, California	34.4
Folsom	Sacramento	43111	Folsom, California	24.2
Sacramento	Sacramento	47630	Sacramento Executive AP, California	17.2

Data Source: http://www.wrcc.dri.edu/Climsum.html



CVIFMS Watershed Plan Annual Precipitation

Annual Precipitation (in)

< 10	16 - 20	28 - 32	40 - 50	70 - 80	
10 - 12	20 - 24	32 - 36	50 - 60	80 - 100	
12- 16	24 - 28	36 - 40	60 - 70	> 100	

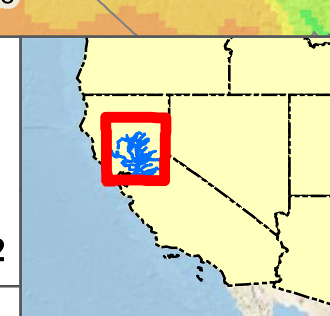


Figure 2-2

US Army Corps of Engineers® Sacramento District

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983 CA State Plane II Feet

PATH: F:\PROJECTS\028_233549_CH2MHILLDWR_CVFPP_TO_14_09\MAP_DOCS\MXD\REPORT\FIGURE_XX_NORCALMEANANNUALPRECIP_10_2.MXD - USER: AARNOLD - DATE: 11/11/2015

Source: http://www.prism.oregonstate.edu/normals/

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2.2.1 Inland Climate Change

Important influences of climate change are changes in temperature; changes in precipitation quantity, intensity, and form (snow versus rain); and changes in sea levels, wind, and wave patterns (USACE, 2012b). All of these factors could affect the water resources projects operated by USACE and its non-Federal sponsors. The USACE must be able to perform its missions and operations under dynamic conditions, whether these result from climate change alone or in combination with other physical, social, or economic global changes (e.g., demographic shifts, land-use and land cover changes, aging infrastructure, etc.; USACE 2012b).

On March 4, 2011, the White House Council on Environmental Quality issued a set of Implementing Instructions for Federal Agency Climate Change Adaptation in response to the growing awareness that Federal agencies must begin to plan for and adapt to climate change. In response to the Implementing Instructions, USACE issued the report USACE Climate Change Adaptation Plan and Report (USACE, 2011b). This report identifies progress and future priorities and includes an overarching agency policy statement that calls for integrating climate change adaptation into all that the USACE does. This includes building adaptation into all USACE activities based on the best available and actionable science when undertaking long-term planning, setting priorities, and making decisions (USACE, 2012b).

This study is intended to identify opportunities to reduce damage associated with flood events and opportunities to enhance the ecosystem in the Sacramento River Watershed. Any future conditions which increase the magnitude or frequency of flood flows would have impacts in the study area. Therefore, inland climate change is a consideration for this study.

The State of California evaluated whether there has been a changing trend in precipitation in the state over the past century by compiling an extensive collection of long-term precipitation and runoff records and then conducting a linear regression of the data. Based on that, the long-term historical trend for statewide average annual precipitation appears to be relatively flat (no increase or decrease) over the entire record. However, it appears that there might be an upward trend in precipitation toward the latter portion of the record (CVFPP, 2012).

In the Sierra Nevada, over the past century, the spring snowmelt runoff has steadily declined. This decrease in snowmelt runoff can be attributed to warmer winters, and/or earlier springtime warming and melting of snowpack (OEHHA, 2013). Temperature driven reductions in snowpack are compounded by dust and soot accumulation on the surface of snow pack which increases the amount of the sun’s energy absorbed by the sun and leads to earlier snowmelt and evaporation (NCA, 2014). The average early-spring snowpack in the Sierra Nevada has decreased by about 9 percent during the last century, a loss of 1.5 million acre-feet of snowpack storage (OEHHA, 2013, DWR 2008). These changes have major implications for water supply, flooding, aquatic ecosystems, energy generation, and recreation throughout the State.

Future inland climate change conditions show there is a high likelihood for seasonal atmospheric temperatures to increase. The average temperature in California is projected to increase by about 2.5 to 5.5 degrees Fahrenheit by 2041-2070 (NCA, 2014). Increased temperatures may alter precipitation and runoff patterns, such as a rise in snow-line elevations, earlier snowmelt occurrence, more precipitation falling as rain instead of snow, and reductions in the volume of overall snowpack (CVFPP, 2012). The combination of warmer storms and earlier snowmelt may cause April watershed total snow accumulation to drop by 5 percent of present levels by 2030, 36 percent by 2060, and 52 percent by 2090 (Knowles and Cayan 2002). The combination of earlier snowmelt and shifts from snowfall to rainfall seem likely to increase flood peak flows and flood volumes (Miller et al., 2003; Fissekis, 2008; Dettinger et al., 2009), which can increase flood risk. Higher snow lines could also increase flood risk because more watershed area contributes to direct runoff. From an O&M viewpoint, higher snow lines could increase erosion rates that would result in greater sediment loads and turbidity, altering channel shapes and depths, and possibly increasing sedimentation behind dams and affecting habitat and water quality (DWR, 2008).

Changes in precipitation form (snow versus rain) associated with temporal shifts in runoff, and potential increases in flood frequencies and magnitudes, are likely to require reevaluation of existing operational rules for the flood control, water supply, and water quality purposes of reservoirs which were developed based on previously accepted historical conditions.

While ecosystems have always naturally changed over time, ecosystem effects of climate change are likely to be exacerbated by the dramatic loss of natural areas experienced in the last 50 years (CEC, 2009c) and by the relatively rapid rate at which climate change and other stresses are advancing. The abundance, production, distribution, and quality of ecosystems throughout California are likely to be dramatically affected during this century by a combination of climate-change-associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (e.g., land use change, pollution, fragmentation of natural systems, overexploitation of resources) (IPCC, 2007a). Most vulnerable to climate change are endangered and threatened species, plants and animals living within confined geographic ranges with limited abilities to move rapidly, and species migrating to new areas where they meet increased competition for habitat or food (IPCC, 2007a). Climate change effects on ecosystem land management include both the geographic loss of habitat and the loss of habitat connectivity. Sea level rise is expected to cause increased seawater intrusion into California's coastal marshes and estuaries. Increased intrusion will likely disrupt marsh and estuary ecosystems, especially at the higher projections of sea level rise. The loss of natural areas in turn reduces opportunities to use ecological systems and functions within flood management systems. Higher water temperatures resulting from climate change are likely to negatively impact aquatic and terrestrial resources. Warmer temperatures can compromise the health and resilience of existing aquatic and terrestrial species and, thus, make it more challenging for them to compete with nonnative species for survival. Of specific concern to Central Valley aquatic habitats, Chinook salmon and steelhead prefer temperatures of less than 64.4 to 68 degrees Fahrenheit (°F) (18 to 20 degrees Celsius (°C)) in mountain streams, although these anadromous fish may tolerate higher temperatures for short periods (Bennett, 2005). The Sacramento River Watershed feeds into the Delta, where summertime water temperatures may increase between 5 and 11 degrees Farenheit by the end of the 21st century. Increased water temperatures could reduce the habitat suitability of California rivers for these species. Globally, terrestrial biological systems are beign strongly influenced by recent climate change (OEHHA, 2013). Impacts on terrestrial ecosystems have also been observed in North America, including changes in the timing and length of growing seasons, timing of species life cycles, primary production, and species distributions and diversity (CEC, 2009c).

Competition for habitat and food will intensify with climate change. For example, climate change is expected to decrease suitable summer habitat of delta smelt, a federally-listed endangered species, because waters in the lower Delta may be too saline and lack food, and freshwater in the upper Delta may be too warm. Climate change could combine with non-climate stressors, such as land use changes, wildfire, and agriculture and cause habitat fragmentation at increasing rates, thus contributing to species extinction (USFWS, 2009).

2.2.2 Sea Level Rise

Increasing temperatures would also result in relative sea-level change due to the melting of land-based glaciers, snowfields, and ice sheets, along with thermal expansion of the ocean as the surface layer warms (DWR, 2008). Estimates of future sea level change were developed by the National Research Council (NRC) in 2012 given three different sets of assumptions, resulting in low, medium and high scenarios for future relative sea level change; resulting figures are provided in Table 2-6.

Table 2-6 Estimates of Future Sea-Level Change in California

Year	Estimated Increase in Sea Level (in inches)		
	Low	Medium	High
2030	1.7	5.7	11.7
2050	4.8	11	23.9
2062	7.3	15.3	32.7
2100	16.7	36.2	65.5

Source: NRC, 2012

Anticipated sea-level increases due to climate change will also increase water-level stages in the Delta and lower reaches of the Sacramento River. Sea level rise would increase existing structures' exposure to waves and wind setup[1], and increase the

[1] Wind setup is the vertical rise in still water at the face of a structure or embankment due to wind stresses. The term is usually used in discussions of reservoirs or small bodies of water; comparable to “storm surge” used to describe similar activity for oceans or larger bodies of water.

hydrostatic pressure on levees, especially on low-lying land currently below sea level. These effects increase the possibility of catastrophic levee failures that could inundate communities, damage infrastructure, and interrupt water supplies (Hanak and Lund, 2008). In addition, water supplies and aquatic habitat would likely be impacted by saltwater intrusion resulting from sea-level rise. Such an increase in the inland penetration of seawater would further degrade drinking and agricultural water quality and alter existing ecosystem conditions.

2.3 Geology and Soils

2.3.1 Geological Provinces

Different geologic processes acting on various rock types over millions of years have created geologically different areas within California. Each area is considered a geomorphic province, and 11 are present, at least partly, in California. Within the Watershed are the the Coast Range, Klamath Mountains, Cascade Range, Modoc Plateau, Great Valley, and Sierra Nevada, Figure 2-3 shows the generalized soil locations and Figure 2-5 shows the different geological provinces within the watershed.

Coast Range Province

The Coast Range Province extends 600 miles from the Oregon-California border in the north to the Transverse Range in Southern California. As the name suggests, the Coast Range Province parallels the California coast along the Pacific Ocean, extending inland 20–80 miles (CGS, 2002a).

As described below, the Coast Range Province is dominated by a parallel series of mountain ranges and fault-controlled valleys. The province consists of Mesozoic marine sedimentary and metasedimentary rocks that have undergone intense folding and faulting.

The Mendocino Range in the northern Coast Range Province is one of the longer and higher ranges in this province, with some peaks that reach 6,000 feet. The Diablo Range lies west of the San Joaquin Valley and extends from Mount Diablo southeast to the Kettleman Hills. Mount Tamalpais is the northern extension of the Santa Cruz Mountains, which continue southward down the San Francisco Peninsula to Monterey Bay. San Francisco Bay is a structural depression between the Diablo Range to the east and the Santa Cruz Mountains to the west.

The Salinas Valley, the longest continuous valley in the province, is bounded by the Gabilan Range on the east side and the Santa Lucia Range on the west side (Reclamation 1997). Mesozoic granitic rocks are exposed in these two ranges. Some Cenozoic volcanic rocks are exposed in the Napa and Sonoma valleys and in the Diablo Range east of Hollister. The mountain ranges parallel the faults and lie between major fault systems.

Klamath Mountains Province

The Klamath Mountains Province covers about 12,000 square miles of northwestern California between the Coast Range Province to the west and the Cascade Range Province to the east. The Klamath Mountains consist of several individual mountain ranges that trend more northward. These mountains consist of Paleozoic metasedimentary and metavolcanic rocks and Mesozoic igneous rocks. They may be a northwest extension of the Sierra Nevada, although the connection is obscured by the younger alluvial deposits of the Central Valley and the volcanic flows of the Cascade Range and the Modoc Plateau (CGS 2002a, 2002b).

Thompson Peak, located in the Trinity Alps, rises to an elevation of 8,936 feet, making it the tallest peak in the Klamath Mountains. Although the peaks of the Klamath Mountains are lower than those of the Sierra Nevada, some of the higher peaks in the Trinity Alps have been glaciated.

The Klamath Mountains have a very complex geology. The province is formed primarily by several mountain belts: the eastern Klamath Mountains, central metamorphic, western Paleozoic and Triassic, and western Jurassic belts. Between these belts, low-angle thrust faults allow eastern blocks to be pushed westward and upward. The Klamath Mountains consist of up to 40,000 feet of eastward-dipping Ordovician to Jurassic marine deposits. The central metamorphic belt contains Paleozoic hornblende and mica schists and ultramafic rocks. The western Jurassic, Paleozoic, and Triassic belts consist of slightly metamorphosed sedimentary and volcanic rocks (Reclamation 1997; CGS 2002b; Irwin and Wooden 1999).

Cascade Range and Modoc Plateau Provinces

The Cascade Range Province and Modoc Plateau Province are presented together because of their geologic similarity. These provinces cover about 13,000 square miles of the northeast corner of California, bordering the Klamath Mountains to the west, the Central Valley to the southwest, and the Sierra Nevada to the south.

The Cascade Range and Modoc Plateau are geologically young provinces with a large variety of volcanic rocks (CGS, 2002a, 2002b). The Cascade Range includes recently active volcanic domes, among them Mount Shasta and Mount Lassen in California (Wakabayashi and Sawyer, 2001). Mount Lassen erupted intermittently between 1914 and 1917, making it the only California volcano active in the 20th century. Evidence indicates that Mount Shasta erupted during the 18th century. The volcanoes of the Cascade Range extend north to British Columbia.

Cascade Range volcanics have been divided into the Western Cascade series and the High Cascade series. The Western Cascade series consists of Miocene-aged basalts, andesites, and dacite flows interlayered with rocks of explosive origin, including rhyolite tuff, volcanic breccia, and agglomerate. This series is exposed at the surface in a belt 15 miles wide and 50 miles long from the Oregon border to the town of Mount Shasta.

After a short period of uplift and erosion that extended into the Pliocene, volcanism resumed, creating the High Cascade volcanic series. This series forms a belt 40 miles wide and 150 miles long just east of the Western Cascade series rocks. Early High Cascade rocks formed from very fluid basalt and andesite that extruded from fissures to create low shield volcanoes. Later eruptions during the Pleistocene had higher silica content, causing more violent eruptions. Large volcanic domes like Mount Shasta and Mount Lassen had their origins during the Pleistocene (Reclamation 1997; Sherrod and Smith 2000; Wright 1984).

The Modoc Plateau consists of a high plain of irregular volcanic rocks of basaltic origin. The numerous shield volcanoes and extensive faulting on the plateau give the area more relief than may be expected for a plateau. The Modoc Plateau averages 4,500 feet above mean sea level and is considered a small part of the Columbia Plateau, which covers extensive areas of Oregon, Washington, and Idaho (Reclamation 1997).

Great Valley Province

The Great Valley Province encompasses the Central Valley, an alluvial plain about 50 miles wide and 400 miles long that is located in the central part of California, stretching from just south of Bakersfield to Redding in the north. Because the Great Valley Province encompasses most of the historical and current floodplain within the study area, it is discussed in more detail than the other geomorphic provinces.

The Central Valley consists of the Sacramento Valley to the north, the San Joaquin Valley to the south, and the Sacramento–San Joaquin Delta (Delta) in the center. The Sacramento Valley and San Joaquin Valley are drained by the Sacramento and San Joaquin rivers, respectively, which flow into the Delta. The Great Valley Province is bounded to the west by the pre-Tertiary and Tertiary semiconsolidated to consolidated marine sedimentary rocks of the Coast Ranges. The faulted and folded sediments of the Coast Ranges extend eastward beneath most of the Central Valley. The east side of the Central Valley is underlain by pre-Tertiary igneous and metamorphic rocks of the Sierra Nevada. The north end is underlain by Tertiary volcanic rocks of the Coast Ranges, and bounded by the pre-Tertiary metavolcanics and granitic and metamorphic rocks, and by the Cenozoic volcanic rocks of the Cascade Range.

Pre-Tertiary marine sediments account for about 25,000 feet of the total amount of sediments deposited in the sea before the rise of the Coast Ranges. Marine deposits continued to fill the Sacramento Valley until the Miocene Epoch and portions of the San Joaquin Valley until the late Pliocene, when the last seas receded from the Central Valley. After the seas receded, continental alluvial deposits from the Coast Ranges and the Sierra Nevada began to collect in the newly formed Central Valley. The Great Valley Province is characterized by alluvial, continental, and marine sediments deposited almost continually since the Jurassic Period (CGS, 2010a).

During much of the Tertiary Period, the Central Valley and the predecessors of the Sacramento and San Joaquin river systems were drained to the ocean through a southern outlet in what is now the Kettleman Hills. As movement along the San Andreas

Fault closed this outlet during the late Tertiary Period, a vast inland lake formed in the Central Valley, depositing much of the sediments that fill the Great Valley Province.

Tectonic activity during the Tertiary Period strongly influenced the evolution of the Central Valley. Such activity alternated between trapping water in the San Joaquin Valley or entire Central Valley to form inland seas that deposited marine sediments, and creating openings that allowed water to drain to the ocean at varying locations at different times. Volcanic deposits originating from volcanic activity to the east in the Sierra Nevada also contributed to sediments that filled the Great Valley Province. Alternating marine and continental deposits of Tertiary age underlie much of the Great Valley Province (Page 1986).

During the more recent Quaternary Period, the inland lake that once filled the Central Valley spilled over low-lying land in the Coast Range Province, ultimately carving the Carquinez Strait and flowing through the Bay Area to the Pacific Ocean (Sloan 2006; Hill 2006). Today, the water originating in the watershed of the Great Valley Province collects in the Delta before draining to the ocean through this outlet. The Quaternary Period was characterized by continental sedimentary deposition. The Sacramento and San Joaquin valleys are filled with about 10 and 6 vertical miles of sediment, respectively. The most recent surficial alluvial deposits are mined for aggregate, as discussed below (CGS, 2002a).

Tertiary and Quaternary continental deposits in the San Joaquin Valley make up the major aquifer of the valley. These deposits consist of the Mehrten, Kern River, Laguna, San Joaquin, Tulare, Tehama, Turlock, Riverbank, and Modesto formations (Ferriz 2001; Page 1986). The aquifer system is discussed further in Section 3.11, “Groundwater Resources.” These continental rocks and deposits consist largely of coarse-grained material derived from the Cascade Range and Sierra Nevada, but also contain lenses of clay and silt comprising lacustrine, marsh, and floodplain deposits (Page 1986).

The Delta is the central, low-lying region that includes tidally influenced portions of the Sacramento and San Joaquin rivers, as well as the Mokelumne and Cosumnes rivers. Flows conveyed from the Sacramento Valley through the Sacramento River, the San Joaquin Valley through the San Joaquin River, or more directly from the Sierra Nevada through the Mokelumne and Cosumnes rivers converge in the waterways of the Delta. The water and sediment that entered the Delta from its tributary rivers interacted in a complex way, leading to the development of thick layers of organic soils and a dendritic network of channels bordered by natural levees. The natural islands of the Delta were generally slightly elevated marshes subject to ponding or frequent inundation during high tides or flood conditions. Human activities to reclaim the Delta islands, described in “Geomorphology” below, caused the islands to subside and required the natural levees to be fortified and raised (Atwater et al., 1979; Florsheim et al., 2008).

Sierra Nevada Province

The Sierra Nevada Province encompasses the mountains of the Sierra Nevada and comprises primarily intrusive rocks, including granite and granodiorite, with some metamorphosed granite and granite gneiss. The province is a tilted fault block nearly 400 miles long, with a high, steep multiple-scarp east face and a gently sloping west face that dips beneath the Great Valley Province (CGS, 2002a). To the north, the Sierra Nevada Province is bounded by the Cascade Range and Modoc Plateau provinces. To the south, it is separated from the Transverse Range Province by the Garlock Fault. East of the Sierra Nevada Province, the Basin and Range Province extends east to Utah.

The central Sierra Nevada Province has a complex history of uplift and erosion. The greatest uplift tilted the entire Sierra Nevada block to the west. The high elevation of the Sierra Nevada leads to the accumulation of snow, including the Pleistocene glaciation responsible for shaping much of the range.

Snowmelt in the Sierra Nevada feeds the Sacramento and San Joaquin rivers and their eastside tributaries—the Yuba, Feather, American, Merced, Tuolumne, Stanislaus, and Mokelumne rivers. These large rivers and their smaller tributaries cut through the granitic rocks present in the upper watersheds of the Sacramento and San Joaquin rivers, and through intrusive formations and sedimentary and metamorphosed rocks in the lower watersheds. The metamorphic bedrock in these watersheds contains gold-bearing veins in the northwest-trending Mother Lode that are not present in the more northerly watershed of the Sacramento River or the more southerly watershed of the upper San Joaquin River (CGS, 2010a). At the western border, alluvium and sedimentary rocks overtop the Sierra Nevada Province. Occasional remnants of lava flows and layered tuff are present in the area at the highest elevations.

2.3.2 Soil Types

Soil cover in the watershed ranges from metasedimentary granitic and basaltic rock in the upper elevations to alluvial deposits in the valley areas. There is also volcanic rock in the northern area of the Watershed. The Watershed is moderately deep with soil classifications varying from sands, silts, and clays in the valley areas to porous volcanic areas in the northern end. Historic Delta soils range from highly mineralized soils to deep peats. The exposure of bare peat soils to air in some areas has caused oxidation, resulting in land subsidence or loss of soil on some of the Delta islands.

Development of individual soils is based largely on parent material, climate, associated biology, topography, and age. These factors combine to create the more than 2,000 unique soils in California. Because soil-forming factors are similar within physiographic regions, soils in the Central Valley are described here according to four distinct physiographic regions: valley basin, valley land, terrace land, and upland.

Valley basin and valley land soils occupy most of the Central Valley floor (Figure 2-3). Valley basin soils consist of organic, imperfectly drained, saline, and alkali soils in the valley trough and on the basin rims. Valley land soils consist of deep alluvial and eolian soils that make up some of the best agricultural land in California. Areas above the Central Valley floor, at higher elevations and on steeper slopes, support terrace land and upland soils. Overall, these soil types are not as productive as valley land and valley basin soils. Without irrigation, these soils are used primarily for grazing and timberland; with irrigation, additional crops can be grown. Soil types and locations are summarized below in Table 2-7.

The watershed is generally underlain by marine sedimentary rocks covered by more recent alluvial deposits, and to a lesser extent volcanic rocks. The levees and river sediments within the watershed are composed of alluvium deposits comprised of loose to medium dense, unweathered gravel, sand, silt and clay. These sediments from the Quaternary Period of the geologic time scale and are estimated to have been deposited 200 to 10,000 years before presently formed levees and floodplains along the Sacramento River.

Table 2-7 Summary of Soils within the Watershed

Physiographic Region and Soil Type	Location	Texture
Valley Basin		
Organic soils	Sacramento-San Joaquin Delta	Peat, organic
Imperfectly drained soils	Sacramento and San Joaquin Valley trough	Clays
Valley Land		
Alluvial soils	Alluvial fans and low terraces in the Sacramento and San Joaquin valleys	Sandy loam-loam
Terrace Land		
Brown, neutral soils	West side of the Sacramento Valley and southeat San Joaquin Valley	Loam-clay
Red-iron hardpan soils	East side of the Sacramento and San Joaquin Valleys	Sandy loam-loam hardpan
Upland		
Shallow depth to bedrock	Foothills surrounding the Central Valley	Loam-clay loams
Deep depth to bedrock	Higher elevations of the Sierra Nevada, Klamath Mountains, and Coast Ranges	Loam-clay loams

Source: University of California 1980

Valley Basin Soils

Valley basin soils occupy the lowest parts of the Central Valley and dominate Delta soils. These soils fall into three categories: organic soils, imperfectly drained soils, and saline/alkaline soils. Figure 2-3 shows the distribution of valley basin soils.

- **Organic soils** are so named, and are dark and acidic, because of their high organic matter content—12 percent or more by weight and typically more than 50 percent in the upper layers. Usually referred to as peat, these soils often form in areas that are frequently saturated with water (poorly drained), and are therefore common in the Delta. As described previously, these soils are prone to rapid oxidation; the development of Delta islands and tracts and the reduced inundation caused by levee construction and maintenance has led to considerable subsidence of Delta lands with this soil type.

- **Imperfectly drained soils** generally contain dark clays, and have a high water table or are subject to overflow under high-intensity precipitation events that exceed the soil's infiltration capacity. These soils are common in the troughs of the Sacramento and San Joaquin valleys, and consist in part of several thick lake-bed deposits.

Valley Land Soils

Valley land soils are generally found on flat to gently sloping surfaces, such as on alluvial fans. These well-drained and moderately well-drained soils have relatively high infiltration capacities, and include some of the best all-purpose agricultural soils in California. Both alluvial and eolian-deposited soils are present in the Central Valley. Figure 2-3 shows the distribution of valley land soils.

- **Alluvial soils** comprise calcic brown, noncalcic brown, and gray desert alluvial soils. Calcic brown and noncalcic brown alluvial soils are found in the Central Valley on deep alluvial fans and floodplains in areas of intermediate rainfall (10–20 inches annually). These two soils tend to be brown to light brown with a loamy texture that forms soft clods. Calcic brown soil is calcareous (primarily composed of calcium carbonate); noncalcic soil is usually neutral or slightly acid. Gray desert alluvial soil is found on alluvial fans and floodplains in areas of low rainfall (4–7 inches annually).

Terrace Land Soils

Terrace land soils are found along the edges of the Central Valley at elevations just above the valley floor. Several groups of terrace soils surround the floor of the Central Valley. Two of the more widespread groups are discussed below..

- **Brown, neutral soils** consist of moderately dense, brownish soils of neutral reaction. These soils are found in areas that receive 10–20 inches of rain per year. In the southeast San Joaquin Valley these soils tend to have a clay texture, while on the west side of the Sacramento Valley these soils have a loamy texture.

- **Red-iron hardpan soils** have a red-iron hardpan layer and are found along the east side of the Sacramento and San Joaquin valleys. These soils consist of reddish surface soil with a dense silica-iron cemented hardpan that is generally 1 foot thick. Some of these hardpan soils have considerable amounts of lime. These soils occur in areas that receive 7–25 inches of rain per year.

Upland Soils

Upland soils are found on hilly to mountainous topography and are formed in place as the underlying parent material decomposes and disintegrates. The more widespread upland soil groups are those with shallow depth, moderate depth, and deep depth to bedrock. Two upland soil groups, shallow depth and moderate depth, are more common because of their geographic locations and elevations. Upland soils are found around the perimeter of the Central Valley. Soils on the west side of the valley have developed mostly on sedimentary rocks while those on the east side typically developed on igneous rocks. Upland soils are well drained or somewhat excessively drained.

- **Upland soils with shallow depth to bedrock** are found in the foothills of the Sierra Nevada and Coast Ranges that surround the Central Valley. The soils have a loam to clay-loam texture with low organic matter, and some areas have calcareous subsoils. These soils usually have a shallow depth to weathered bedrock, less than 2 feet, and are subject to overland flow. These soils are found in areas of low to moderate rainfall that support grasslands used primarily for grazing. Tilled areas are subject to considerable erosion.
- **Upland soils with deep depth to bedrock** are found at the higher elevations in the Sierra Nevada and Coast Ranges on hilly to steep topography. These soils are characterized by moderate to strongly acidic reaction, especially in the subsoils, which can extend 3–6 feet before reaching bedrock. Bedrock consists of metasedimentary and granitic rocks. Soils forming on granitic rocks consist of decomposed granitic sands. These soils receive 35–80 inches of precipitation per year and support extensive forests.

2.3.3 Seismic Activity

The Coast Range, Great Valley, and Sierra Nevada provinces are subject to minor tectonic activity. Fault activity is shown in Figure 2-4 and province locations are shown in Figure 2-5.

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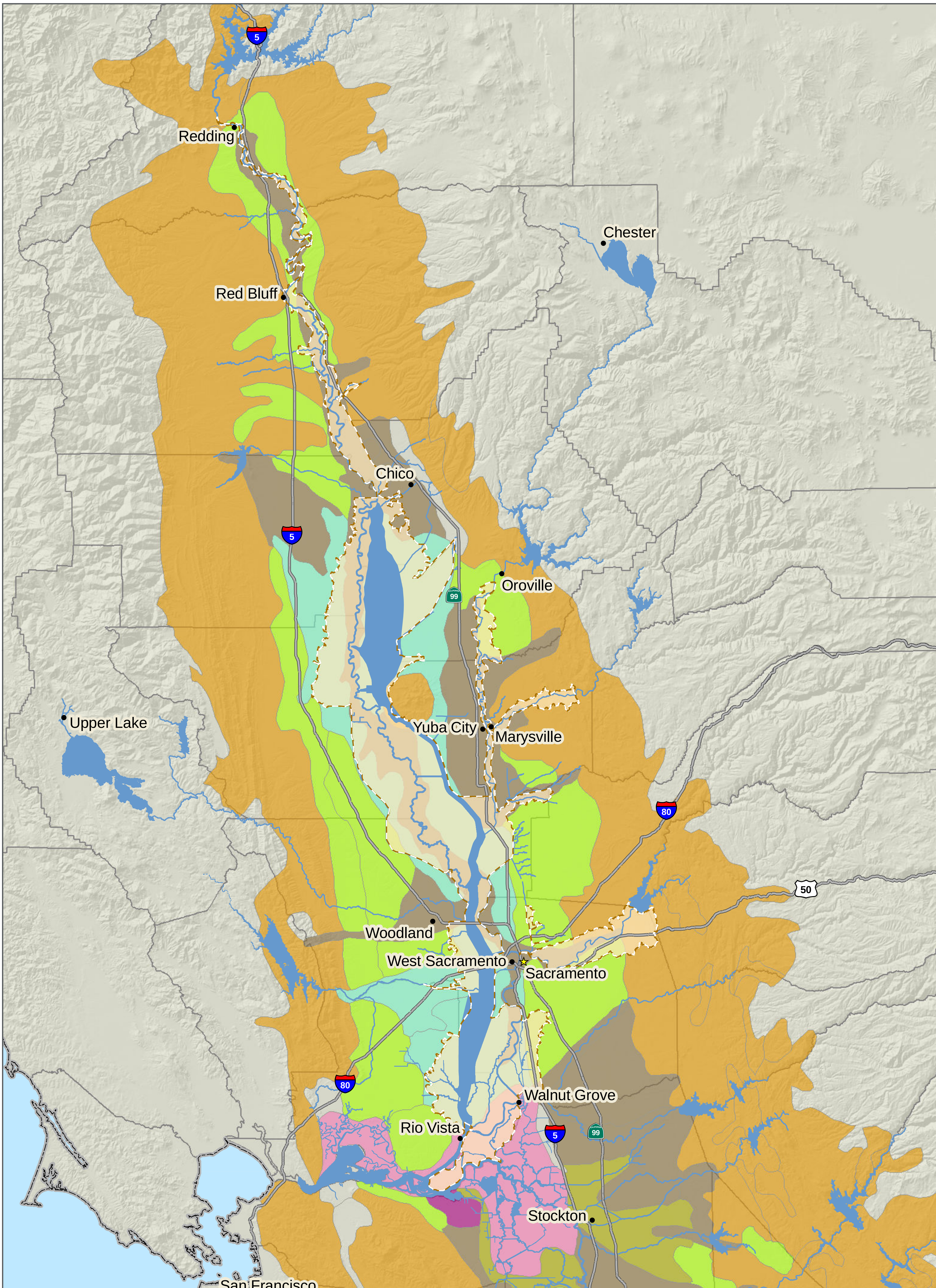

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Sacramento District

Generalized Soil Types

CVIFMS Opportunity Areas

Soil Types

- Terrace Soils
- Upland Soils
- Valley Basin Soils, Imperfectly Drained Soils
- Valley Basin Soils, Organic Soils
- Valley Basin Soils, Saline and Alkali Soils
- Valley Land Soils, Aeolian
- Valley Land Soils, Alluvial

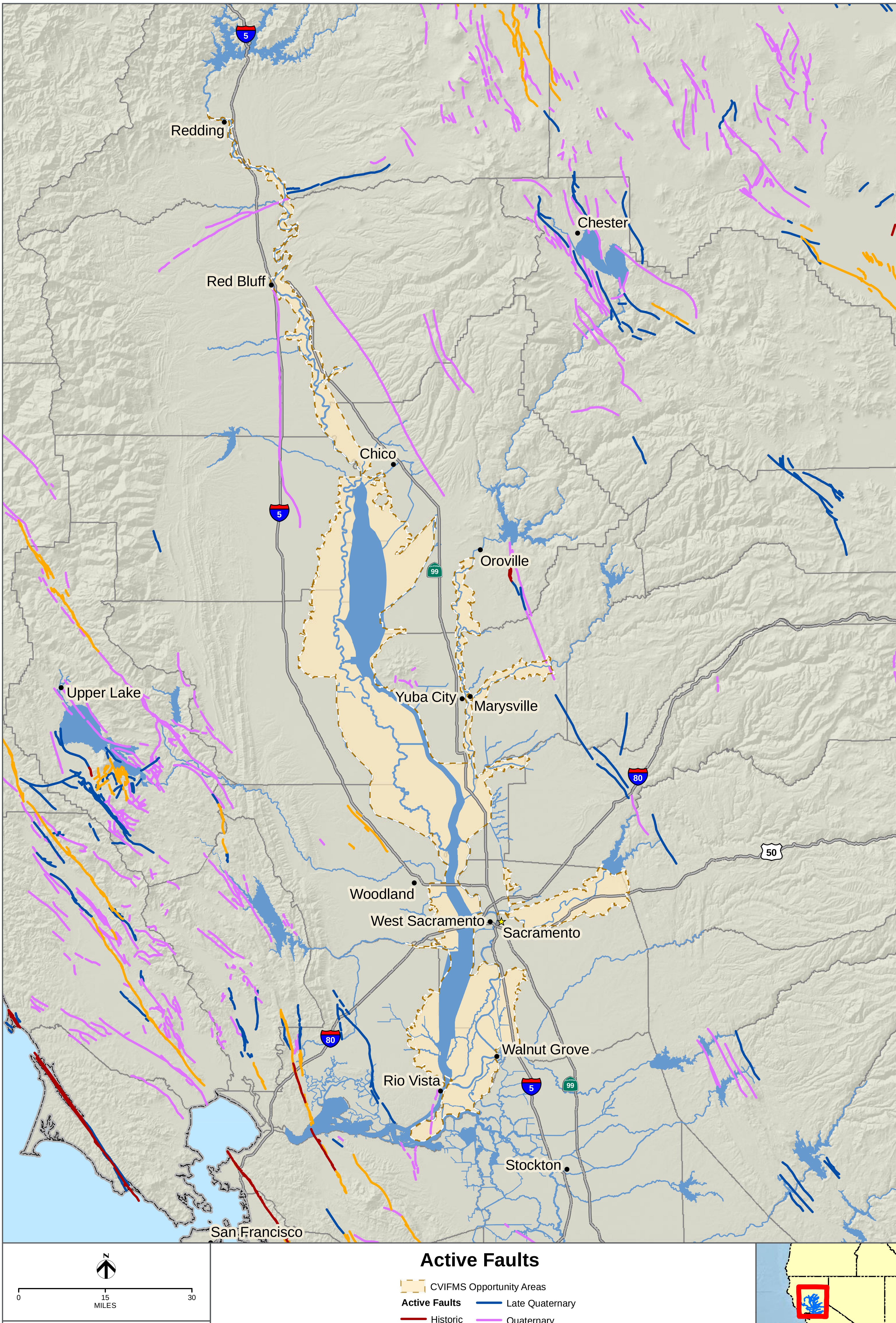
Figure 2-3

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983
CA State Plane II Feet

PATH: F:\PROJECTS\028_233549_CH2MHILLDWR_CVFPP_TO_14_09\MAP_DOCS\MXD\REPORT\FIGURE_3.10-4_CVFPIA_GENERALIZED_SOILS_11X17.MXD - USER: AARNOLD - DATE: 10/14/2015

Source: 2012 CVFPP



Active Faults

Figure 2-4

US Army Corps of Engineers® Sacramento District

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983 CA State Plane II Feet

PATH: F:\PROJECTS\028_233549_CH2MHILLDWR_CVFPP_TO_14_09\MAP_DOCS\MXD\REPORT\FIGURE_3.10-2_ACTIVE_FAULTS_11X17.MXD - USER: AARNOLD - DATE: 10/14/2015

Source: 2012 CVFPP

California Geological Survey Geomorphic Provinces

CVIFMS Opportunity Areas

CGS CA Geomorphic Provinces

Basin and Range
Cascade Range
Central Valley
Coast Range
Klamath Mountains
Modoc Plateau
Sierra Nevada

Figure 2-5

US Army Corps of Engineers®
Sacramento District

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983
CA State Plane II Feet

PATH: F:\PROJECTS\028_233549_CH2MHILLDWR_CVFPP_TO_14_09\MAP_DOCS\MXD\REPORT\FIGURE 3.10-1 CGS_CA_GEOMORPHIC_PROVINCES.MXD - USER: AARNOLD - DATE: 10/14/2015

Source: 2012 CVFPP

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Both the Sacramento Valley and Sierra Nevada provinces are part of the Sierra Nevada microplate (also referred to as the Sierran microplate), which is one component of a broad, tectonically active belt that accommodates motion between the North American plate to the east and the Pacific plate to the west. On its eastern side, the Sierra Nevada microplate is bounded by the Sierra Nevada frontal fault system, marking the beginning of the Basin and Range Province. This system, marked by the steep eastern escarpment of the Sierra Nevada, is characterized by normal and right-lateral strike-slip faults[2]. To the west, the microplate is bounded by the fold and thrust belt of the Coast Range Province (Wakabayashi and Sawyer, 2001).

Relative to the North American plate to the east, the right-lateral movement of the Sierra Nevada microplate is 10–14 millimeters (mm)/year (0.4 to 0.6 inches (in)/year). The microplate's right-lateral motion relative to the Pacific plate to the west is much higher, at 38–40 mm/year (1.5 to 1.6 in/year). Much less deformation occurs within the Sierra Nevada microplate than along its boundaries. However, vertical deformation along the frontal fault system has caused the Sierra Nevada mountain block to tilt toward the west or southwest (Bartow 1991; Wakabayashi and Sawyer, 2001). Westward tilting has been concurrent with 5,610–6,330 feet of uplift by the Sierra Nevada crest over the past 5 million years—uplift of 0.34 to 0.39 mm/year (0.013 to 0.015 in/year) (Wakabayashi and Sawyer, 2001). This uplift triggered rapid stream incision and deep canyon erosion by the San Joaquin River and its tributaries, which drain the range (Wakabayashi and Sawyer, 2001).

The easternmost fault subsystem separating the Central Valley from the Coast Ranges is the Great Valley blind thrust, part of the San Andreas Fault system. This reverse fault separates Great Valley sequence deposits to the east from Franciscan rocks to the west. The fault subsystem consists of at least 14 segments covering an area of more than 300 miles, although precise locations of the fault's surface traces are not well documented (USGS 1996). The San Andreas fault system includes many smaller faults with varying rates of motion and seismic risk. Within the study area, the San Andreas, Calaveras, and Hayward faults are three of the most active faults in this system. The San Andreas Fault is a northwest-trending fault in the northern, central, and southern Coast Ranges. The Calaveras and Hayward faults are northwest-trending faults in the central Coast Ranges. The Great Valley thrust system is thought to accommodate 0.5 to 1.5 mm/year (0.02 to 0.06 in/year) of motion (CGS 2010b; USGS 1996).

2.3.4 Future Without-Project Conditions

Basic physical conditions in the Sacramento River Watershed are expected to remain relatively unchanged in the future. No major changes to area geology or soils are foreseen.

[3] The program considers events ranging from those with a greater than 99 percent chance of occurrence in any given year to those with 0.2 percent chance of occurrence in any given year.

2.4 Land Use Overview

Below are discussions of historic and current land use in the study area as is relevant to this watershed planning process.

2.4.1 Historic Land Uses

California's socioeconomic and public policy history has been an important influence on land use and flood management in the Central Valley. Major population growth in California, spurred by the discovery of gold in the Sierra Nevada in 1848, drove development of multiple industries that affected land use, and hence, increased the potential for flood events in the Central Valley.

Spanish missionaries and explorers settled in California before the discovery of gold and forcibly moved indigenous peoples from small scattered villages (which the Spaniards termed rancherias) to central communities called pueblos. Pueblos, usually sited around military presidios or Franciscan missions, used small-scale water development projects to provide community-owned water. Water development structures included minor dams and ditches to divert water for irrigated agriculture. In addition to pueblos, the Spanish monarchy also granted private property—ranchos—to politically favored individuals. The water rights associated with ranchos were usually only for watering livestock, although some small-scale irrigation was also conducted. Spanish settlement resulted in only limited changes to California's rivers and streams. As populations grew in the late 1700s and early 1800s, logging, farming, and grazing activities increased, but these operations were small in scale and had little impact on water resources (Mount 1995).

Spurred by the Gold Rush, grazing and agricultural development occurred throughout the foothills and Central Valley to provide food for the rapidly growing population. The Central Valley became California's most productive farmland. The majority of the early levee systems in the Sacramento and San Joaquin River Basins and the Delta were built to maximize agricultural development in the fertile floodplains (Mount 1995).

Before agricultural development started in the 1850's and 1860's, the Delta was essentially a broad expanse of water-based habitat and natural channels. Large-scale reclamation of the Delta for agriculture began in 1868; by 1900, most of the lands with mineral-organic soils, around the Delta's exterior, were reclaimed. The final period of Delta reclamation occurred between 1900 and 1920 on lands in the Delta's interior. The result of these reclamation efforts is largely what is seen as the Delta today—approximately 700 miles of meandering waterways and 1,100 miles of levees protecting more than 538,000 acres of farmland, as well as homes and other structures.

Until the 1960s, land uses in the Sacramento and San Joaquin valleys were principally agriculture and open space, with urban uses limited to a handful of small cities such as Sacramento, Stockton, and Fresno and scattered small farm communities. Although agriculture and food processing are still the major industries in the Sacramento and San Joaquin valleys, population expansion from the San Francisco Bay Area and local industrial growth over the past 30 years have created major urban centers throughout the Sacramento Valley. The land area devoted to agriculture peaked around 1959, and has since gradually declined as urban areas continued to expand into the floodplains of the Sacramento and San Joaquin Rivers.

2.4.2 Current Land Uses

Today, the Sacramento River Basin includes large areas of forests such as the Mendocino and Trinity National Forests in the Coast Range, Shasta and Lassen National Forests in the southern Cascades, and the Plumas, Tahoe and Eldorado National Forests on the western slopes of the Sierra Nevada. The basin is also home to Lassen Volcanic Park, which covers 106,000 acres centered around Lassen Peak, the southernmost Cascade volcano. Whiskeytown- Shasta-Trinity National Recreation Area, which is over 200,000 acres in size, straddles much of the upper Sacramento and Trinity Rivers, centering around three popular human-made lakes—Shasta Lake, Trinity Lake, and Whiskeytown Lake. Many other state parks and recreation areas lie within the watershed.

In the watershed upstream of Shasta Dam, much of the land area is managed by the U.S. Forest Service for multiple uses such as timber production, grazing, and recreation. Large tracts of mixed conifer forest are privately owned and used for commercial timber production. Particularly in the more arid northern and eastern portions of the basin, high desert forest and sagebrush lands are managed by the Bureau of Land Management (BLM). Alluvial valleys in the upper watershed are mostly privately owned and used for irrigated agriculture and cattle ranching.

Most of the Sacramento Valley has been intensely cultivated, with some 2 million acres of irrigated farmland growing crops that include rice, wheat, orchard fruits and olives, corn, alfalfa, tomatoes, and vegetables. Along with this agricultural base, the basin is also home to about 2.2 million people, almost half of whom live in the Sacramento metropolitan area. Other larger cities in the basin are Redding, Chico and Yuba City/Marysville. The Sacramento River Basin covers all or most of nine counties and extends into portions of 11 other counties (Figure 2-6). The Sacramento Valley can be broken into six subregions that include distinct segments of the Sacramento River and/or lands surrounding major tributaries that feed the Sacramento River. Although all are part of the Sacramento Valley watershed, varying elevations, soil types, combinations of public and private land ownership, and land use histories differentiate them. Following are more detailed discussions for each of the seven subregions.

Upper Sacramento River and Tributaries

In addition to the headwaters of the Sacramento River, Shasta Dam stores and regulates the flows of the two primary upper watershed tributaries, the McCloud and Pit Rivers. Recreation and tourism are two of the primary drivers of the local economy in the Sacramento River headwaters upstream of Shasta Dam. While timber production is still prominent, many businesses and communities in the watershed have shifted their economic base away from that of logging and forest products industries to take advantage of the region’s abundant recreational and scenic qualities. Attesting to the high-quality source waters, two waterbottling plants operate in the headwaters.

Rural lifestyles and low population numbers generally characterize the McCloud River subwatershed. Timber and tourism are among the top industries for the area's residents. The majority of the watershed is characterized by a checkerboard land-ownership pattern. A corridor of mostly private land follows the McCloud River, and large blocks of Shasta-Trinity National Forest occur throughout the watershed. The Nature Conservancy owns and manages a 2,330-acre preserve along the river corridor below McCloud Reservoir.

Early European settlers recognized the hydropower opportunity on the Pit River system and in 1920 embarked on establishing the largest hydropower system in northeast California at that time. In the following years, drainage and water management improvements were made to expand irrigated agriculture in the valley. Irrigated agriculture (pasture, hay, and some specialty crops such as mint and wild rice), livestock production (cattle and sheep), timber production, and recreation (camping, hiking, hunting, and fishing) are the principal economic drivers in the Pit River subwatershed. The Goose Lake Basin in the upper Pit River is an area of mixed ownership and multiple land uses. Today, the local economy is supported mostly by ranching, timber production, and recreation. Limited industrial uses in the basin include a mercury mine, gravel pits, small gold mines, and lumber mills. Tourism and recreation are very important to the local economy.

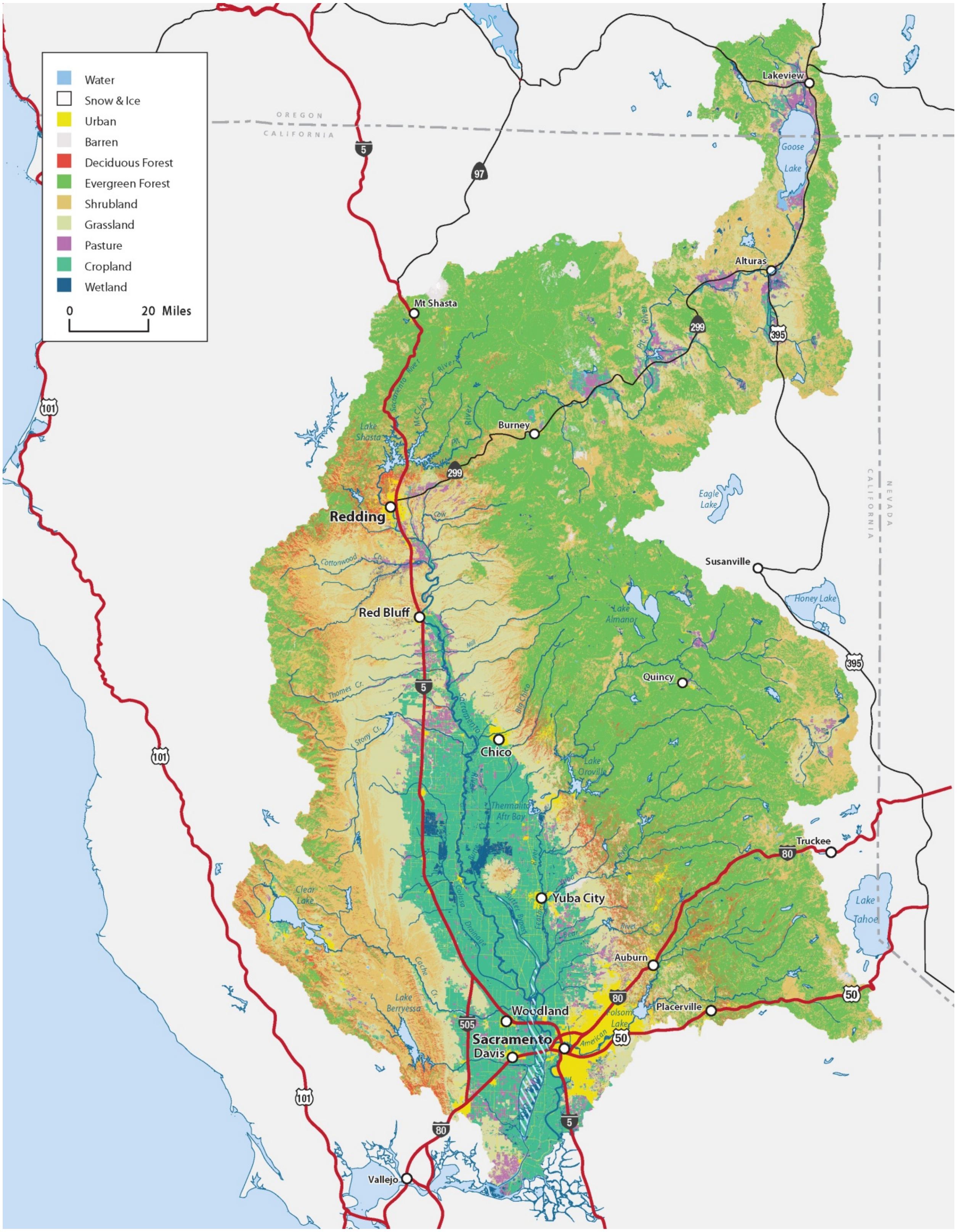


Figure 2-6 Current Land Use within the Sacramento River Watershed

Rural lifestyles with low population density characterize the Hat Creek, Burney Creek, and Fall River areas of the Pit River subwatershed. A large percentage of the watershed is held by the U.S. Forest Service and the National Park Service. Large private timber companies also manage a significant portion of the watershed. Private ranch lands on the valley floor support livestock production, pasture and hay, and recreation. The local economy has been hurt in recent years by the decline in the forest products industry. Nearby, Lassen Volcanic National Park and McArthur–Burney Falls Memorial State Park receive approximately 200,000 visitors annually, providing some benefit to the local economy.

Overall population in the Sacramento River headwaters is sparse (approximately 11,000) and most residences occur in the two Siskiyou County communities of Mount Shasta and Dunsmuir. The largest community in the McCloud River subwatershed is the town of McCloud with a population of 1,101 (2010). Most residents of the Goose Lake Basin live in Lakeview, Oregon, (population 2,294) or the small, rural communities of New Pine Creek and Davis Creek. The largest city in the Upper Pit River Watershed is Alturas, with a current population of 2,827. Other communities include Adin, Bieber, McArthur, and Fall River Mills. The largest town in the Fall River watershed is Fall River Mills (population 573). McArthur is another center of population.

I-5 and the Union Pacific Railroad are the main north-south transportation corridors within this subregion.

Western Foothills and Tributaries

The Western Foothills and Tributaries subregion includes the western tributaries of the Sacramento River south of Shasta Dam, extending from the Clear Creek subwatershed south to the Putah Creek subwatershed. Land use in Upper Clear Creek includes residential, recreation, commercial timber production, and mining. Historically, placer and tunnel gold mining was prevalent in the area, reaching their peak in 1900 to 1915, although some of the mines are still being operated today. The historic mining town of French Gulch (population 346) is now a center for rural residential development and tourism and is within a popular recreational area for activities such as camping, fishing, boating, hunting, and nature study. Lower Clear Creek is partially located within the city limits of Redding, industrial (sand and gravel) and commercial enterprises (lumber mills, electrical generation, and auto shops) exist along Clear Creek Road, which runs adjacent to much of the Lower Clear Creek stream zone. In recent years, the BLM has attempted to acquire and manage much of the land area along Clear Creek, and there is now a public access greenway that follows Clear Creek most of the way from the Whiskeytown Dam to the Sacramento River (a distance of approximately 9 miles). Swimming, hiking, fishing, gold panning, and kayaking are popular in this public land area. Clear Creek near the Sacramento River confluence is a densely populated area, and the Redding municipal wastewater treatment plant is located here, with discharge to the Sacramento River.

In general, agriculture, timber, and public lands cover most of the land area in the Cottonwood Creek subwatershed. Upper reaches of the south fork of Cottonwood Creek lie within the Yolla Bolly Wilderness Area on the Mendocino National Forest.

Large private ownerships of ranch and grazing land are common, and much of this land base is covered in the Land Conservation Act of 1965 (Williamson Act). The town of Cottonwood is the major urban center (population 3,316), and there are several other smaller, unincorporated community centers (Igo, Ono, Beegum, Platina, and Bowman).

Rural lifestyles and low population density (approximately 5 persons per square mile) generally characterize the tributary watersheds in western Tehama County. Ranching, farming, and timber are the primary resource activities throughout the subwatershed. Cattle, pasture and hay, orchards, and some grain crops dominate agricultural land use. Gravel extraction in and adjacent to stream channels historically has been one of the principal industries. The watershed is rich in recreational resources such as hiking, camping, hunting, and fishing, particularly in the upper watershed on the Mendocino National Forest. Maintaining the rural agricultural lifestyle is a major concern for much of the watershed community. The largest community is Red Bluff with a population of 14,076. Other towns, mostly along the I-5 corridor, include Corning, Tehama, Gerber, and Paskenta.

Public lands, including the Mendocino National Forest, BLM-managed lands, and State Lands Commission lands make up a large percentage of the area in the Stony Creek tributary subwatershed. The USACE's Black Butte Dam and Reservoir is also located on the lower creek. Historically important, timber harvesting saw a dramatic decline in the 1990s, going from 85 million board feet harvested then, to around 3 million board feet harvested annually on National Forest lands now. On the private ranch lands, cattle, sheep, and irrigated hayfields contribute to the commercial agricultural economy. The upper portion of this subwatershed is sparsely populated. Lower Stony Creek is mostly private land and supports agriculture (dairy operations, orchards, and annual crops such as wheat, corn, and forage grasses), livestock grazing, gravel mining, and rural residences. The city of Orland south of Stony Creek has a population of 7,291 (2000).

Much of the upper reach of Cache Creek (just below Clear Lake) passes through a steep, inaccessible canyon. The creek becomes more accessible once it reaches SR 16 and flows through Capay Valley, which includes the unincorporated communities of Rumsey, Guinda, Brooks, Capay, Esparto, and Madison. The creek then flows north of Woodland, the largest town in the subwatershed (population 55,468) and the county seat of Yolo County. Cache Creek is very popular for recreationists in the summer months, providing opportunities for kayaking, rafting, canoeing, innertubing, hiking, and camping. In October 2005, Cache Creek was added to California's Wild and Scenic Rivers System, which protects 31 miles of the river from land conversion, curtailing construction of any new dams and water diversions.

Capay Valley supports a wide variety of agriculture, including almonds, walnuts, pistachios, oranges, mandarins, and many varieties of organic produce. In 1985, the Yocha Dehe Wintun Tribe opened a bingo hall in the Capay Valley community of Brooks. It was renovated in 2002 and completed in 2004 as a destination casino resort that includes 200 rooms, day spa, nine restaurants, and an 18-hole championship golf course. Today, the tribe is the largest private employer in Yolo County. Gravel mining continues in the lower watershed, providing another major source of income for local residents.

The Putah Creek subwatershed encompasses four counties: Lake, Napa, Solano, and Yolo. Land in the upper subwatershed is used mainly for recreation and rangeland. Putah Creek and its respective lakes offer excellent swimming holes, opportunities for boating, and bicycling and jogging trails. Fishing is a major recreational activity in this subwatershed. On an annual basis, Putah Creek has one of the highest rates of angler use per mile of any similar-sized stream in California.

The major feature in the Lower Putah Creek watershed is University of California, Davis (UC Davis). UC Davis established the Putah Creek Riparian Reserve in 1983 to preserve creekside habitat on campus property for research, teaching, and wildlife habitat protection. The Putah Creek Riparian Reserve is approximately 640 acres, along 5.5 miles of Putah Creek, on the UC Davis campus. The reserve is a natural haven for wildlife in an urbanized and agricultural landscape and presents a unique opportunity to conduct field research on a riparian system near the central campus.

Eastern Tributaries

The Eastern Tributaries subregion encompasses the tributaries on the east side of the Sacramento Valley starting in the north with the Churn/Stillwater Creek subwatershed in east Redding and going south to and including Butte Creek. These are subwatersheds that drain to the Sacramento River from the Southern Cascade Mountains and Sierra Nevada (north of the Feather River subwatershed).

Population in the Stillwater-Churn Creek subwatershed has been steadily on the rise despite the slowdown in recent years. From 1960 to 2000, Shasta County's overall population nearly tripled. Of all lands located in the subwatershed, 96 percent is privately owned and 4 percent is administered by three Federal agencies (BLM, U.S. Forest Service [USFS], and U.S. Bureau of Reclamation [USBR]). City and county general plans have zoned nearly 65 percent of the subwatershed for urban and suburban residential use, 12 percent for commercial/industrial, 10 percent for parks and open space, and 13 percent for mining and agriculture. In the rural portion of the subwatershed, hunting, fishing, equestrian and off-road vehicle (ORV) use are popular recreational activities. The success and popularity of Redding's Sacramento River trails system, the Clover Creek Preserve, and the McConnell Foundation's Lema Ranch have increased the public's interest in expanding opportunities for local water-oriented recreation and open space.

The Cow Creek subwatershed is dominated by privately held lands. At just over 30% of the land base, timber production is a significant commercial activity on private lands (major landowners include Roseburg Resources Company, Beaty and Associates, and Sierra Pacific Industries). Ranching and livestock production are a major agricultural component contributing to the rural character and country lifestyle so valued by residents of this subwatershed. The Williamson Act, which offers tax incentives for preservation of agricultural lands, is an important mechanism in maintaining the rural lifestyle, and currently about 75,000 acres in the Cow Creek subwatershed are enrolled in that program. Residential development is centered around the small communities of Palo Cedro, Bella Vista, Millville, Oak Run, and Whitmore. Outdoor activities such as camping, fishing, hunting, and ORV use are important pastimes for most residents and also significantly contribute to the local economy. The Latour State Forest is the largest publicly owned parcel in the subwatershed.

The Bear Creek tributary subwatershed is sparsely populated, and land use is predominantly timber production and livestock grazing. Agricultural operations (mostly irrigated pasture) are sustained by surface water diversions and groundwater pumping. The largest community is Shingletown, with a population of approximately 2,283. One of the principal management concerns of the subwatershed residents is the possibility for an increase in rural residential development and its potential impact on open space, country lifestyle, and wildland resources.

A prominent feature of the Battle Creek tributary subwatershed is the Lassen Volcanic National Park, established in 1916 as this country's thirteenth National Park. It includes four major geophysical regions; four National Recreation Trails; the world's largest plug dome volcano; a 900-foot escarpment created from a fault fracture; habitat for 360 species of wildlife including bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), black bear (*Ursus Americana*), mule deer (*Odocoileus hemionus californicus*), and rainbow trout (*Oncorhynchus mykiss*); and expansive vistas of sage, pine, fir, and Sierra mountain streams. The Lassen National Forest surrounds the park and encompasses 1.2 million acres of recreational lands and productive commercial timber stands. The mid-reaches of the Battle Creek Watershed subwatershed include thousands of acres of private timberland, family-owned ranches, and small farms producing a variety of products such as apples, alfalfa, Christmas trees, and grapes. The communities are small and unincorporated. They include Manton (population 347), Mineral (population 123), and Shingletown (population 2,283). There are several private, state, and federal fish hatcheries that take advantage of the large supply of cold, clean spring water. An expansive system of dams, canals, and powerhouses was acquired in 1916 by Pacific Gas & Electric (PG&E) and has been in operation since that time. The BLM Sacramento River Management Area in the Lower Battle Creek Watershed subwatershed is managed for natural values, outdoor recreation, and protection of archaeological resources.

Land ownership in the Tehama East subwatershed is approximately 24% public and 76% private. Many northern California cattle ranchers use Tehama County as winter grazing land. Cattle that are summered in the mountain meadows are brought to the Tehama East subwatershed foothills to graze during the winter and spring. Irrigated agriculture is predominantly orchard crops that include walnuts, prunes, almonds, and olives. Timber has always played a large role in the economy of this area; however, in recent years, this resource activity has seen about a 50% decline compared to harvest rates and timber value in the 1980s. With the exception of the city of Red Bluff, population in the subwatershed is small and widely scattered. Rural communities include Dairyville, Lyonsville, and Paynes Creek.

The Mill Creek subwatershed was first inhabited by the Yahi people for approximately 4,000 years, until dominant European settlement in the middle 1800s. Lassen National Forest, Lassen Volcanic National Park, and the state-owned Tehama Wildlife Area constitute the majority of the public land holdings in the subwatershed. The Tehama County General Plan lists five major land use designations in the Mill Creek subwatershed; timberlands, grazing lands, agricultural lands, recreational lands, and residential lands. Collins Pine Company and Sierra Pacific Industries are the largest private timberland owners with about 10,000 acres combined. Livestock grazing occurs throughout the subwatershed on both public and private lands. Agriculture occurs on the valley floor from the Sacramento River to the mouth of the Mill Creek canyon and consists primarily of irrigated pasture, prunes, almonds, and walnuts. Residential development and commercial businesses are mainly adjacent to the SR 99 corridor, including the community of Los Molinos that has a population of about 2,037. Outdoor recreation, including camping, hiking, fishing, hunting and wildlife viewing, is a major activity. There are many public campgrounds on both the National Forest and Lassen Volcanic National Park lands.

Land in the Deer Creek Watershed subwatershed is a mix of public (USFS) and private ownership. The 65,000 acres of Lassen National Forest that comprise the upper subwatershed are popular for hunting, fishing, and hiking, and several public campgrounds are located along Deer Creek. The upper subwatershed also has a large acreage of private commercial timberland. The mid- and lower-elevation lands, on the other hand, are dominated by large private ranches. On the valley floor near the Sacramento River, irrigated agricultural land is mostly in pasture and orchard crops. The main transportation routes are state SR 36 and SR 32 through the upper watershed area and SR 99, which crosses the lower watershed between Red Bluff and Chico. There are no population centers other than the small town of Vina near the point that Deer Creek merges into the Sacramento River. The Abbey of New Clairvaux is located in Vina.

The Big Chico Creek subwatershed is also located in the study area. California State University at Chico (CSU Chico), with its population of approximately 17,000 students (plus faculty and staff), comprises an important part of the local economy.

Several other large government and private employers also are located in the watershed. CSU Chico faculty and students, along with many public and private schools, take advantage of the educational opportunities provided by the creek and have provided valuable data on conditions in Big Chico Creek and the subwatershed overall.

The city of Chico, with an estimated population of 86,187 is the largest urban center in the subwatershed. This diverse community is the home to CSU Chico; the University greatly influences the character of the city and provides many diverse benefits to the community and subwatershed.

In recent years, acquisitions of large tracts of private land along the creek, along with the City-owned Bidwell Park (at 3,670 acres one of the largest city parks in the United States) provide thousands of acres along the creek corridor for public use.

The new Chico Creek Nature Center is an environmental education and interpretive center focusing on Bidwell Park and Big Chico Creek, and their natural resources, and is designed to foster environmental stewardship in both adults and children.

Recreation opportunities also abound in the subwatershed. In the upper regions, more rural pursuits such as hunting, fishing, mountain biking, horseback riding, and camping are available. Residential development, forestry, grazing, and irrigation agriculture are the main land uses. In the lower subwatershed, urban recreational examples include playgrounds, bicycling and hiking paths, parks, and golf courses, while State and Federal wildlife areas in the lower subwatershed provide valuable wetland habitat, particularly for waterfowl.

Much of the Upper Butte Creek subwatershed is forest land, owned in large part by private timber companies and the Lassen National Forest. The Butte Meadows area is a popular multi-season recreation destination. Considerable portions of the canyon reach are rugged and privately owned, making overland access difficult. Once the creek exits the canyon, much of the land is held in large agricultural parcels.

Agriculture is very important in the Upper Butte Creek subwatershed, particularly in the lower portion, with rice production as the dominant crop. Significant acreage is also dedicated to cattle grazing, orchards (almonds, walnuts, prunes, etc.), and row crops. Timber production and recreation are the primary activities in the upper subwatershed. Fishing, hunting, cycling, hiking, skiing, water sports, nature study, and many other recreational opportunities abound in the watershed, on both public and private lands. Of particular note are the large numbers of waterfowl hunting clubs in the lower subwatershed, generally associated with rice fields and wildlife areas managed by private and government entities. This area is an important stop on the Pacific Flyway for migratory waterfowl.

Feather River and Tributaries

The Feather River and Tributaries subregion includes all waters of the Feather River from its headwaters in the Sierra Nevada downstream to its confluence with the Sacramento River. This subregion also captures the Yuba and Bear River tributary subwatersheds.

Sixty-five percent of the Upper Feather River subwatershed contains land that is publicly owned and administered by the USFS (Plumas National Forest). Communities in the subwatershed traditionally have been dependent on resource-based industries such as agriculture, grazing, mining, and logging. In recent times there has been a shift in dependence on these resource-based industries to more service-based industry such as tourism. This shift also has seen an increased demand for rural residential and resort development. There are no large metropolitan areas in the watershed, and the population density is low (8.2 persons per square mile). The majority of the subwatershed population, approximately 33,000 residents, resides in the communities of Quincy, Greenville, Portola, the Almanor Basin, and Indian Valley.

There are several distinct social groups, including longtime residents employed in the logging, lumber, and agricultural industry; urban emigrants; government workers; retirees; and the business community. Ranching and cattle production is the principal agricultural land use. Timber harvesting and lumbering, once predominant, are being replaced by service-sector and recreation-based jobs.

The Lower Feather River subwatershed includes the expanding urban centers of Yuba City (population 64,925), Marysville (population 12,072), and Oroville (population 15,546). Population in this tri-county area is expected to double in the next 40 years. Agriculture is a significant source of jobs and revenue; income from agriculture and timber production exceeded $1.3 billion in 2005. Rural outdoor recreation is important in the subwatershed also, with most activities centered around rivers, creeks, and lakes. Multiple private and public entities provide campgrounds, marinas, hunting clubs, and resorts to the general public.

Recreation and tourism are two of the primary drivers of the local economy in the Yuba River subwatershed. Thirty-nine miles of the Lower South Yuba River (between Lake Spaulding and Englebright Reservoir) are designated as a California Wild and Scenic River and federally recommended as a Federal Wild and Scenic River. The area is used heavily for recreational purposes. While timber production is still prominent, many businesses and communities in the subwatershed have shifted their economic base away from that of logging to take advantage of the region’s abundant recreational and scenic qualities. Overall population is sparse and most residents reside in Nevada City in the upper subwatershed (population 3,068), and Marysville in the lower subwatershed (population 12,072). The subwatershed also includes South Yuba River State Park located near the town of Bridgeport.

There are more than 990 miles of streams, creeks, and rivers within the Bear River subwatershed. This subwatershed also contains more than 2,000 miles of roads, creating one of the highest road densities of any subwatershed in the Sierra Nevada region. Consequently, approximately 45 percent of the streams are within 100 meters (~330 feet) of a public road.

In the upper subwatershed, PG&E maintains a picnic ground, visitor center, and the publicly accessible Sierra Discovery Trail. The upper subwatershed also includes the community of Grass Valley (population 12,860), home to the Empire Mine State Historic Park and Empire Mine—one of the oldest gold mines in California. Historical reminders of Native Americans and the gold-rush era are woven throughout the landscape, and gold prospectors continue to travel to the area to pan for gold. Below Camp Far West Reservoir, the Bear River flows through privately owned land that is developed largely for agriculture. It also flows through Beale Air Force Base, built in 1942 and home to the 9th Reconnaissance Wing of the U.S. Air Force.

American River

The American River subregion originates at the crest of the Sierra Nevada just west of Lake Tahoe, within Tahoe and El Dorado National Forest boundaries. The American River has three forks: the North, Middle, and South. Folsom Dam and lake, located at the confluence of the North and South Forks, divides the upper and lower subwatershed.

Approximately 85 percent of the canyons in the upper subwatershed are Federally owned public lands. The main communities in the lower subwatershed are Placerville, Auburn, Foresthill, and El Dorado Hills. An increase in the population over the past decade has been attributed to an increase in professional services, industries, and residential development.

This subwatershed is heavily used for recreation. The rivers offer a wide variety of whitewater recreation opportunities, including Class IV and V whitewater adventures. More than 100 miles of trails provide access for hikers, anglers, and other recreationists. Winter months provide skiing and snowmobiling opportunities. The Middle Fork is used extensively for both motorized and non-motorized recreation, including fishing, whitewater adventuring, bicycling (mountain and road), horseback riding, trail running, and hiking. It also contains areas used for hydroelectric generation, mining, and agricultural timber cultivation and harvesting. Likewise, the South Fork also has multi-use recreation areas, including the Rubicon Trail for motorized adventuring, and whitewater rafting. The South Fork also features Coloma, the site where gold was discovered in California in 1848. Recreational gold panning is a popular family activity.

The Lower American River headwaters are located in the town of Folsom (population 72,209) and flow westward through the communities of Orangevale, Fair Oaks, Carmichael, and into the city of Sacramento (population 466,488). The watershed is highly urbanized and relies on a network of levees to protect the area from flooding.

Bordering both sides of the Lower American River is the American River Parkway Trail, a 30-mile paved bicycle and trail network that provides a greenbelt area from Nimbus Dam to the confluence of the Sacramento River. Folsom Lake and Lake Natoma also provide a surplus of recreational opportunities. The Effie Yeaw Nature Center, an environmental and cultural education center, is located along the American River Parkway. The area is rich in history and culture, including Native American artifacts, early European settlements, and gold rush era reminders. Major employers in the subwatershed include: Intel in Folsom, multiple hospitals, the State government, Sacramento Municipal Utility District and neighboring California State University, Sacramento (CSU Sacramento).

Sacramento Valley

Agriculture is the largest industry in the Sacramento Valley subregion with major crops that include rice, orchards (stone fruits and nuts), grain, pasture, tomatoes, and vineyards. The largest urban centers are Redding, Chico, Oroville, Marysville/Yuba City, Woodland, Davis, and Sacramento. In addition to the agricultural and food processing industries that are key employers in the region, important economic sectors include government, business and professional services, wood products, transportation, trucking and warehousing operations, and health care. The State capitol, Sacramento is a city of approximately 500,000 and is the headquarters for numerous State and Federal government agencies. Wastewater treatment for the city is the responsibility of the Sacramento Regional County Sanitation District. Major academic institutions in the region are UC Davis, CSU Chico, and CSU Sacramento.

The Sacramento River provides a major source of public recreation in this subregion. On any summer weekend, thousands of boaters, rafters, and canoeists will be on the river between Redding and Sacramento. Sport fishing is popular, particularly for salmon (*Oncorhynchus* species [spp.]) and steelhead (*Oncorhynchus mykiss*) throughout the fall and winter, striped bass (*Morone saxatilis*) and sturgeon (*Acipenser* spp.)in the lower river, and resident rainbow trout between Redding and Red Bluff. The State and national refuges and private duck clubs offer high quality opportunities for waterfowl hunting.

There are more than 120,000 acres of land in National Wildlife Refuges (NWR) in the Sacramento Valley subwatershed. Key among those wildlife refuges are the Sutter NWR (2,591 acres), Colusa NWR (4,567 acres), Delevan NWR (5,797 acres), Sacramento River NWR (10,146 acres), Sacramento NWR (10,819 acres), Stone Lakes NWR (18,000 acres), and Modoc NWR (7,000+ acres) (U.S. Fish and Wildlife [USFWS] 2009, 2011a, 2011b, 2011c, 2011d, 2011e, 2011f). The Sutter, Colusa, Delevan, Sacramento River, and Sacramento NWRs are associated with the Sacramento NWR Complex, which collectively includes more than 35,000 acres of USFWS-owned lands, and more than 30,000 acres of conservation easements on private lands (USFWS 2011g).

Sacramento-San Joaquin Delta

Downstream of the Sacramento metropolitan area, the Sacramento River and the Yolo Bypass enter the tidally influenced Delta, where the river flows through a network of channels separating islands. The Delta includes approximately 500,000 acres of waterways, levees and farmed lands extending over portions of five counties: Contra Costa, Sacramento, San Joaquin, Solano and Yolo.

The rich peat soil in the central Delta and the mineral soils in the higher elevations support a strong agricultural economy. The Delta islands have access to the fresh waters of the 700 miles of rivers and sloughs lacing the region. These waterways and uplands also provide habitat for fish, amphibians, reptiles, mammals, and birds, including several Rare and Endangered species. such as the salt marsh harvest mouse (*Reithrodontomys raviventris*).

Today, the Delta is largely devoted to agriculture, and includes about 55 islands or tracts that are imperfectly protected from flooding by over 1,000 miles of levees. Many of the islands in the central Delta are 10 to nearly 25 feet below sea level because of land subsidence associated with drainage (e.g., groundwater extraction) for agriculture. There are also numerous smaller, unleveed islands that remain near sea level. Remnants of the natural tule marsh are found on the unleveed “channel” or “tule” islands and along sloughs and rivers. The strips of natural riparian forest have nearly vanished, except on some of the larger channel islands, but relicts can be viewed at the Nature Conservancy's Cosumnes River Preserve in the northeastern Delta.

Although the Delta is an exceptionally productive agricultural area, its unique value to the rest of the State is as a source of freshwater. The Delta receives runoff from about 40 percent of the land area of California and about 50 percent of California's total streamflow. It is the heart of a massive north-to-south water-delivery system whose giant engineered arterials transport water southward. State and Federal contracts call for export of up to 7.5 million acre-feet per year from two huge pumping stations in the southern Delta near the Clifton Court Forebay (DWR, 1993). About 83 percent of this water is used for agriculture and the remainder for various urban uses in central and southern California. Two-thirds of California's population of more than 20 million people gets at least part of their drinking water from the Delta (Delta Protection Commission, 1995).

2.4.3 Future Without-Project Conditions

Urbanization has resulted in substantial loss of agricultural land in the State. Housing developments are the most frequent and largest category of newly urbanized land. The increase is associated mostly with single-family homes located at the periphery of existing cities, and to a lesser degree, with apartment complexes.

Future implementation of development projects anticipated in city and county general plans would further convert Important Farmland to nonagricultural uses. Often, conversions of Important Farmland, whether from past, present, or future projects, also result in conversions of land under Williamson Act contracts to uses inconsistent with the contracts and contract cancellations.

2.5 Hydrology

2.5.1 Flood History

Flooding in the Sacramento River Hydrologic Region (watershed) occurs as slow-rise, flash, or stormwater flooding. In the Sacramento River Hydrologic Region, exposure to a 0.2-percent ACE flood event would threaten approximately one in three residents, over $70 billion of assets (crops, buildings, and public infrastructure), 1.2 million acres of agricultural land, and over 340 sensitive species (CVFPP, 2012). Also, almost 95 percent of Sutter County residents, more than 55 percent of Yuba and Yolo County residents and more than 50 percent of agricultural land region-wide are at risk from the 0.2-percent ACE flood event.

It should be noted that historical floods are difficult to compare to one another due to constant changing in the flood protection system and the general hydrology of the Watershed. A more accurate comparison of frequency of flood events would be achieved by using estimates of unregulated flows.

Early flood history most notably includes the 1861-1862 flood (the “Great Flood”). This flood was remarkable for the exceptionally high stages reached on most streams, repeated large flooding events, and prolonged and widespread inundation in the Sacramento River Watershed. Reports published during this flooding period describe the lower Sacramento River Watershed as one vast sea of water. Overflow from the American River led to the flooding of the City of Sacramento, causing loss of life and property, while flooding from the Sacramento River enveloped large sections of the lowlands around Colusa, severely damaging ranches and drowning or starving cattle. It was this flood that provided the impetus for raising the levees around the City of Sacramento.

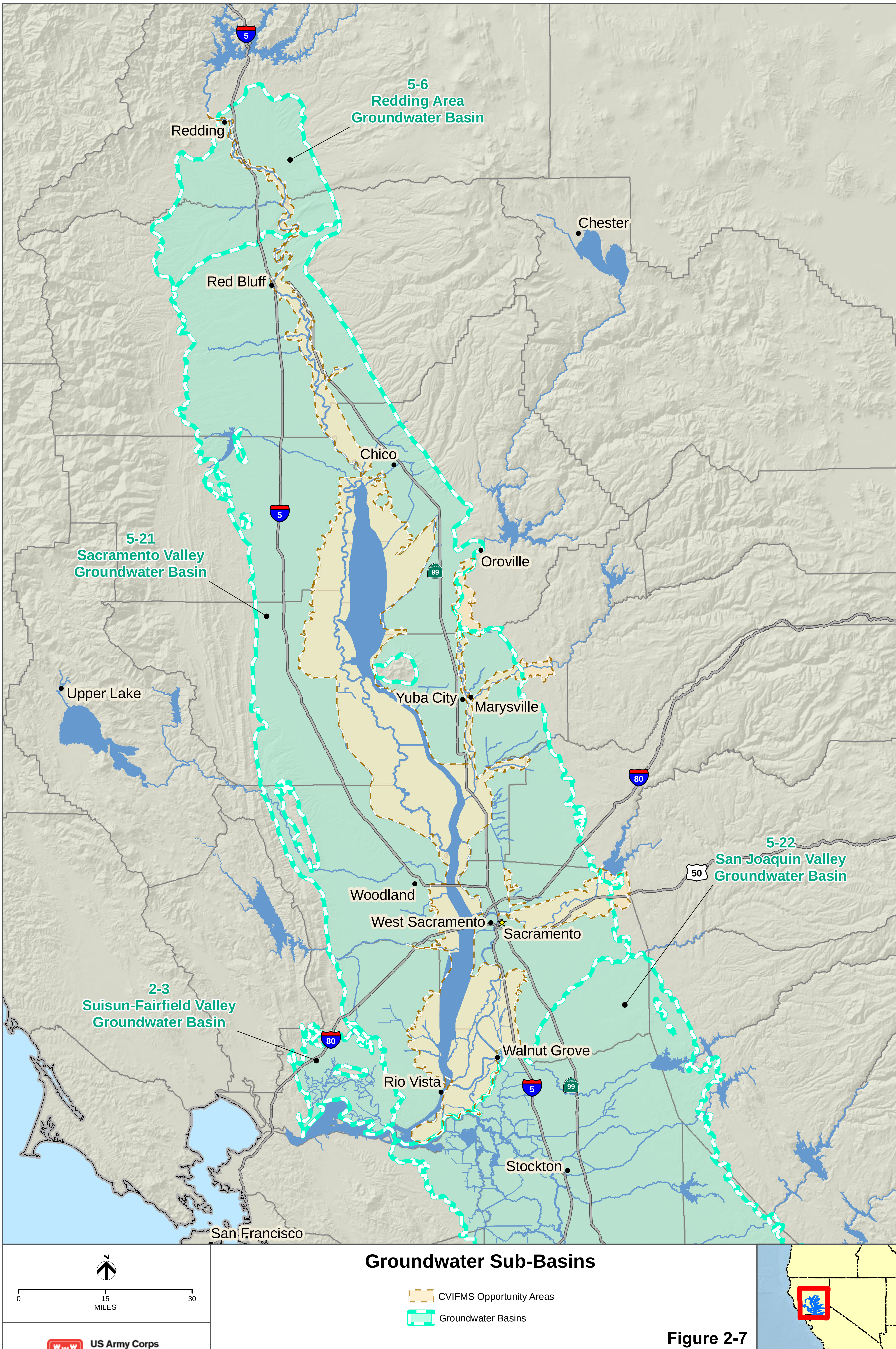
The early 1900s flooding in 1907 and 1909, the latter of which was recorded as a 12,000 year return period, led to an overhaul of the California-wide flood protection designs. This eventually led to the design and construction of the SRFCP.

Since 1950, several sizeable floods have inundated portions of the Sacramento River Hydrologic Region. The floods of 1955, 1964, 1967, 1969, 1970, and 1974 were all characterized by extremely large flows, including record flows at some locations (see Section 1.7 *Watershed Problems and Project Goals, Objectives and Constraints* for a more detailed synopsis of historical flooding). The SRFCP and other flood management programs had been implemented, and project levees, dams, reservoirs, and waterways were employed to control much of the flood flows through the Sacramento system.

2.5.2 Groundwater Resources and Hydrogeology

The Sacramento River Hydrologic Region consists of the Sacramento River watershed (DWR, 2010), and 63 groundwater basins located within its boundaries (DWR, 2003) (Figure 2-7). The Sacramento Valley Groundwater Basin, which is divided into 18 groundwater subbasins (DWR, 2003), and the Redding Area Groundwater Basin, divided into six subbasins, are the primary groundwater basins in this hydrologic region. Many of these subbasins have been deemed by DWR as high or medium priority subbasins due to critical overdraft conditions. The remaining groundwater basins in the Sacramento River Hydrologic Region are not substantially relied upon for water supplies.

The following subsections speak to groundwater storage capacity, production, existing levels, quality and recharge for each of the two primary basins mentioned above—the Sacramento Valley Groundwater Basin and the Redding Area Groundwater Basin.



Groundwater Sub-Basins

Figure 2-7

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Coordinate System: Datum: NAD 1983
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Source: 2012 CVFPP

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2.5.3 Groundwater Storage Capacity

The net changes in groundwater storage in the Sacramento River Hydrologic Region (which includes both the Redding Area and Sacramento Valley Groundwater Basins) that occurred in water years 1998–2005 are presented in Table 2-8. The table generally shows the symbiotic relationship between the region's annual hydrologic conditions and changes to groundwater storage in this hydrologic region. Generally, groundwater storage tends to decrease during dry years, when precipitation was less than 100 percent of normal. However, storage also decreased in 1999 and 2000, two normal (or slightly above-normal) water years. A negative change in groundwater storage during these years can result from various factors, such as increased groundwater pumping in the region, long-term drought, or high-intensity storms that result in more runoff than recharge to the aquifer. The decrease in groundwater storage in 2005 (another above-normal water year) could have been caused by declining groundwater levels (from the previous six calendar years) that had not yet responded to a positive shift in hydrologic conditions at the surface.

Table 2-8 Yearly Net Changes in Groundwater Storage 1998-2005

Water Year	1998	1999	2000	2001	2002	2003	2004	2005
Percent of Normal Precipitation	168%	101%	105%	67%	91%	99%	90%	127%
Change in Groundwater Storage (thousand acre-feet)	740	-1731	-151	-1147	-1418	-1470	-1640	-1211

Source: DWR 2009

Sacramento Valley Groundwater Basin

Total groundwater storage capacity of the alluvial unconfined aquifer in the Sacramento Valley Groundwater Basin is estimated to be 46,000 thousand acre-feet (TAF), extending to a depth of 200 feet, or assuming a 200-foot-thick aquifer (DWR, 2003).

Redding Area Groundwater Basin

Total groundwater storage capacity in the Redding Area Groundwater Basin, distributed among six subbasins, is estimated to be approximately 5,500 TAF (DWR, 2003).

Groundwater Extraction

The U.S. Geological Survey (USGS) simulated groundwater pumping for the entire Central Valley using the Central Valley Hydrologic Model for years 1962–2003. Pumping for urban uses in 1962 ranged between 600 and 2,000 TAF, making up less than 5 percent of total pumping but urban use increased to about 30 percent of pumping in the late 1990s to early 2000s (Faunt 2009). Based on average annual data between 1998 and 2005, groundwater extraction in the Sacramento River Hydrologic Region made up 27 percent of the total urban-use water supply, or 2.6 million acre-feet (DWR, 2009).

Sacramento Valley Groundwater Basin

The cities of Red Bluff, Corning, Woodland, Davis, and Dixon are completely reliant on groundwater extraction in the Sacramento Valley Groundwater Basin for their sole source of water (DWR, 2003). Production rates in the groundwater subbasins beneath the cities of Red Bluff, Corning, and Colusa range from 81 to 310 TAF per year for agricultural uses and from 6.6 to 14 TAF per year for municipal and industrial (M&I) uses. Groundwater is also pumped from the Colusa Subbasin to support environmental wetlands. Nearly 90 TAF per year (81 TAF for agricultural uses and 8.9 TAF for M&I uses) is extracted in the Red Bluff Subbasin, which is much more pumping than occurs in neighboring subbasins to the east (approximately 19 TAF in the Antelope Subbasin and 340 acre-feet in the Bend Subbasin).

Redding Area Groundwater Basin

As of 1995, approximately 12.5 percent of water used in the Redding Area Groundwater Basin was derived from groundwater, the vast majority of which was used to meet M&I demands (Shasta County Water Agency 2007). Total annual groundwater pumping in this groundwater basin is approximately 37 TAF (DWR, 1998). This is a minor amount compared with the basin's groundwater discharge to surface water of 266 TAF (Shasta County Water Agency 1998). Groundwater extraction is greatest in the Anderson Subbasin of the Redding Area Groundwater Basin, with approximately 3 TAF of groundwater extracted for agricultural uses and 20 TAF for M&I uses (DWR, 2003).

2.5.4 Groundwater Levels

This section describes groundwater levels in the Sacramento Valley and Redding Area Groundwater Basins.

Sacramento Valley Groundwater Basin

In general, groundwater levels in the Sacramento Valley Groundwater Basin declined during the 1976–1977 and 1987–1994 droughts, before generally recovering in the 1990s to pre-drought conditions of the early 1970s and 1980s (DWR, 2003).

Groundwater levels in composite wells (wells that combine confined and unconfined portions of the aquifer) in the northern part of the East Butte Subbasin experienced the greatest declines during the drought periods, decreasing by 30–40 feet. Groundwater levels also declined in the South Yuba Subbasin, causing a cone of depression to develop in the subbasin as early as the 1960s. However, by the 1990s, groundwater levels in the South Yuba Subbasin had increased by 10 feet due to increased deliveries of surface water and groundwater recharge. As documented in DWR monitoring records, groundwater levels in the South Yuba Subbasin increased from then until the recent 2010-2015 drought where they have decreased substantially. Unfortunately, long-term trends of substantial groundwater decline continue to be prevalent in localized areas within the Yolo Subbasin near the cities of Davis, Woodland, and Dunnigan/Zamora, where pumping has created a cone of depression (DWR, 2003).

In general, groundwater in the Sacramento Valley Groundwater Basin flows toward the Sacramento River, and then parallels the river. Under localized conditions, it may be possible for groundwater levels to rise in recharge areas after precipitation events and come within a few feet of the ground surface; in other areas, groundwater could flow in an artesian manner from wells. Under those conditions, the ground could become completely saturated, resulting in ponding on the ground surface. Overland flow could also result from high-intensity precipitation events that exceed the infiltration capacity of the soils; however, such overland flow would be a result of soil conditions, not a result of high groundwater levels.

Localized cones of depression exist within the Sacramento Valley Groundwater Basin; to date, large-scale groundwater recharge projects have not been implemented to replenish the aquifer.

Redding Area Groundwater Basin

Groundwater levels in the Redding Area Groundwater Basin declined during the 1976–1977 and 1987–1994 droughts, but were generally able to recover to pre-drought conditions of the early 1970s and 1980s (DWR, 2003). Overall, groundwater levels in this groundwater basin have remained relatively stable, fluctuating seasonally by approximately 2–15 feet (DWR, 2003).

2.5.5 Groundwater Quality

This section describes groundwater quality in the Sacramento Valley and Redding Area Groundwater Basins.

Sacramento Valley Groundwater Basin

The concentration of total dissolved solids (TDS) in groundwater in the Sacramento Valley Groundwater Basin is typically sufficient for M&I and agricultural uses, averaging less than 500 milligrams per liter (mg/L). This average value is below both the California and U.S. Environmental Protection Agency (EPA) secondary drinking-water standards of 500 mg/L and the agricultural water-quality goal of 450 mg/L as stated in the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Basin Plan) (Central Valley RWQCB, 2009). Localized groundwater quality issues, in some cases, have been associated with natural impairments of water quality at the north end of the Sacramento Valley, where marine sedimentary rocks containing brackish to saline water are near the surface (DWR, 2003). However, some groundwater quality issues in the Central Valley, including the Sacramento Valley Groundwater Basin, have been attributed to agricultural practices.

Redding Area Groundwater Basin

Groundwater in the Redding Area Groundwater Basin is typically sufficient for M&I and agricultural uses, averaging less than 400 mg/L TDS. This range is below both the California and EPA secondary drinking-water standard of 500 mg/L and the agricultural water quality limit of 450 mg/L. Groundwater impairments in the Redding Area Groundwater Basin are typically associated with localized areas of boron, iron, manganese, chloride, and TDS (DWR, 2003).

2.5.6 Groundwater Recharge

High demand for water has led to the lower groundwater levels as discussed in previous sections. Due to this, groundwater recharge is critically important. There are opportunities for groundwater recharge, especially in the areas of the valley where the soils are permeable and the depth to groundwater is relatively shallow (Figure 2-8). Increased groundwater recharge would have water supply, water quality and ecosystem benefits. Groundwater may be recharged by various methods:

- Injection wells – Injecting water directly into aquifers through wells.
- Spreading basin - Spreading water on the ground in basins and allowing it to percolate
- Transitory storage - Capture floodflows that percolate into the ground
- In-lieu - Using surface water in-lieu of groundwater for supply purposes to allow the groundwater to recover naturally.

2.5.7 Ground Subsidence

Subsidence resulting from aquifer compaction (caused by declines in groundwater levels) has been an issue in the Sacramento Valley Groundwater Basin, but no subsidence has been reported in the Redding Area Groundwater Basin.

Subsidence has occurred in the Sacramento Valley Groundwater Basin in areas where the underlying aquifer is overdrafted, causing compaction of the aquifer system. (Groundwater overdraft is the condition in which the amount of water withdrawn by pumping in a basin exceeds the amount of water that recharges the basin over a period of years, during which water supply conditions are approximately average (DWR, 2005).) By 1973, compaction of the aquifer system had resulted in 2 feet of subsidence in two localized areas east of the town of Zamora and west of the town of Arbuckle in the Sacramento Valley (Williamson et al., 1989; Lofgren and Ireland ,1973). Lofgren and Ireland (1973) identified six general areas with probable subsidence: northwest of Sacramento, northeast of Sacramento, southeast of Yuba City, 10 miles north of Willows, 20 miles north of Willows, and in the Arbuckle area

A program studying subsidence between 1986 and 1989, led by USGS, documented the extent and magnitude of land subsidence in the Sacramento Valley Groundwater Basin. The maximum average rate of land subsidence in the southern Sacramento Valley Groundwater Basin was estimated to be 0.17 foot per year, or approximately 2.9 feet in the 17 years since the previous evaluations were completed using leveling data (Ikehara 1994). According to this study, land subsidence occurred along a northsouth trending area between Zamora and Davis in the southern Sacramento Valley Groundwater Basin (Ikehara 1994).

DWR is conducting several surveys to improve data collection and its understanding of aquifer system compaction in the Sacramento Valley Groundwater Basin (DWR, 2010). In addition, DWR is monitoring land subsidence with extensometers installed in the

Sacramento Valley, from which the location and data are available in DWR's Water Data Library (DWR, 2010).

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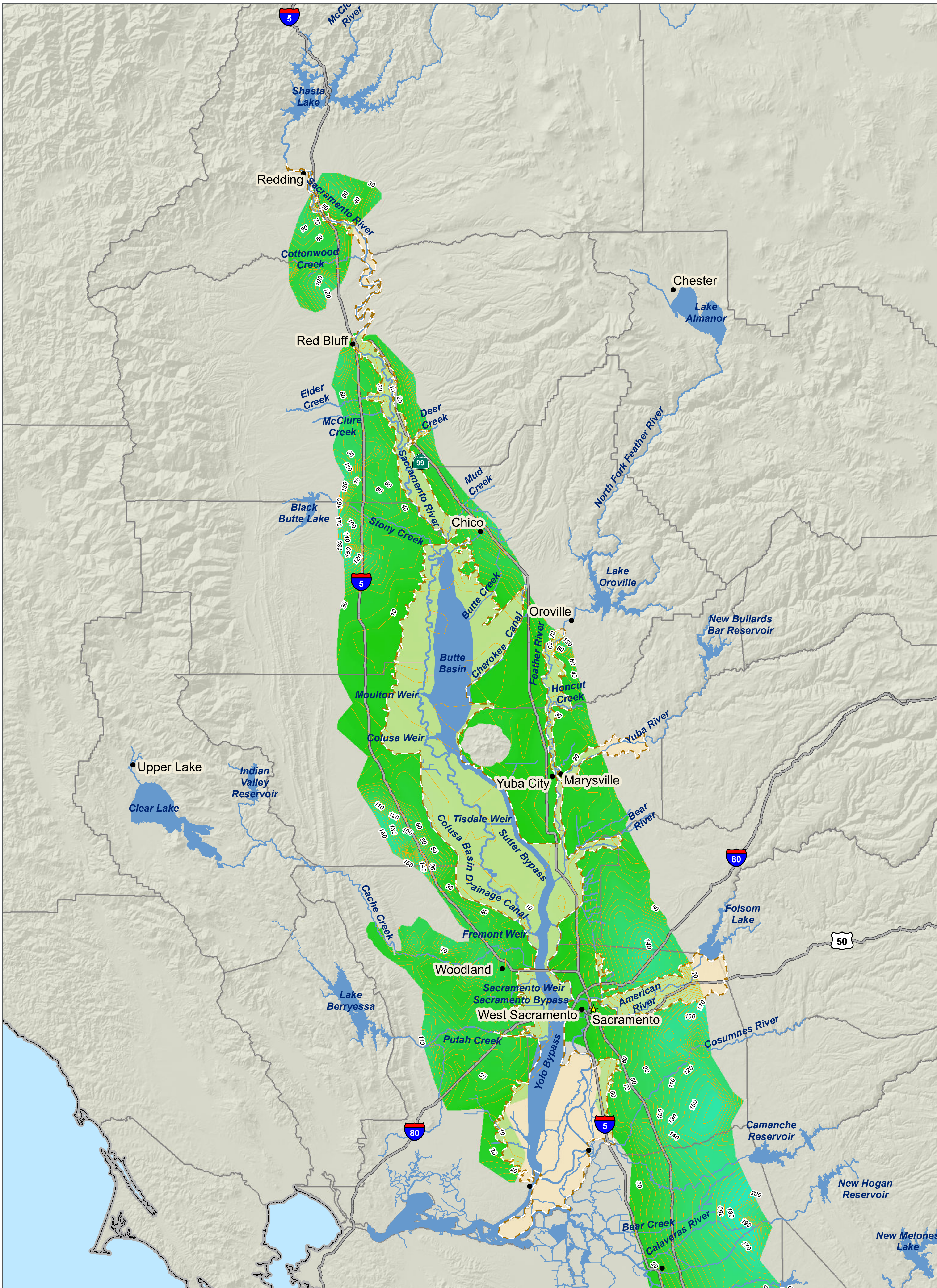

2015 Groundwater Depths

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CVIFMS Opportunity Areas

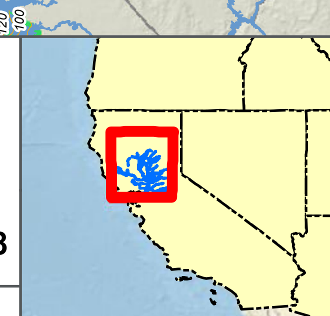
Groundwater Depth in feet below surface

High : 670.736

Low : 1.13006

S2015 DBGS Contours (ft)

Figure 2-8



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A 2015 study by NASA shows that depletion of groundwater basins has led to significant ground subsidence in the Central Valley (NASA, 2015). Not only does this threaten the water supply, it also threatens the infrastructure on the surface, including the flood risk management infrastructure.

Opportunities exist to recharge water on agricultural land using river floodwaters. This floodwater approach has the dual benefit of withdrawing large amounts of water from a river that is at or near flood stage and reducing downstream flood risks (Bachand et al., 2011). Recycled water (highly treated wastewater) is another potential source (O’Geen et. al. 2015).

O’Geen (O’Geen et. al. 2015) developed a groundwater banking index based on five factors that determine the feasibility of groundwater recharge on agricultural land:

1. Deep percolation: Soils must be readily able to transmit water beyond the root zone (1.5 meters or 5 feet).
2. Root zone residence time: The duration of saturated/near saturated conditions after water application must be acceptable for the crops grown on lands under consideration for groundwater banking throughout the entire crop root zone.
3. Topography: Slopes that negatively influence the even distribution of water will be more difficult to manage.
4. Chemical limitations: High soil salinity may result in saline leachate (poor water quality) that must be avoided to protect groundwater quality.
5. Soil surface condition: Certain soils may be susceptible to compaction and erosion if large volumes of water are applied. Surface horizons with high sodium are prone to crusting that may contribute to decreased surface infiltration rates.

The results from the NASA study show that there are some excellent, good and moderately good areas for groundwater banking in the Sacramento River Valley (Figures 2-9 and 2-10). The highly rated soils are most abundant on broad alluvial fans on the east side of the Central Valley stemming from the Mokelumne, Stanislaus, Merced, Kern and Kings rivers (O’Geen et. al. 2015). Table 2-9 provides information on four existing groundwater recharge programs in the Sacramento Valley Groundwater Basin and their implementation statuses

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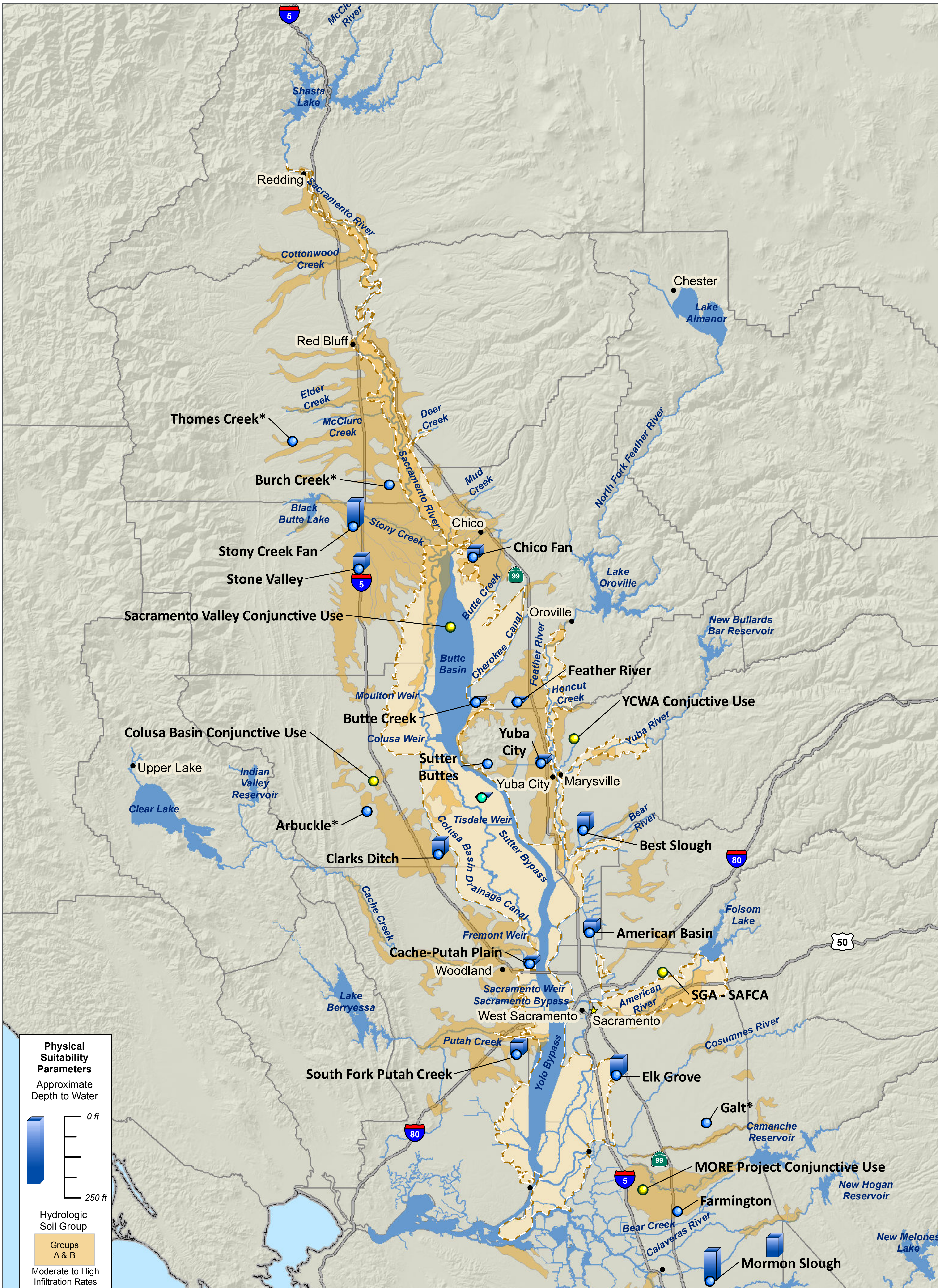

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Potential Groundwater Recharge Sites and Methods

CVIFMS Opportunity Areas

Potential Groundwater Storage Opportunity

- Active (spreading basins or injection wells)
- Transitory Storage
- In-Lieu

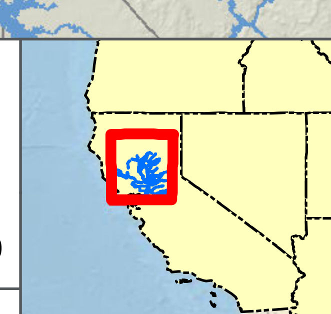

Figure 2-9

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Table 2-9 Potential Groundwater Recharge Projects and Sites in the Sacramento River Valley

Site Name	Location Description	Recharge Mechanism	Distance From River (miles)	Available Storage Volume/Capacity	Water Quality	Soil Suitability	Aquifer Suitability	Groundwater Extraction Facilities	Project Status	Opportunity for Integration with Flood Management
Sacramento Valley System										
Sacramento Valley Conjunctive Use Program	Northern Sacramento Valley	In Lieu	N/A	Storage capacity is relatively small (i.e., basin is generally full); basin would need to be exercised to create storage	Unknown	N/A	N/A	Depends on program implementation	Feasibility Study	Limited by full aquifer, high cost to implement
Yuba County Water Agency Conjunctive Use Programs	Yuba County/Yuba groundwater sub-basins	In Lieu	N/A	Yuba groundwater sub-basins are generally full as a result of historical surface water deliveries	Generally very good	N/A	N/A	Yes	Groundwater basin is being exercised through groundwater substitution transfers	Limited; no additional flood storage operations have been identified at New Bullards Bar Reservoir
SGA-SAFCA	Sacramento area	In Lieu	N/A	Approximately 500 TAF total available storage space	Unknown	N/A	N/A	Yes	Pilot/Implementation phase	Successful pilot test of integrated groundwater banking and flood operations
Colusa Basin Conjunctive Use Opportunities	Western Sacramento Valley	Direct Recharge, In Lieu	N/A	Unknown	Unknown	Some good site-specific soil permeability corresponding to alluvial fan deposits associated with western foothill streams	N/A	Depends on program implementation	Conceptual	Limited by full aquifer, high cost to implement, limited public acceptance

Key:
N/A = not applicable
SAFCA = Sacramento Area Flood Control Agency
SGA = Sacramento Groundwater Authority
TAF = thousand acre-feet

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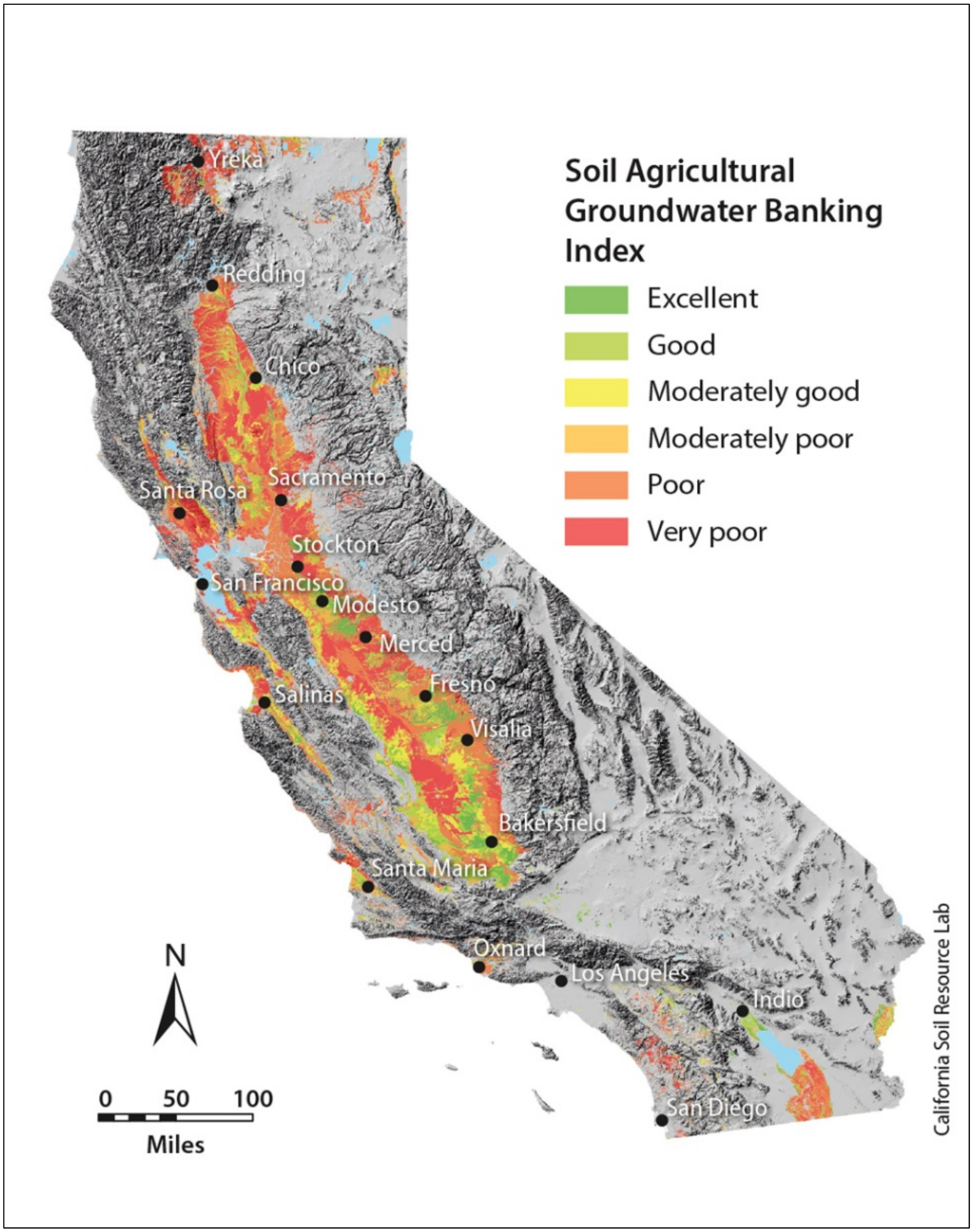


Source: http://ucanr.edu/calag/fig6902p82.jpg

Figure 2-10 Soil Agricultural Groundwater Banking Index

Groundwater Management

Groundwater is a critical and integral component of California's overall water supply, serving residents, businesses, farms, industries, and the environment. Unlike surface water, groundwater has not been regulated on a statewide basis. Except in specific c adjudicated basins, a landowner may extract an unlimited amount of groundwater if put to a reasonable and beneficial use without seeking permission to use the water. In certain parts of the State, long-term groundwater use has had serious impacts including:

- Alarming declines in groundwater levels and storage
- Degradation in water quality
- Irreversible land subsidence
- Ecosystem impacts associated with streamflow depletion and the reduced connection between groundwater and surface water systems.

The drought starting in 2011 has increased Californians' awareness of groundwater management issues. Approximately thirty million Californians (about 75 percent) depend on groundwater for a portion of their water supply. On average, groundwater provides about 40 percent of total annual agricultural and urban water uses. Some areas are 100 percent dependent on groundwater for their supply (DWR, 2015).

On September 16, 2014, the Governor signed into law a three-bill legislative package: AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley). These laws are collectively known as the Sustainable Groundwater Management Act. The legislation provides for financial and enforcement tools to carry out effective local sustainable groundwater management through formation of Groundwater Sustainability Agencies and the development of Groundwater Sustainability Plans (DWR, 2015).

2.5.8 Drought History and Impacts

Measurements of California water conditions cover only a small slice of the past. Widespread collection of rainfall and streamflow information began around the turn of the 20th century. During the period of recorded hydrology, the most significant statewide droughts occurred during 1928-34, 1976-77, 1987-92, and 2011-2015. Historical data combined with estimates created from indirect indicators such as tree rings suggest that the 1928-34 event may have been the driest period in the Sacramento River watershed since about the mid-1550s.

During times of drought, vegetation is visibly dry, stream and river flows decline, water levels in lakes and reservoirs fall, and the depth to water in wells increases. As drought persists, longer-term impacts can emerge, such as groundwater level declines, land subsidence, seawater intrusion, and damage to ecosystems. Unlike the immediate impacts of drought, however, long-term impacts can be harder to see, but more costly to manage in the future.

Short Term Drought Impacts

During drought, declines in Surface water flows can be detrimental to hydropower production, navigation, recreation, and habitat for aquatic and riparian species. Several California Water Science Center streamgages have recently recorded streamflows that are below all-time record lows for specific days of the year. Annual runoff, which is calculated from this streamflow data, supplies many of our needs for water, Recent runoff estimates for California show measurements on par with 1930's and late 1970's droughts.

Unlike the effects of a drought on streamflows, Groundwater levels in wells may not reflect a shortage of rainfall for a year or more after a drought begins. Despite reduced availability, reliance upon groundwater increases during drought often resulting in increased groundwater pumping to meet water demands. If a well is pumped at a faster rate than an aquifer is recharged by precipitation or other underground flow, water levels in the well can drop, resulting in decreased water availability and deterioration of groundwater quality.

Nearly all surface water features - streams, lakes, reservoirs, wetlands, and estuaries - interact with groundwater. In addition to being a major source of water to lakes and wetlands, groundwater plays a crucial role in sustaining streamflow between precipitation events - especially during protracted dry periods. Although the contribution of groundwater to total streamflow varies widely among streams, hydrologists estimate the average contribution is somewhere between 40 and 50 percent.

Long Term Drought Impacts

Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials. Excessive groundwater pumping and aquifer depletion can cause land to sink, which can cause permanent loss of groundwater storage in the aquifer system and infrastructure damage.

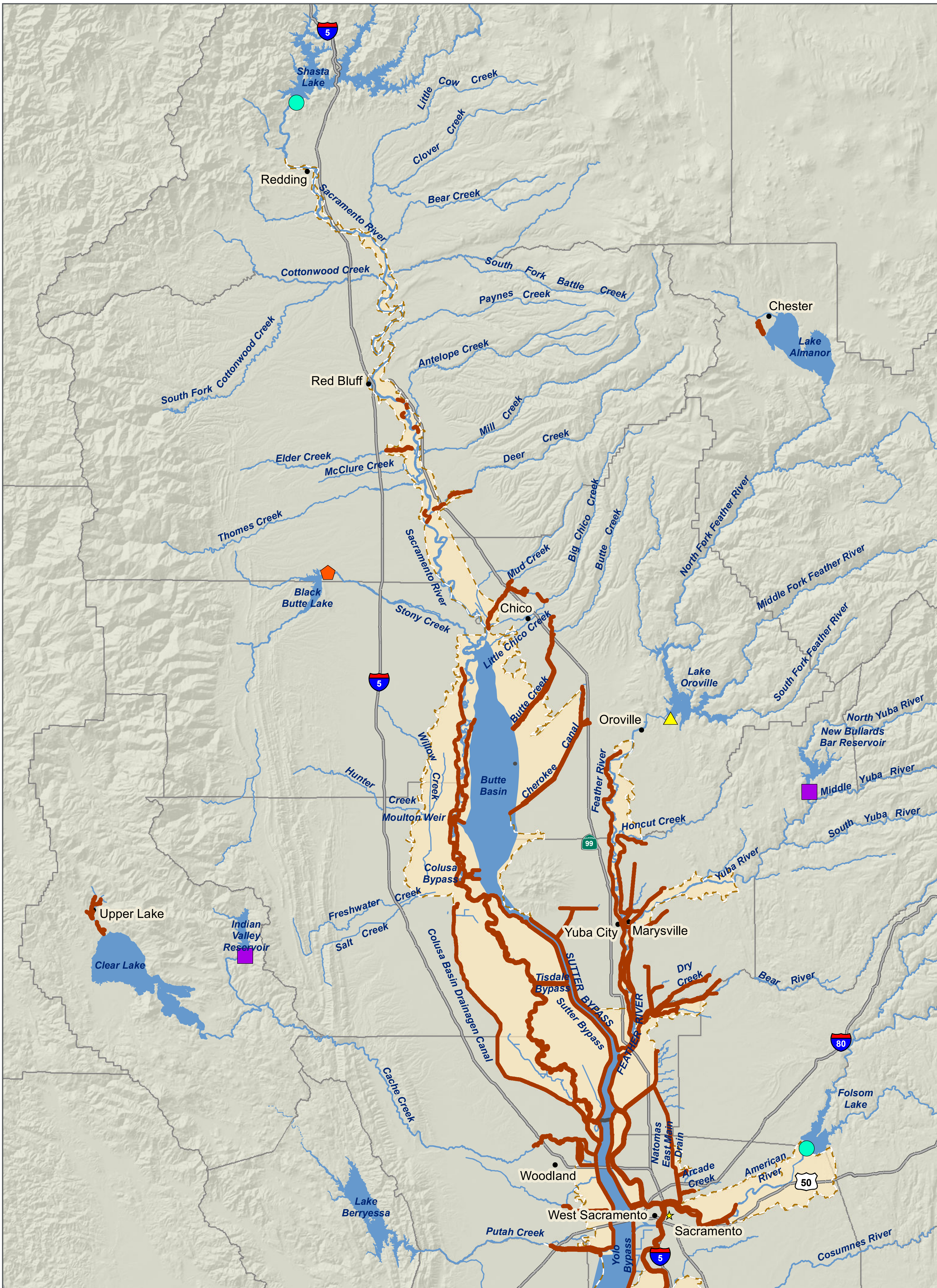
Dry, hot and windy weather, combined with dry vegetation and a spark - either through human intent, accident or lightning - can start a wildfire. Drier-than-normal conditions can increase the intensity and severity of wildfires. In the aftermath of wildfires such as the 2013 Rim Fire, ash, woody debris and sediment can flow downstream from burn areas and contaminate water supplies. Flash flooding and mudslides in burn areas can also be damaging and deadly.

USGS science - conducted both in "real-time" and over the long-term - helps inform decision makers in communities across the country who have to deal with complex issues and competing interests in times of drought. The California Water Science Center monitors the immediate impacts of drought on water availability and water quality through streamflow, surface water, and groundwater monitoring and data collection. Long-term data collection is needed to asses the effects of climate variability on water sources, to monitor the effects of regional aquifer development, and to obtain data sufficient for analysis of surface water and groundwater-level trends.

2.5.9 Multipurpose Reservoir Projects

Many of the storage facilities that contribute to flood management in the Sacramento and River Basin are also operated for other purposes, such as water supply and power generation, but are not part of the SPFC because they include no State assurances to the federal government. Debris dams in the upper Yuba River Basin contribute in a minor way to flood management in the Sacramento River Basin, and hydroelectric reservoirs in the Upper Sacramento River Region provide credit space for larger downstream multipurpose reservoirs. USACE has participated in each of these reservoirs by establishing (funding in most cases) seasonal flood reservation storage and developing rules for operation of flood storage. Note that Oroville Dam is the only major multipurpose project listed that is part of the SPFC. Multipurpose reservoirs within the Sacramento River Basin are shown on Figure 2-11.

During high-water periods, reservoir operators coordinate with DWR and USACE during daily operations conferences at the State-federal Flood Operations Center in Sacramento. These conferences lead to voluntary modifications of individual reservoir operating rules to improve overall system operation. In total, these reservoir operations significantly reduce flood flows to the downstream levee system.



Multipurpose Facilities and SPFC Levees

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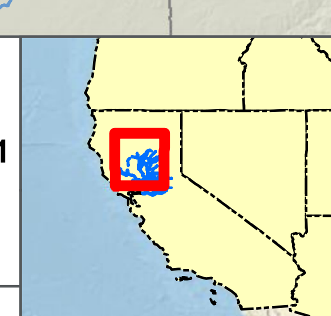
Sacramento District

CVIFMS Opportunity Areas

Multipurpose Reservior Dams

- Department of Water Resources (DWR)
- Local Agency
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation
- SPFC Levee
- Weirs

Figure 2-11



The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983 CA State Plane II Feet

PATH: F:\PROJECTS\028_233549_CH2MHILLDWR_CVFPP_TO_14_09\MAP_DOCS\MXD\REPORT\FIGURE_3.13-1_MULTIPURPOSEPROJECTS_11X17.MXD - USER: AARNOLD - DATE: 11/9/2015

Source: 2012 CVFPP

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2.5.10 Hydrological Studies

USACE completed a systemwide hydrologic analysis of the Watershed in 2002 as part of the Sacramento and San Joaquin River Basins Comp Study. The Comp Study was intended to provide a master plan for flood damage reduction and ecosystem restoration following the disastrous floods of 1997. For this, USACE undertook a reconnaissance-level hydrologic and hydraulic analysis of the basins. The Comp Study analyses have served as the basis for recent local and systemwide flood management alternative evaluations by local flood protection agencies, the State, and USACE. The Comp Study technical studies have been used for various different planning and design studies and projects.

Following the Comp Study, the DWR and USACE partnered to develop the Central Valley Hydrology Study (CVHS). These efforts were conducted in 2012-2013, in coordination with the USGS and Federal Emergency Management Agency (FEMA). The procedures used in the CVHS built upon Comp Study methodologies and relied heavily on some of the fundamental products and procedures from that study, specifically the datasets and models developed. The CVHS directly addressed and enhanced the noted assumptions and limitations from the Comp Study, in terms of storm centerings, local-flow contributions, and ungaged stream contributions. CVHS is a comprehensive assessment of stream flow frequencies and magnitudes in the Sacramento and San Joaquin River Basins. The goal of the hydrologic analysis was to estimate peak flows and hydrographs for various ACE probabilities, which could then be used to describe flood hazards throughout the basins. The study includes flood flow frequency relationships (curves) and hydrographs for more than 200 locations.

The new hydrology flow frequency curves developed as part of CVHS supports the Central Valley Floodplain Evaluation and Delineation Program (CVFED), initiated in 2008, and the CVFPP. The CVFED Program had multiple goals, including improving the quality and accuracy of flood hazard data and mapping available to local communities. Accomplishments of the CVFED Program have included:

- Updated technical information about flood risks that can help communities comply with California code requirements,
- Detailed aerial photographs and topographical data for many Central Valley communities that is available for use by local governments,
- Updated hydrologic and hydraulic models acceptable to the DWR, FEMA, and USACE have been made available for use by local governments,
- More detailed and current flood risk information is available to inform the development of local land use plans and emergency preparedness plans.

To date, no basin-wide analysis of future land use and the resulting impacts to flood hydrology have been performed for the Sacramento River Basin. In general, continued urban expansion can be expected to increase both peak flows and runoff volumes; these factors will have the largest effect on occurrences of storm events with a greater than the four percent ACE.

As previously discussed in Section 2.2 *Climate and Precipitation*, increased temperatures due to climate change may also alter precipitation and runoff patterns. The combination of earlier snowmelt and shifts from snowfall to rainfall seem likely to increase flood peak flows and flood volumes, which is likely to affect associated flood risk.

2.5.11 System of Reservoirs and Reoperation

DWR is currently conducting a multi-phase system reoperation study (SRS) in cooperation with other State and Federal agencies, local water districts, groundwater managers, and other stakeholders to identify strategies for reoperation of the statewide flood protection infrastructure and water supply systems (DWR, 2014). Per state legislation, the goals include the following:

- Improve reliability of municipal and irrigation water supply
- Reduce flood hazards
- Restore and protect ecosystem function and habitat conditions
- Buffer the hydrologic variations expected from climate change
- Improve water quality

Many of the facilities in the Central Valley were developed in the early to mid-20th century and were not specifically designed to operate as an integrated system. The region's two largest supply-oriented projects are the State Water Project (SWP) operated by DWR and the Central Valley Project (CVP) operated by USBR. Over the years, coordination and integration has grown. In addition, the Central Valley's water supply and flood management infrastructure has ample physical interconnections; however, it is believed individual and system reservoir operations can be improved to further reach the above goals.

The State of California is currently focusing its efforts on the Central Valley of California because this region has an abundance of water facilities, large sources of runoff from the foothills and snowpack covered mountains surrounding the valley, and the greatest potential for ecosystem restoration since the existing infrastructure has a profound impact on the abundant and varied aquatic ecosystems found here.

The Sacramento River Watershed covers nearly 27,000 square miles and produces an exceptional average annual runoff of 22,000,000 ac-ft each year compared to San Joaquin River which produces approximately a third of that amount. Mean annual precipitation is higher in the northern portion of the Central Valley compared to the south. Major reservoirs in the Sacramento River watershed include Shasta Dam (4.55 MAF), Oroville Dam (3.54 MAF), Folsom Dam (977 TAF), New Bullards Bar Dam (966 TAF), Indian Valley Dam (301 TAF) and Black Butte Dam (136 TAF). All of these reservoirs are multi-purpose and include a mix of flood control and water supply storage. The most recent Water Control Diagrams (document that stipulates reservoir operations when the pool encroaches in the flood control storage space) were all derived in the 1970s and 80s except for Folsom Dam which is currently being updated and Black Butte which has an interim water control diagram from 2005

Reoperation Strategies

DWR recently (February 2014) completed Phase 2 of a reservoir reoperation study (DWR, 2014). The study defined a list of infrastructure reoperation strategies designed to meet multiple objectives. These strategies are thought of as “building blocks” that can be combined together in various permutations for optimization of results. Per this study, these building blocks include:

- Reoperate reservoirs by changing the storage and discharge regime.
- Integrate management of groundwater and surface water by utilizing dewatered aquifer space for storage in conjunction with reservoir reoperation.
- Transfer water among willing parties to reallocate limited supplies from existing water rights holders to uses bearing a higher/different economic or social value.
- Change stream flow patterns to improve magnitude, duration, frequency, timing and location of both high and low flow events below reservoirs to restore the more natural flow conditions conducive to ecosystem health and productivity.
- Expand through-valley flood conveyance and reactivate floodplains via levee set-backs, expanded flood bypasses, increased transitory storage, easements, and similar actions.
- Retrofit dams, such as expanding outlets, adding or relocating outlets, increasing the spillway size, retrofitting sluice gates, and other physical changes that allow changes in reservoir flow releases.
- Change points, timing and/or volume of diversions to reduce or alter diversions (e.g., the isolated conveyance facility proposed within the Bay Delta Conservation Plan).
- Improve conveyance; interconnections can increase the flexibility of water storage and delivery in the Central Valley.
- Improve fish passage, such as installing fish passage facilities around dams.

Phase 2 involved taking an initial list of reoperation strategies and narrowing them down to a smaller subset that were identified to move forward for further study. In addition, a trade-off analysis was performed, recognizing that re-prioritization of some goals for reservoir operations could have negative or positive impacts on other goals.

Recently, DWR has been implementing a strategy called Forecast Coordinated Operations (F-CO) in the Central Valley in targeted watersheds. The strategy involves developing a common platform of data sharing software, reservoir modeling tools, and linked communication systems whereby DWR, USACE, the National Weather Service (NWS), and other water agencies can closely work together to make coordinated real-time reservoir release decisions during a flood event. Since DWR is already in the process of implementing F-CO operations in the Central Valley, it is not being considered as part of the reservoir reoperation strategy for CVIFMS.

Forecast-Based Operations

One result of the DWR Phase 2 Reoperation Study was the identification of a promising strategy called Forecast-Based Operations (F-BO). F-BO is different than FCO in that the Water Control Diagram is directly modified to facilitate the use of forecasts in determining reservoir releases. Figure 2-12 below illustrates the difference between typical Water Control Diagrams and an F-BO based Water Control Diagram. Traditionally, Water Control Diagrams have a distinct delineation between water supply and flood control space on a daily or seasonal basis as shown in (a) in the figure below. During the height of the rainy season, a significant amount of flood space is set aside to protect a downstream community from a specific size flood event. In other words, there is a rigid requirement that this part of the reservoir be kept empty in case of the onslaught of a large flood. These reservoir design events are typically rare in occurrence and require a significant amount of space. An example would be the 1% ACE flood which only has a 1 in 100 chance of occurrence in any given year. In contrast, an F-BO Water Control Diagram has “variable space” which can be used for either water supply storage or flood control, depending upon current weather conditions. When the weather forecast indicates there are no storms of a given threshold approaching, the reservoir is allowed to retain a larger volume of water.

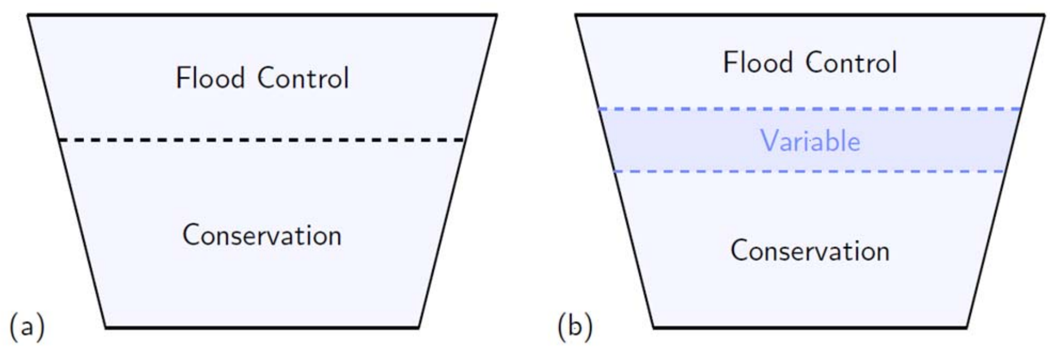

Figure 2-12 Difference Between Traditional and F-BO Water Control Diagrams*

**Taken from Appendix A of DWR 2014.*

This potentially allows the reservoir to retain more water throughout the rainy season and result in water savings at the end of the year. In other words, water supply storage is only reduced when it is truly needed. If a forecast shows a significantly large storm approaching, the reservoir is drawn down to make space for the future incoming runoff. In this scenario, the amount of flood control space created during the pre-emptive release could potentially be greater than the space available in a typical Water Control Diagram as shown in (b) in the figure. This can result in a greater level of protection for downstream communities. At the tail end of a large storm event, the reservoir will be allowed to refill back to its previous level, assuming no other significant storms are forecast in the next 3 to 5 days. Consequently, F-BO can potentially be beneficial for multiple goals including flood damage reduction and water supply. NWS forecast product confidence diminishes significantly 3 to 5 days forward into the future; therefore, reservoirs which are able to make large releases downstream in a short time period (thus creating significant flood control space) are the ones in which application of the F-BO strategy is most promising. Several Sacramento River watershed dams potentially fall into this category. USACE's Sacramento District is currently researching an F-BO based operation plan for Folsom Dam that potentially could be implemented once the Joint Federal Project (JFP) construction is completed in 2017. USACE Sacramento District and San Franscisco District are also part of the multi-agency FIRO (Forecast Informed Reservoir Operations) Project at Lake Mendecino in the Russian River Watershed which is also looking at the possibility of incorporating forecast informed operations at Lake Mendecino. Specifically looking at the potential to use the new technology for forecasting where an atmospheric river will land in California. Both the JFP and FIRO results will be the basis of how incorporating forecasts into reservoir operations will proceed in the future.

NWS Forecast quality has improved over the years due to better radar technology and software models. For example, the NWS is currently developing an Ensemble forecast software product which is a numerical weather prediction method that generates a representative sample of the possible future states of a dynamical system. In other words, instead of producing one deterministic precipitation forecast, a series of probabilistic forecasts are derived for the end-user which more appropriately allows the assessment of risk.

Summary

DWR completed Phase 2 of a system reservoir reoperation study in February 2014. The report specifically recommends additional reoperation studies be conducted in Phase 3 for Shasta, Oroville, and New Exchequer Dam (New Exchequer Dam is located on the San Joaquin River) as these appear to have potential for success. The reoperation strategies would include F-BO, conjunctive use, system integration, and environmental flows. Phase 2 indicated that implementing reoperations strategies such as F-BO can provide multiple benefits. Reoperation strategies that increase water supply also provide opportunities to operate reservoirs for ecosystem restoration. Phase 2 evaluated potential F-BO operations on a reservoir by reservoir basis, rather than on a system-wide basis. The report recommends future study be performed that implements reoperation strategies like F-BO on a system-wide basis, as this could potentially result in additional benefits.

The Sacramento-San Joaquin Bay Delta is the largest coastal wetland in the Western United States. As both the San Joaquin and Sacramento Rivers discharge into the Delta, all components are inter-related and compose a complete ecosystem. As such, future reservoir reoperation studies should consider modeling the entire Central Valley to enhance the quantification and assessment of trade-offs that are possible under reoperation.

In summary, USACE and DWR analyses indicate reservoir reoperation can potentially provide significant benefits for water supply, flood damage reduction, and ecosystem restoration. Further analysis of reservoir reoperation is recommended. DWR desires USACE to participate in these future studies which would include more detailed analyses and ranking of reoperation alternatives, and quantification of benefits and costs.

2.5.12 Future Without-Project Conditions

Basic physical conditions in the Sacramento River Watershed are expected to remain relatively unchanged in the future. No major changes to area hydrology are foreseen. In areas where the rivers are not confined by geological or man-made formations and are given space to meander, more natural river channel meandering and migration patterns would occur as a result of geomorphic processes.

2.6 Hydraulics

2.6.1 Physical Conditions

Major rivers in the Sacramento River Watershed include the Sacramento, Feather, and American Rivers. The Sacramento River is the major source of water supply in California, it flows generally north to south from its origin near Mount Shasta to its mouth at the Delta. As the Sacramento River travels to the Delta, it picks up additional flows from its two largest tributaries, the Feather and American Rivers. The Feather River flows generally north to south from its origin near Lassen Peak and joins the Sacramento River from the east at Verona. The American River originates in the Sierra Nevada, flows generally east to west, and enters the Sacramento River at the City of Sacramento. Cottonwood Creek, entering the Sacramento River near the town of Cottonwood, is the largest tributary on the west side of the Sacramento River Watershed that enters the river directly and is the only large tributary that is uncontrolled. Other significant westside tributaries include Cache, Putah, and Stony Creeks; however, they first enter the Yolo Bypass, which then discharges to the Sacramento River near Rio Vista. The eastside tributaries are influenced greatly by snowmelt, however snowmelt has a negligible effect on the westside tributaries' flood runoff.

Tributary flows from numerous small creeks, primarily those draining the western slopes of the Cascade Range and the Sierra Nevada, also feed the Sacramento River. The volume of flow increases as the river progresses generally north to south and is increased considerably by the contribution of flows from the Feather and American River Basins as the flow travels to the Delta. At Shasta Dam, the Sacramento River drains 6,421 square miles. Downstream at Ord Ferry, the drainage area increases to 12,250 square miles, and at Rio Vista, downstream from Sacramento, the drainage area is approximately 26,300 square miles (USACE 1999). Locations along the Sacramento River are referenced by river mile (RM) with RM 0 at Collinsville, the river mouth, and RM 302 at Keswick Dam.

Downstream from Keswick Dam in Redding, the Sacramento River flows south-southeast for 58 river miles until it reaches the valley floor south of Red Bluff. Along the valley floor, the river continues to flow south southeast for 186 river miles to the City of Sacramento, where it changes to a southwesterly course and flows for an additional 60 river miles to its terminus at Suisun Bay in the Delta near Collinsville. The Sacramento River outgoing flows combine with incoming tides from the San Francisco Bay (the Bay) to strongly influence water levels in the Delta. This often causes backwater effects on the San Joaquin River in and near the Delta, causing sediment deposition.

Through the valley floor reach, the Sacramento River is flanked by overflow basins, two of which, the Sutter and Yolo, contain leveed floodways (the Sutter and Yolo Bypasses). These floodways comprise part of the flood management improvements that have been developed along the lower 175 miles of the river on the east bank, along the lower 185 miles of the west bank, and along the lower reaches of the river's major tributary streams. Butte Basin is the northernmost of the regulated overflow basins flanking the Sacramento River. Water flows naturally over the banks into the Butte Basin downstream from Chico Landing through the M&T Flood Relief Structure and Three B's overflow area when Sacramento River flows exceed a certain amount.

2.6.2 Flow and Flood Management in the Sacramento River Watershed

The historic hydrology and hydraulics of the Sacramento River have been greatly affected by the construction of flood management levees, channel modifications, bank protection placement, dam construction, hydraulic mining, and urbanization. The levees and bank protection have restricted river movement downstream from Chico and modified overflows to the natural flood basins during high flows. Overflow to the Colusa Basin was blocked by levees for protection of agricultural lands.

A number of flood management projects along the river affect the flow and operation of facilities. These facilities include dams and reservoirs, levees, and weirs. Shasta Lake collects flow in the Upper Sacramento River Region, but many uncontrolled tributaries enter the Sacramento River downstream from the dam. Stream gages have been added to the major uncontrolled tributaries entering downstream from Shasta Lake (Cow, Battle, Cottonwood, and Thomes Creeks), and dam releases can be adjusted to accommodate uncontrolled flows, subject to storage availability and other operational constraints.

The current flood management system uses five weirs and three flood relief structures located along the river to divert part of the flood flows to three overflow basins and bypasses: Butte Basin, Sutter Bypass, and Yolo Bypass. The weirs function as flow-relief structures that permit high Sacramento River flows to enter the overflow basins and bypasses. The weirs were designed to begin operation in a certain order (upstream to downstream), as follows: Moulton Weir, Colusa Weir, Tisdale Weir, Fremont Weir, and Sacramento Weir.

The Sacramento River is divided into six segments for descriptive purposes in the following sections. Each segment is contained within a different drainage area, and each segment has different flow and flood management characteristics.

The most northern portion of the Sacramento River Watershed, upstream from Shasta Dam, is drained by the Pit River, the McCloud River, and the headwaters of the Sacramento River. The total drainage area is about 6,700 square miles, excluding the Goose Lake drainage of the Pit River (USACE, 1999). Although Goose Lake is topographically within the Pit River Basin, it seldomly contributes to the flow in the Pit River. The last outflow from Goose Lake was in 1880. Only a small Federal channel improvement project in Adin, near Alturas, is found in this segment of the Sacramento River.

Flows in the Sacramento River in the reach between Shasta Dam and Red Bluff (RM 244) are regulated by Shasta Dam and reregulated downstream at Keswick Dam (RM 302). In this reach, flows are influenced by tributary inflow. Major westside tributaries to the Sacramento River in this reach of the river include Clear and Cottonwood creeks. Major eastside tributaries to the Sacramento River in this reach of the river include Battle, Bear, Churn, Cow, and Paynes creeks.

The major flood management facility in this reach of the Sacramento River is Shasta Dam, which creates Shasta Lake, the largest reservoir in the CVP. Keswick Dam, completed in 1950 as part of the CVP, serves as an afterbay for the Shasta and Spring Creek power plants. Since 1964, some flows from the Trinity River Basin, more specifically from Whiskeytown Lake, have been exported to the Sacramento River Watershed through CVP facilities.

The Sacramento River enters the Sacramento River Watershed about 5 miles north of Red Bluff. Along the stretch of river between Red Bluff (RM 244) and Chico Landing (RM 194), the river meanders through alluvial deposits. Flows accumulate downstream on the Sacramento River as major tributaries enter from the east side – Antelope, Mill, Deer, Big Chico, Sycamore-Mud, Rock, and Pine Creeks – and from the west side – Thomes, Elder, Reeds, and Red Bank Creeks. These tributaries influence Sacramento River flows during storms. In this reach of the river, the Chico Landing to Red Bluff Project provides partial bank protection and some channel modifications. The Red Bluff Diversion Dam diverts water from the Sacramento River to the Corning and Tehama-Colusa Canals.

In the reach between Chico Landing (RM 194) and Colusa (RM 143), the Sacramento River meanders through alluvial deposits between widely spaced levees. Stony Creek is the only major tributary in this segment of the river. Big Chico Creek/Mud Creek drain flood waters from the east side of the valley in the Chico area. Black Butte Lake on Stony Creek is the only reservoir operated to manage flood flows in this Sacramento River reach. Floodwaters in the Sacramento River overflow the east bank at three sites in the reach, referred to by the State as the Butte Basin Overflow Area. The first points of diversion, moving downstream, are upstream from Ord Ferry (the M&T and 3Bs flood relief structures). Floodwaters overflow the east bank of the river and flow into the Butte Basin. Under extraordinarily high-river stages at Ord Ferry, floodwaters may also overflow the west bank of the river and flow into the Colusa Basin. Farther downstream, the floodwaters are diverted over the Goose Lake flood relief structure, Moulton Weir, and over the Colusa Weir into Butte Basin. In this river reach, several Federal projects begin, including the SRFCP, Sacramento River Major and Minor Tributaries Project, and Sacramento River Bank Protection Project (SRBPP). Levees of the SRFCP begin in this reach, downstream from Ord Ferry on the west (RM 184) and downstream from RM 176 above Butte City on the east side of the river. It should be noted that these levees were not all constructed to provide the same level of protection.

The Sacramento River meanders between Colusa (RM 143) and Verona (RM 79). The levees, which began upstream, continue in this river reach. The levee spacing, east to west, is wider between the upstream sections, from RM 176 to RM 143 at Colusa, than the levee spacing downstream from Colusa. The Feather River, the largest eastside tributary to the Sacramento River, enters the river just above Verona. Flood management diversions occur at two places in this segment of the river. The first point of diversion, moving downstream, is at the Tisdale Weir. Floodwaters flow over the Tisdale Weir into the Tisdale Bypass, which routes the water into the Sutter Bypass. Farther downstream, floodwaters from the Sacramento River, Sutter Bypass, and Feather River combine and flow over the Fremont Weir into the Yolo Bypass.

The Feather River has a drainage area of 5,921 square miles and contributes about 44 percent of the annual flow in the Sacramento River. The rest of the basin extends south and includes the drainage of the Yuba and Bear Rivers. Annual precipitation in the Feather River Basin varies from about 20 inches in the valley near Oroville to nearly 90 inches on the ridges near the west branch of the North Fork of the Feather River. Of the total flow, 75 percent originates above Oroville, and about half of that comes from the North Fork. Two major tributaries to the Feather River are the Yuba River and Bear River, contributing on average about 30 percent of the total Feather River flow (Reclamation, 2005c). During large flood events, the lower Feather River (below USGS RM 7.5) comingles with the Sutter Bypass. As a result of this confluence during large flood events, the lower reaches of the Feather River (above and below RM 7.5) are subject to backwater conditions and increased sedimentation.

Between Verona (RM 79) and Collinsville (RM 0), the Sacramento River flows past the City of Sacramento to the Delta. The Yolo Bypass parallels this river reach to the west. Flows enter this river reach at various points. First, flows from the Natomas Cross Canal enter the Sacramento River approximately 1 mile downstream from the Feather River mouth (RM 80). The American River (RM 60), the southernmost major Sacramento River tributary, enters the river at the City of Sacramento. The flows in the Yolo Bypass reenter the river near Rio Vista (RM 12). As the river enters the Delta, the Georgiana Slough branches off from the main stem of the river, routing flows into the central Delta. The one diversion point for flood management is at the Sacramento Weir, where floodwaters are diverted from the Sacramento River through the Sacramento Bypass to the Yolo Bypass.

The American River drains an area of 1,921 square miles in the north- central portion of the Sierra Nevada. Mean annual unimpaired runoff is estimated at 2.6 MAF at Fair Oaks. Folsom and Nimbus Dams regulate flow for irrigation, power, flood protection, municipal and industrial use, and other uses. The American River joins the Sacramento River about 25 miles downstream from Nimbus Dam (DWR, 1996b).

2.6.3 Future Without-Project Conditions

Basic physical conditions in Sacramento River Watershed are expected to remain relatively unchanged in the future. No major changes to area hydraulics are seen. In areas where the rivers are not confined by geological or man-made formations and are given space to meander, more natural river channel meandering and migration patterns would occur as a result of geomorphic processes. Potential changes in SPFC levee conditions, channel capacities, flood protection structures, and floodplains are summarized below.

Future levee conditions in the Watershed are likely to be affected by drivers related to, climate change, regulations addressing environmental degradation and water quality, and availability of public funding for flood management system improvements. Further, many levees in the system are very old and have reached, or will reach, the end of their useful design lives. Erosion and storm-related effects will continue to degrade levee conditions in some locations, affecting their performance and the cost of maintenance.

Similar to levee conditions, channel conveyance capacities in the region would be impacted by larger and more frequent floods from climate change and the possible subsequent sedimentation, limited availability of public funding for flood management system improvements, and regulations addressing environmental degradation and water quality. Mercury-contaminated sediments are expected to continue to effect channel conveyance because they hinder dredging operations; however, dredging and vegetation management will remain an important means of maintaining channel capacity for flood management and navigation in portions of the region.

The capacity and performance of some flood protection structures in the region would be impacted by larger and more frequent floods from climate change, and limited availability of public funding for flood management system improvements.

Increased urbanization and climate change effects will likely alter runoff characteristics (more frequent and higher flood peaks), potentially increasing the depth and extent of flooding in the region.

2.7 Geomorphology

The geomorphology of the Sacramento River varies throughout the region. The Geomorphic Provinces within the Watershed are shown above in Figure 2-5. The river in this area is generally narrow and deep, and the floodplain is similarly narrow. From here, the river emerges onto the broad alluvial floodplain of the Sacramento Valley (USACE, 2001).

For about the next 50 river miles, the Sacramento River historically meandered, over time, across a wide floodplain. By eroding and depositing sediment, the river migrated across deep alluvial soils from the Red Bluff area to about Hamilton City and Chico Landing. At RM 190, Stony Creek joins from the west, and flows from the Big Chico Creek approach from the east at RM 193. From this point downstream, flood flows along the Sacramento River were split between the main stem and the adjacent flood basins separated from the main stem by natural levees. Because of the natural geomorphic processes associated with valley basins such as the Sacramento, the size and capacity of the main stem decreased in the downstream direction and topographically, the river banks are higher than the connecting floodplains. The sheer magnitude of flood flows resulted in several distributary flood paths across the flat valley floor into which main stem flows spilled (USACE, 2001). Both base flows and flood peak flows have been regulated to the extent that they limit natural geomorphic and ecosystem functions.

Channel migration, meander cutoff, and other important ecosystem processes are severely limited by water infrastructure, including bank revetment and near-channel levees. Such constraints reduce the potential for these ecosystem processes to occur. For example, levees disconnect channels from the floodplain, and thus eliminate or reduce overbank flows. Overbank flows provide access by native fish to the floodplain, and water, sediment, nutrients, and seeds to the floodplain, and thus, maintain floodplain ecosystems.

Bank revetment (i.e., the hardening of streambanks by riprap or other material to prevent erosion) generally causes the river to become narrower and deeper, thereby reducing hydraulic complexity. Bank revetment may also increase the incidence of riverbend cutoffs, thus reducing the overall length and sinuosity of the river. Bank revetment and levees also reduce the potential for channel migration. This reduction in channel migration affects Shaded Riverine Aquatic (SRA) cover and large woody material, two important aspects of habitat for salmonids and other native fish species.

2.7.1 Historic Mining

Hydraulic mining had a major influence on the flow carrying capacity of the Sacramento River system and especially the eastside tributaries beginning in 1853. Hydraulic mining consisted of excavating hillside areas with high-pressure water cannons or “monitors” to get to the gold-bearing materials, resulting in the generation of more than 1.1 billion cubic yards of mining debris and sediment that flowed downstream to the valley floor during high-flow events. The Yuba, Bear, and Feather Rivers received the highest mining sediment loads. Accordingly, these rivers and the Sacramento River downstream from the confluence with the Feather River were severely impacted by the large sediment loads in the late nineteenth and early twentieth centuries. These changes to channels resulted in increased flood stages, repeated bank and levee failures, and severe peripheral flood damages (James and Singer, 2008).

2.7.2 Sedimentation and Erosion

Under natural conditions, the Sacramento River had insufficient capacity to carry the heavy winter and spring flows generated by wet season precipitation and/or snowmelt (USACE, 1999). The rivers overflowed onto the surrounding countryside as they exceeded the channel capacity. The flow velocity in the overbank areas would be greatly reduced from that in the channel. Thus, the sediment carrying capacity would also be reduced, allowing much of the material naturally eroded from mountain and foothill areas and carried in the streams to drop out of suspension. The Sacramento River built up its beds and formed natural levees composed of the heavier, coarser material carried by the flood flows each year. The finer material stayed in suspension much longer and would drop out when the overflow water ponded in the basins that developed east and west of the rivers. The flow regime and the sediment supply have changed significantly from natural conditions in the Sacramento River because of human activities.

Many levees were originally designed to narrow the channel to promote high velocities and resultant scouring in order to move the large amounts of sediments from hydraulic mining and to deepen the channel for navigation. The narrow channel design after the mining era contributed to the self-eroding phenomena of the levees, which now adds significantly to maintenance costs. To protect the banks from erosion, levees are armored with large boulders (riprap), which is expensive and has ecological impacts on riparian habitat in the channel. Today, the optimal design for a self sustaining channel is regarded as a wide, meandering channel that is compatible with natural geomorphic processes, allows riparian habitat, and has the capacity to carry flood flows.

Upper Sacramento River

From the base on Mount Shasta for about 75 miles downstream to near elevation 300 near the town of Red Bluff, the Sacramento River is constrained by erosion-resistant volcanic and sedimentary formations. The Chico Landing to Red Bluff Project, authorized in 1958, provides for bank protection (erosion protection) and incidental channel modifications along 50 miles of the Sacramento River between Chico Landing and Red Bluff. In this reach, 21.5 miles of bank protection have been installed to hold the river in place and prevent meandering of the channel (USACE, 1999). Erosion from meandering channels damages adjacent agricultural lands.

Feather River

As a result of the deposition of hydraulic mining debris transported from the Yuba River and Bear Rivers between 1850 and 1910, the Feather River aggraded by up to 20 feet near Marysville and reduced its sinuosity thereby increasing the overall channel gradient. With subsequent reductions of sediment loads following cessation of hydraulic mining and dam construction, the river incised by 4 to 20 feet by the end of the 1960s and is currently resting on its native (erosion resistant) formation (Ayres, 1997). This aggradation followed by incision has left the floodplain of the Feather River largely disconnected (elevated) from the mainstem, thereby reducing the duration and frequency of floodplain inundation, which is essential to the ecological function of the river corridor.

Yuba and Bear Rivers

Rivers in the foothill and lower basin areas have been severely affected by rapid aggradation caused by hydraulic mining activities. Since the ban of hydraulic mining in 1893, many channels have since incised into the debris (USACE, 1999). Natural and constructed debris impoundments remain both within the channels and in overbank areas. Debris input into the Lower Yuba River prompted the relocation of the Lower Yuba River to its current location. The lower Bear River is a single-channel river characterized by low sinuosity and channel degradation over the last century. The lower Yuba River, which received significantly more mining debris than the Bear River, is characterized by high terraces of mining sediment alongside a degrading river channel with a steep gradient. Degradation has been accelerated along the lower Yuba River by dam construction and the gradual movement of sediment and mining debris down the Feather River.

Cache Creek

High velocities of water carry larger sediments down from upstream hill locations. As water slows either from flow rates dropping or flows overtopping banks, aggregates settle out in concentrated deposits. The 16- mile stretch of Cache Creek between the towns of Capay and Yolo has been extensively mined for aggregates, which has changed the sediment balance in the waterway, thereby increasing the erosion potential downstream. The Cache Creek Settling Basin is where waters from Cache Creek are impounded over a broad area to allow sediment to settle out so that the adjacent Yolo Bypass, which must carry away Sacramento River flood water, does not clog. The Cache Creek Settling Basin has been affected by mercury deposits and is contaminated.

The Cache Creek Settling Basin impounds flood waters from Cache Creek over a broad area to allow sediment to settle out before entering Yolo Bypass. This system is outdated and currently causes a flooding problem for the City of Woodland. CCSB is being reevaluated by State and ACOE to determine if it can be modified to reduce flood risks to Woodland while opening up the system to significant ecosystem restoration potential for integrated floodplain managment with an expanded Yolo Bypass. Flood system upgrades on the Sacramento River at Sacramento and elimination of outdated wastewater treatment facilities downstream of CCSB have created an new opportunity to reconfigure the CCSB/Yolo flood bypass system to provide reduced flood risks while providing expansive floodplain ecosystem restoration and connectivity opportunities within a Systemwide approach for Yolo Bypass and the lower Sacramento River system.

Lower Sacramento River

The lower Sacramento River is a single-channel watercourse with moderate to low sinuosity that is confined by levees located immediately adjacent to the riverbanks. The gradient of the river channel is relatively low and flat and becomes more so as it approaches the Delta. Sediment is generated from upstream reaches of the Sacramento River, tributaries, and bank erosion. Sediment deposition occurs most notably in the Yolo Bypass and in the Delta. The lower Sacramento River is a perched system, meaning that ground elevation generally decreases with distance from the river. This is due in part to historic (before hydraulic mining) sediment deposition that occurred more rapidly alongside the river than in the adjacent floodplains, forming natural levees and gradually elevating the river channel.

2.7.3 Future Without-Project Conditions

Basic physical conditions in the Watershed are expected to remain relatively unchanged in the future. No major changes to area topography, geology, geomorphology, or soils are foreseen.

2.8 Biological Resources

2.8.1 Sources of Ecological Significance

There are numerous sources of institutional, public and technical significance for the ecological resources of the Sacramento River Watershed. Some of the more general sources of significance that are applicable to the overall watershed are identified here.

The Sacramento River Watershed encompasses more than a third of the entire Delta Watershed [1], which has been recognized by USACE as a National priority aquatic ecosystem of significance [2]. The Sacramento River is the largest river in California and the most important for anadromous fish [3]. The multi-agency CALFED Bay Delta Programmatic Record of Decision (ROD) approved by Congress in 2004 [4], and the San Francisco Bay Comprehensive Conservation and Management Plan (CCMP) established under the National Estuary Program are two examples of Federal plan recognition of the national significance of the overall San Francisco Bay-Delta watershed including the Sacramento River Watershed. The ROD and CCMP both include restoration of Sacramento River aquatic habitats among their proposed actions [5,6].

Historically, there has been a severe loss of aquatic habitats in the Sacramento River Watershed because of agriculture, urban development, construction of dams and levee systems, water diversions, and mining impacts. About 88 percent of the watershed's pre-1900's riparian, wetland, and other floodplain habitats have been lost [7]. In 1992, the USFWS estimated that 93 percent of the original shaded riverine aquatic cover had been removed from 84 miles of channels within the extent of the Sacramento River Bank Protection Project on the lower Sacramento River [8]. Control of river flows and armoring of riverbanks have also resulted in a loss of natural dynamic hydrologic and geomorphic processes including overbank flows and channel meandering.

Because of extensive habitat losses and modifications, native plant and animal populations have been significantly reduced and fragmented. As a result, there are numerous special status plant and animal species in the watershed, including Federally-listed species. Federal special status fish species include three Chinook salmon populations, steelhead, green sturgeon, and delta smelt (*Hypomesus transpacificus*).

The presence of several special status fish species has resulted in significant constraints on the operation of the Federal CVP and the SWP, both of which use water primarily from the Sacramento River to supply 22 million residents and to irrigate over 3.6 million acres of farmland [9]. The degradation of habitat in the Sacramento River

Watershed has therefore contributed to significant limitations on the production and use of ecosystem goods and services throughout the Delta's watershed.

The Sacramento River Watershed is an important part of the Pacific Flyway, providing a continuous 250-mile migratory corridor for waterfowl, shorebirds and passerine birds. The seasonal and permanent wetlands of the Sacramento Valley support 60 percent of wintering and migrating waterfowl from the Pacific Flyway [10]. The Central Valley Joint Venture is one of the original six priority joint ventures formed under the North American Waterfowl Management Plan in 1988; it now has 19 Federal and State agencies and non-governmental organizations (NGOs) as members [11].

The State's Upper Sacramento River Fisheries and Riparian Habitat Management Plan provides an additional source of significance for the aquatic habitats of the Sacramento River [3]. The 1989 Plan was prepared by a 25-member Advisory Council that included representatives of Federal, State and county governments and various interest groups, including USACE. The plan identifies 22 actions to restore riparian habitat and fisheries on the Sacramento River from Keswick Dam near Redding to the mouth of the Feather River near Verona, a distance of 222 river miles. The Sacramento River Conservation Area was formed in 2000 and continues the work of the Advisory Committee through the Sacramento River Conservation Area Forum (SRCAF) which changed its name to the Sacramento River Forum in 2015, including development of the SRCAF Handbook. The Handbook identifies seven major actions to preserve and restore riparian habitat along the Sacramento River.

The State has established the Sacramento River Wildlife Area consisting of 3,900 acres along 70 miles of the Sacramento River in Colusa, Glenn, Tehama and Butte Counties. All 13 units of the Wildlife Area are contiguous with the river. The principal purpose of the Wildlife Area is to protect and enhance habitat for wildlife species [12].

The federal Sacramento River National Wildlife Refuge Complex (Refuge) of five wildlife refuges and three wildlife management areas consists of over 10,000 acres in 26 units along 77 miles of the Sacramento River between Red Bluff and Princeton [13]. The Refuge Complex was created to provide wintering habitat for waterfowl and to protect and restore riparian habitat. The Refuge's vision is to create a linked network of up to 18,000 acres of floodplain forests, wetlands, grasslands, and aquatic habitats. The WMAs consist of a combination of private lands protected with conservation easements and Service-owned lands (the Butte Sink Unit of the Butte Sink WMA, and the Llano Seco Unit of the North Central Valley WMA). The conservation easements are owned and managed by private landowners, and the Service-owned lands are owned and managed by the U.S. Fish & Wildlife Service.

The Nature Conservancy, as one of many environmental NGOs active in the watershed, has protected a 24,000 acre corridor of land, with a 2015 goal of 30,000 acres, and restored 6,000 acres of riparian habitat under its Sacramento River Project [14]. California Waterfowl Association is restoring and improving waterfowl habitat all over the state and is making hundreds of acres both public and their own lands more accessible to hunters within the basin.

2.8.2 Vegetation and Wetlands

The Sacramento River Basin includes several distinct ecosystems. The Sacramento Valley floor consists largely of a mosaic of irrigated agriculture, and rangelands, with small areas of wetlands, and riparian habitats along rivers. East and west of the valley, the foothills are primarily annual grasslands and oak woodland. Particularly on the west side of the valley, there are large tracts dominated by chaparral (brush species) that is overly thick and decadent as a result of the many years of fire suppression policy. With increasing elevation, the landscape consists predominantly of mixed conifer species such as pine, fir, and cedar (Sacramento River Watershed Program, 2010). With regard to vegetation and watershed management, three dominant themes emerge for the basin overall:

- Reduce forest fuel loads to decrease potential for catastrophic wildfire,
- Restore, expand, reconnect, protect and enhance remaining riparian corridors, and
- Eradicate noxious and invasive plant species that are competing with native plant communities.

To discuss the vegetation conditions, the watershed has been divided into the 6 distinct subwatersheds described shown below in Figure 2-13. In the following sections, the Northest subregion is referred to as the Upper Sacramento River and Tributaries. Figure 2-14 also provides a broad overview of the landcover types that are present in the Sacramento River Watershed.

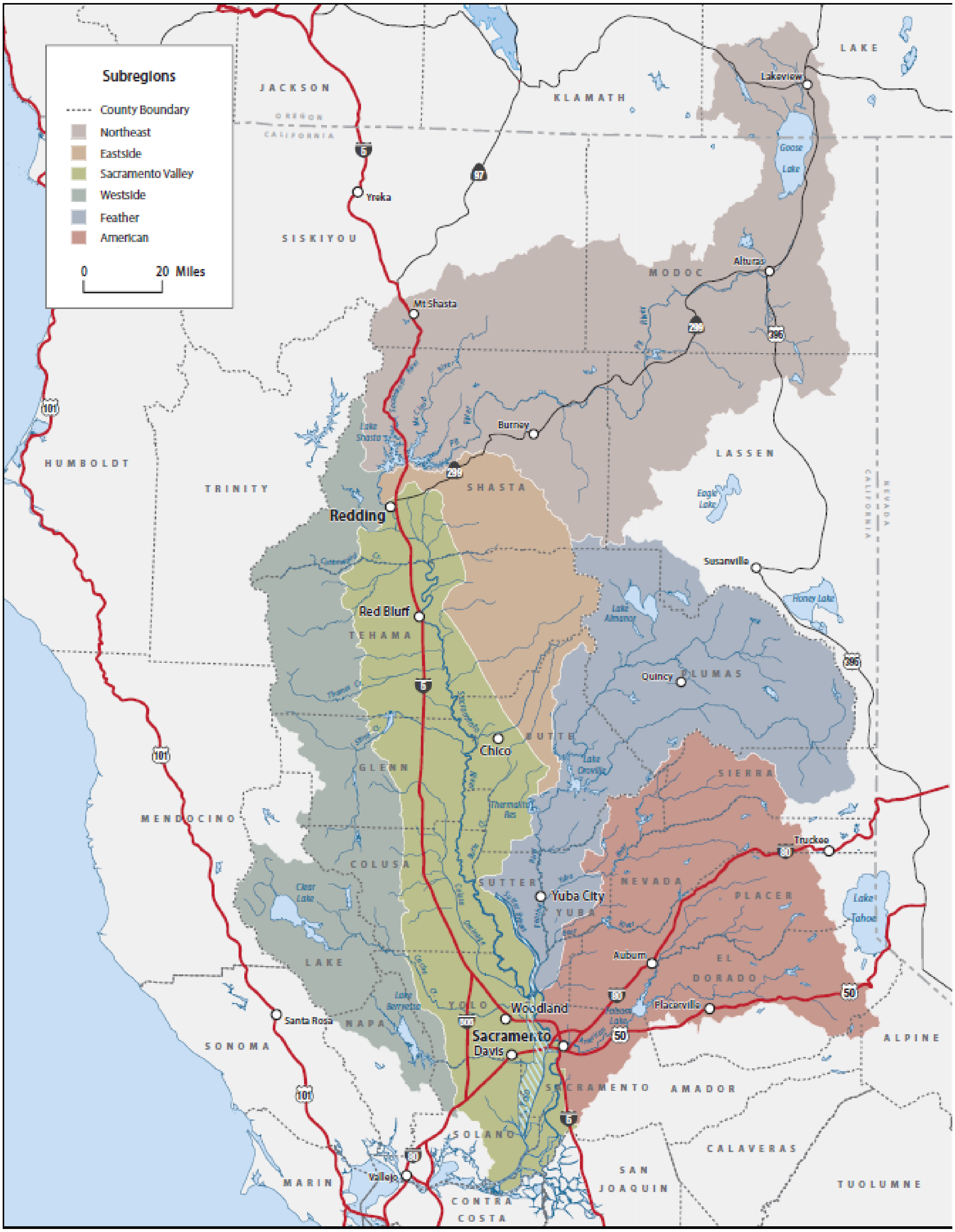

Figure 2-13 Six Subwatersheds of the Sacramento River Valley

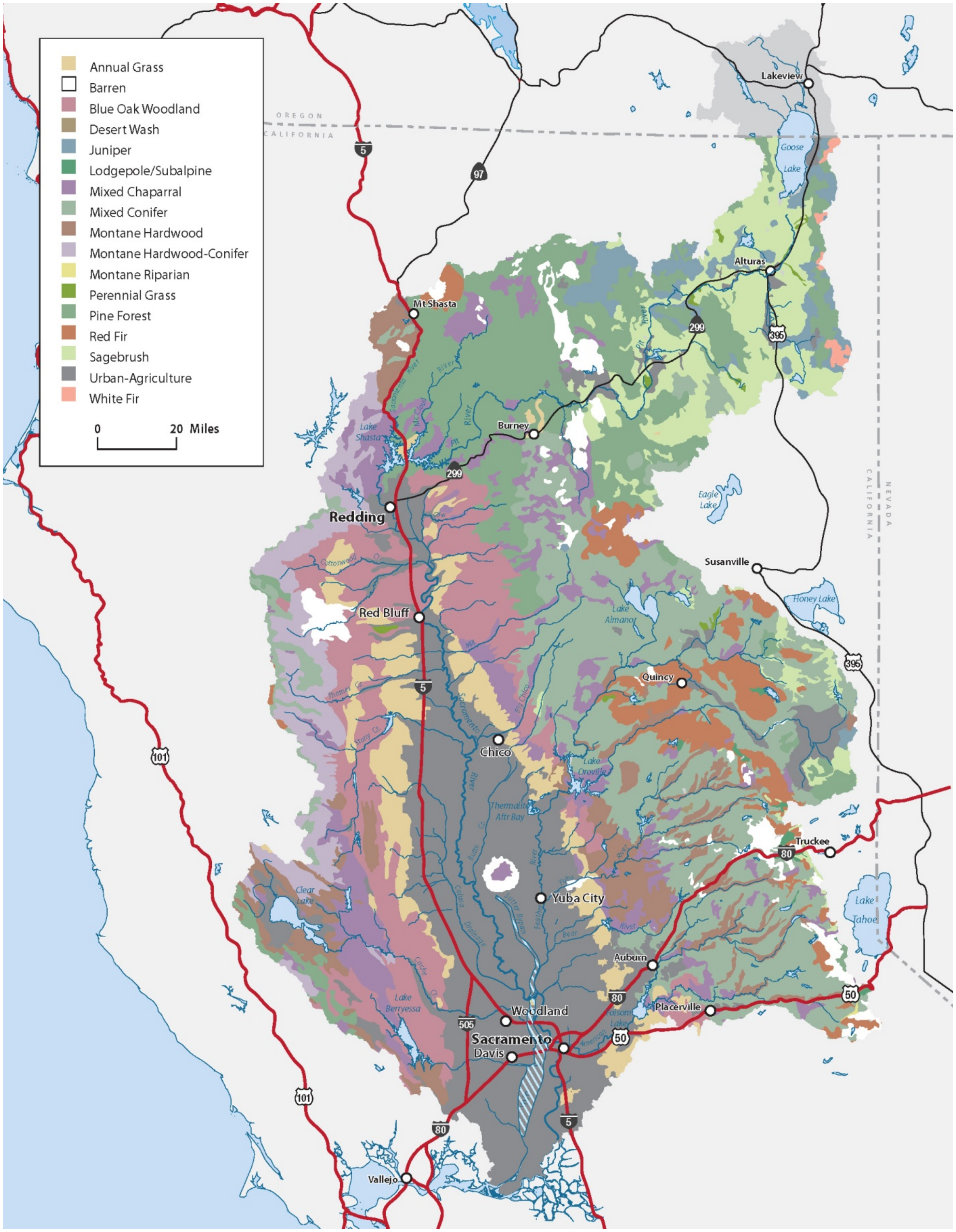

Figure 2-14 Land Cover Types

Source: Sacramento River Watershed Program, 2010

Upper Sacramento River and Tributaries

This subregion includes three major river basins: the Upper Sacramento River, McCloud River, and Pit River. These rivers drain a four-county area in the north and northeastern part of the Sacramento River Basin and flow generally southwest into Lake Shasta.

The Upper Sacramento River Watershed contains more than 250,000 acres of forested lands. This acreage includes major commercial stands of pine, fir, and cedar. Noncommercial stands of chaparral and hardwoods (black oak and live oak) are common, particularly in the lower elevations. Climate conditions and the generally steep terrain severely limit irrigation agriculture in this watershed. The dominant vegetative community is mixed conifer, covering approximately 46% of the watershed area. Mixed hardwood is next most prevalent, covering about 12%. Pacific yew, Indian rhubarb, and white alder are only a few of the native plants to be seen in the riparian area adjacent to the river.

Western Foothills and Tributaries

The western foothills include all watersheds on the west side of the Sacramento Valley starting with Putah Creek to the south and extending north to the Clear Creek Watershed west of Redding. Drainages from the west side of the Sacramento Valley typically originate in areas of moderate elevation (3,000 to 5,000 feet), and hydrology is driven by rainfall rather than by the extended spring-summer snowmelt that feeds rivers and streams on the east side of the valley.

Vegetation and land use on the west side typically consist of conifer stands in the upper elevation with commercial timber production, oak hardwood and annual grassland in the mid-elevation foothill region that supports livestock grazing, and irrigated agriculture on the valley floor. In many of the watersheds, vegetation is dominated by large areas of decadent brush fields that are a high fire risk and have minimal value for livestock forage or wildlife habitat.

The principal driving forces behind the existing vegetation conditions in this subregion include (1) introduction of nonnative plant species, (2) grazing by domestic livestock, and (3) alteration of historical fire regime.

For example, historically, Native Americans in Upper Stony Creek intentionally burned the watershed’s rangelands on a regular basis. This prevented establishment of climax plant communities and maintained an abundant and diverse community of native grasses. European introduction of domestic livestock and a change in fire management eventually led to native perennial bunch grasses being replaced by exotic annual grasses. Today, a diverse mosaic of vegetation exists in the Upper Stony Creek Watershed. In the lower elevations, this includes a patchwork of grasslands, blue oak and valley oak, foothill pine, and chaparral. In upper elevations (above 2,000 feet), hardwood and conifer forests are dominated by species such as live oak, black oak, Douglas fir, and white fir. Vegetation in the foothill regions of Lower Stony Creek is similar to that in the lower elevations of the upper watershed. Prior to Black Butte Dam, riparian vegetation along Stony Creek occurred in a relatively continuous corridor from the Sacramento River upstream to the Coast Range. This corridor was dominated by willow and cottonwood. In recent times, giant reed and saltcedar have flourished in Lower Stony Creek, replacing much of the abundance and diversity of native riparian species.

Vegetation along Upper Cache Creek includes cottonwoods, willows, oaks, and alders. Much of the Upper Cache Creek Watershed consists largely of mixed chaparral habitat. Riparian vegetation within the Wilderness Area reach is largely intact and invasive giant reed (Arundo donax) and salt cedar (Tamarisk spp.) have been eradicated.

The natural riparian forest in the Putah Creek Watershed is composed mostly of Central Valley mixed riparian woodland. Typical understory species include box elder, Oregon ash, white alder, Goodding and red willow, buttonwillow, mulefat, California nettle, wild rose, wild grape, and California blackberry. Typical canopy species include Fremont cottonwood, valley oak, and California sycamore. Canopy vegetation in the Riparian Reserve established by UC Davis is dominated by valley oaks and northern California black walnut. Arroyo willow and narrow-leaved willow are found on the streambanks closest to the water and within the annual flood zone.

Nonnative species such as giant reed (Arundo donax), saltcedar (Tamarisk spp.), and Ravenna grass threaten the health of riparian corridors. This is particularly a problem in Cache Creek. In the lower watershed's riparian corridors, these species have displaced native trees and shrubs and exacerbated bank erosion by laterally diverting streamflows. In Capay Valley, nonnative species such as yellow starthistle, barbed goatgrass, and medusahead threaten the quality of agricultural rangelands.

Eastern Tributaries

The Eastern tributaries subregion includes all tributary watersheds on the east side of the Sacramento Valley starting in the north with the Churn/Stillwater Creek Watershed in east Redding and going south to and including Butte Creek. Relatively high-elevation source waters, fed by ample precipitation and snowmelt, provide mostly year-round flow in these streams through the watershed and into the Sacramento River.

Upper elevations in this region are dominated by conifer forest and commercial timber production, and there are large tracts of National Forest and National Park land that offer public access for hunting, fishing, hiking, and camping. Mid-elevations are oak hardwood mixed with annual grassland, and mostly privately owned ranchland used for domestic livestock grazing. Because of the ample water supply and surface water diversions, irrigated pasture in the mid-elevations of this region is much more prevalent than on the west side of the Sacramento Valley. In the lower reach of most watersheds, near the Sacramento River, the land is in irrigated agriculture--orchards, rice, and row crops. This lower watershed area also has some of the most valuable wildlife habitat and includes vernal pools, riparian corridors, and wetlands.

Vegetation in this subregion has been shaped and modified mainly by fire suppression policy, timber harvest practices, livestock grazing, and introduction of nonnative plant species. Native plant communities in the watershed have been altered significantly by aggressive fire suppression, conversion for agriculture, and the introduction of invasive species. Historically, coniferous forests were open and park-like, whereas today's forests are dominated by dense, small-diameter, shade-tolerant trees with thick understory and an accumulation of fuels on the forest floor. This condition results in significant fuel loading and high fire danger.

Vernal pools are particularly significant, and a large complex exists on Nature Conservancy Vina Plains Reserve as well as in the Tehama East watershed. Vernal pools fill with water in the winter months, dry down in the spring, and are completely desiccated in the summer months. They support numerous endemic and special status species.

In the rural portion of this watershed area, dominant vegetative habitat is blue oak woodland with a mixture of annual grassland, chaparral, and Digger pine and other conifer species. Seasonal emergent wetlands are scattered throughout the watershed, as are small reservoirs, farm ponds, and marsh areas. Urban habitat (urban, commercial, suburban, and residential) makes up about 17% of the Churn/Stillwater Creek watershed area.

American River and Tributaries

The American River subregion includes four watersheds: Upper American River Watershed, Yuba River Watershed, Bear River Watershed, and Lower American River Watershed.

The subregion consists of roughly 5,375 square miles and includes portions of six counties. The foothill and mountain counties are undergoing land-use transitions from primarily extractive industries and agriculture production to rural and urban development. The subregion covers a large and diverse area from elevations as high as 9,148 feet to 23 feet at the confluence of the Sacramento River. The higher elevations consist of mixed conifers and montane hardwoods progressing to oak woodland, chaparral, and grasslands in the lower elevation. The landscape is characterized by rugged topography with steep canyons in the upper watershed and both highly urbanized areas and rural agricultural communities in the lower watershed.

Mixed conifer dominates the upper watershed, which includes ponderosa pine, Douglas-fir, and incense cedar among others. The Upper Bear River valley also supports excellent wet meadow and riparian habitat. The watershed is also home to oak woodlands and chaparral communities transitioning to grassland and agricultural lands in the lower elevations. Of the vegetation types most frequently documented to contain rare and unique species, the foothill woodland and chaparral communities have been particularly damaged and fragmented by changes in agriculture and development.

Habitat in the Lower American River Watershed represents both natural and altered landscapes. After the discovery of gold, portions of the river were dredged by the gold mining companies, leaving behind large piles of cobble and excavated areas. The slow process of natural reclamation has returned some areas to a semi-natural state, while the most severely altered areas can still be seen today. The banks of the river channel provide riparian habitat—both scrub and forest consisting of cottonwood, valley oak, and willow, with occasional white alder, box elder, and Oregon ash. Understory species include wild grape, wild rose, blackberry, and elderberry. Emergent marsh habitat is found in still or slow-moving shallow water located on the edges of the river and on the banks of open water areas. These marshes are dominated by aquatic vegetation such as cattail, tule, soft rush, and blue vervain. Habitat above the riverbed consists of oak woodlands (valley and interior live oak) and grasslands (largely nonnative, but some native filaree, wild geranium, mustard, wild radish, California poppy, larkspur, and yarrow). The area outside of the American River Parkway is highly urbanized.

Habitat in the American River Basin was historically a large wetland area. Today the floodplain is principally rice fields in the north and central areas, with the metropolitan area of Sacramento to the south. Above the floodplain the creeks pass through the rolling hills of Placer County, and cities of Lincoln, Roseville, and Rocklin. This area is a mixture of agricultural lands, grasslands, oak woodlands, and urban development.

Feather River and Tributaries

This subregion includes all waters of the Feather River from its headwaters in the Sierra Nevada downstream to the Sacramento River confluence. The river is divided into an upper watershed and lower watershed by the 3.5 million-acre-foot Oroville Reservoir, the keystone of the State Water Project.

A hundred-year legacy of mining, grazing, timber harvest, roads, and railroads (together with fire suppression and, more recently, rural residential development) has affected the Upper Feather River watershed conditions in both the uplands and the waterways. The Lower Feather River meanders through the lush valley agricultural lands and joins the Sacramento River at Verona north of the city of Sacramento. The landscape is dominated by orchards, rice, and other irrigated row crops. Yuba City and Marysville are rapidly expanding, major urban centers in this watershed area.

Roughly 70% of the Upper Feather River Watershed is composed of mixed conifer forest (pine, fir, and cedar species). Irrigated agriculture (mostly pasture, hay, and alfalfa) is the next largest vegetative cover type. Sagebrush communities are common on the eastside, and meadow and riparian land-forms are extensive throughout the watershed. Restoring these wet meadow and riparian environments continues to be a priority management issue.

The lower Feather River watershed supports several primary terrestrial communities interspersed with wetland habitat types. The foothills in the north and east portions of the watershed generally consist of blue oak woodlands with scattered chaparral and other shrub-dominated communities.

The Central Valley portions of the watershed are mostly in irrigated agriculture, including orchards, vineyards, and row crops. Annual grasslands dominate areas where land is not being farmed. Valuable riparian, vernal pool, and wetland habitat is located along river corridors and in annual grassland depressions. Wildfire is a natural part of conifer, chaparral, and oak woodland ecosystems and is now a major management concern, partly because of expanding residential land use and the many years of fire suppression policies.

Sacramento Valley

The Sacramento Valley is a rich mosaic of farmlands, cities and small communities, and managed wetlands and a vast network of meandering rivers, streams, canals, and agricultural drains. It is not a watershed in itself but rather the terminus and conglomerate of the many individual tributary watershed areas. There are nearly 2 million irrigated acres in the valley that support orchard crops (stone fruit and nuts), rice, grain, pasture, vineyards, tomatoes, and a variety of other field crops. With mild winters and hot, dry summers, agriculture is dependent on surface and groundwater supplied through a complex system of canals and drains.

Approximately 60 commercial crops are grown on irrigated farmland in the Sacramento Valley. Rice is the number one crop in the Sacramento Valley Region, accounting for 26% of the total agricultural acres. The next most prominent group is field crops (19%) followed by orchards (15%), pasture (11%), and grains (10%). In general, the lowlands of the valley primarily are planted in rice, rotated into winter cereal grains, or are permanent wetlands. Orchards generally are grown on alluvial soils near major rivers and tributaries and tend to be concentrated on the eastern or far western areas of the Sacramento Valley.

Historically, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with valley oak woodland covering the higher river terraces. In low-lying areas beyond the riparian and hardwood forests, there were vast seasonal marshlands that would transition to dry alkaline sinks during the summer. Beginning in the mid-1800s, agricultural conversion and urbanization aided by dams, levees, and channelization altered this riparian system to where currently there are approximately 24,000 acres of riparian habitat in the river corridor, less than 5% of the original amount. As in the other watersheds discussed above, invasive species are also problematic in the Sacramento Valley and disrupt the remaining native riparian vegetation communities.

Future Without-Project Conditions

This section discusses the future without-project conditions related to vegetation and wetlands in the study area in the year 2070. Generally, the various county and city general plans indicate that all future development would be focused on the conversion of agricultural land to developed lands. One of the more prominent effects on the future of vegetation in this watershed might be the full implementation of vegetation management to comply with O&M requirements. These requirements are stated in the USACE levee vegetation policy (ETL 1110-2-583).

At this time it is probably too speculative to adopt and consider a single future compliance scenario. Therefore, this document acknowledges the following possible future scenarios in regard to the USACE levee vegetation policy, as it relates to the without-project conditions:

- Full application of USACE levee vegetation policy, under which some woody vegetation may be removed from within the levee prism or within 15 feet of the landside or waterside levee toes, or
- No application of the vegetation policy; assuming the continued existence into the future of the vegetation conditions at this time, or
- Application of the interim guidance for USACE levee vegetation policy from the framework process, meaning trees within the levee prism on the landside slope, upper 20 feet of the waterside slope, or within 10 feet of the landside toe must be trimmed up 5 feet above the ground (or 12 feet above the crown road) and thinned, or
- Application of a possible variance, such as the variance issued for the Natomas Levee Improvement Plan under USACE's draft variance policy, including removal of trees within the levee prism on the landside slope or within the landside operations and maintenance corridor, and allowance of trees within the levee prism on the waterside slope based on the ability to demonstrate no affect on the critical levee prism.

Other factors that could affect the future without-project conditions, but for which no information was available or predictions can't currently be made, include, but are not limited to:

- Modifications to existing city and county general plans and future build-out areas,
- Possible highway and infrastructure improvement projects,
- Conversions of natural communities to agriculture uses,
- Changes in agriculture land use, and
- Future habitat mitigation projects (e.g., Habitat Conservation Plans [HCP]/Natural Community Conservation Plans [NCCP] restoration projects, wildlife refuge expansions).

Riparian Habitats are likely to be primarily impacted within the Sacramento River Watershed due to factors described above. Various development activities and levee construction activities may also affect other vegetation categories such as wetlands and upland areas. While setback levees are considered to be the environmentally-preferred option, the setback footprint can overlay important wetland areas and upland habitats. These will likely be mitigated during implementation, but the value to species may not be fully replaced.

Overall, it is likely that riparian habitat will be reduced, at least initially, through the implementation of the above mentioned projects, particularly compliance with USACE levee vegetation policy and overall changes in land use.

2.8.3 Wildlife and Habitats

Upper Sacramento River and Tributaries

The Upper Sacramento River watershed provides important habitat for a number of special-status plant and animal species, Shasta salamander, and northern spotted owl. Today there are 75 mammal species living on the Upper Sacramento River, including 17 species of bat. Visitors to the area are likely to observe wildlife such as river otter, bald eagle, osprey, and great blue heron.

There are approximately 217 species of wildlife associated with the habitat found in the McCloud River Watershed, including 132 birds, 55 mammals, 19 reptiles, and 11 amphibians. Beneath the dense mixed conifer and oak forests, active wildlife includes black bear, mountain lion, wolverine, ringtail cat, and gray fox. The Shasta salamander makes its home on the canyon’s limestone outcrops and occurs nowhere else on earth. Along the river, otters move through pools lined with white alder, Indian rhubarb, and horsetail. The forest and sagebrush uplands are important habitat for mule deer and other wildlife species. During the fall and winter, Goose Lake provides resting habitat for large numbers of migrating waterfowl.

Given its large and relatively uninhabited landscape, the Upper Pit River Watershed is one of the State’s most important regions for fish, wildlife, and associated aquatic resources. This diverse and unique natural aquatic fauna includes some federally and state-designated special-status species (e.g., Modoc sucker, rough sculpin, Pit roach, western pond turtle, and Shasta crayfish).

Wetlands and irrigated agricultural habitats in the watershed provide habitat for both migratory and resident waterfowl. There are abundant populations of duck species, white and dark Canada geese, and sandhill cranes. Both Ducks Unlimited and California Waterfowl Association have been actively working with landowners on projects to improve waterfowl habitat. Upland areas contain some of the State’s most important habitat for mule deer, elk, and antelope.

Populations of the endangered Shasta crayfish have been found in most of the major headwater springs of the Fall River and Tule River. Protection of Shasta crayfish and rough sculpin (state-listed as threatened species) is a principal management issue. The Fall River Valley is a major habitat area for resident and migratory waterfowl, and both Ducks Unlimited and California Waterfowl Association are working with private landowners to protect and enhance waterfowl habitat.

Hat Creek has had recent problems with sedimentation that has led to a decline in aquatic plant growth and production of aquatic insects. Other notable aquatic species unique to this area are the endangered Shasta crayfish and rough sculpin. CDFW operates a large fish hatchery on Hat Creek at Baum Lake, and both Crystal Lake and Baum Lake provide significant wetland habitat for waterfowl production. The heavily forested, sparsely inhabited uplands provide habitat for species such as spotted owls, northern goshawks, and pine martens, while more open areas (including irrigated pasture lands) are important habitat for mule deer and greater sandhill cranes.

Throughout the Burney Creek watershed expansive, sparsely populated forest and meadow areas provide important habitat for a variety of mammals, raptors, and waterfowl.

The lower reach of the Pit River supports native and nonnative fish species which are important prey items for the significant population of bald eagles. The Lower Pit River Watershed harbors one of the State's most important bald eagle populations, and it includes both resident and migratory birds.

Western Foothills and Tributaries

Upper Clear Creek provides habitat for a significant resident and migratory blacktail deer herd. Special-status species of note include northern spotted owl, bald eagle, and northern goshawk.

The Cottonwood Creek watershed supports a variety of wildlife species reflective of the diversity of the landscape (open space with agriculture, annual grassland, oak woodland, and conifer stands). Recreationally important species include blacktail deer, wild turkey, quail, and feral pigs. Special-status species include northern spotted owl, red- and yellow-legged frog, valley elderberry longhorn beetle, and vernal pool fairy shrimp.

Wildlife in the Tehama West Watershed provides opportunities for observation, hunting, and other recreational pursuits. In part because of changes in the vegetation community (factors cited in the Vegetation section), wildlife habitat protection and enhancement are an important management objective. Historically, Tehama West has been home to one of the State's major blacktail deer populations. Special-status species include yellow-legged frog, northern spotted owl, and valley elderberry longhorn beetle.

Lower Stony Creek is habitat for a total of 28 documented species—13 native and 15 exotic. In addition to fish species which are discussed in Section 2.8.6, special-status species in the Upper Stony Creek Watershed include valley elderberry longhorn beetle, western pond turtle, and foothill yellow-legged frog.

Wildlife resources in the Cache Creek Watershed include the second largest wintering population of bald eagles in California and the golden eagle, osprey, red-tailed hawk, kestrel, prairie falcon, northern harrier, and several species of owls. Approximately 50 of California's endemic tule elk also reside in the watershed, using a variety of habitats year-round. The black bear is commonly seen, especially near the creek foraging for fish. Other non-game species commonly spotted include mountain lion, coyote, gray fox, bobcat, badger, raccoon, beaver, and river otter. Game species sought by hunters include blacktail deer, black bear, wild pig, gray squirrel, wild turkey, mourning dove, and California quail. Dense chaparral habitat supports species such as the blacktailed jackrabbit, brush rabbit, wrentit, California thrasher, and California towhee.

The creek and its riparian vegetation are a refuge for wildlife that is otherwise rare or declining in the region, including the giant garter snake, the valley elderberry longhorn beetle, the northwestern pond turtle and Swainson's hawk. The Putah Creek Watershed is home to 220 bird species, 31 butterfly species, 14 species of reptiles and amphibians, and 31 species of mammals. Small mammals such as beavers, squirrels, and raccoons are abundant along the creek. Bears and mountain lions are sometimes spotted in the Putah Creek Riparian Reserve. During the spring and fall, the bushes along the creek are rich with migrating warblers and sparrows.

An invasive species that is of concern in this watershed is the New Zealand mudsnail. It was first discovered along Putah Creek in October 2003. It is thought that anglers are spreading this invasive species on wading gear between areas in the watershed. The New Zealand mudsnail can choke out other native snails and insects, deprive fish of their main sources of food, multiply rapidly, and damage fisheries and native habitats.

Eastern Tributaries

The Battle Creek watershed has a diverse assemblage of wildlife habitats and wildlife species that are commonly associated with the vegetation communities discussed earlier. This includes several special-status species. Blacktail deer are the most important big game species, and herd numbers are known to be in decline.

The Eastern Tehama Blacktail Deer Herd, the largest migratory herd in California, makes use of the watershed as part of its migration and for winter range. Their numbers have been in decline over the last 50 years, attributed to fire management, urban encroachment, timber operations, and shrinking habitat. The watershed is also home to numerous state and/or federal special status species of amphibians, reptiles, birds, and invertebrates.

Butte Creek Watershed also contains important vernal pool habitat for listed plant and invertebrate species, and riparian areas provide habitat for important avian and other wildlife species. Loss of riparian habitat is of particular concern, as it provides multiple benefits to both the aquatic and terrestrial communities. The oak woodlands support numerous species, including portions of the large Tehama Deer Herd, that make these areas their home, either permanently or while passing through. Impacts from a variety of invasive non-native plant and wildlife species have been significant and continue to threaten the native populations.

Cow Creek supports a large population of blacktail deer, but that herd is known to be in decline partly because of a reduction in early plant succession habitat (a principal food source for deer). Turkeys, bear, mountain lion, feral pigs, and more recently elk, are all well established in the watershed.

The total size and diversity of habitats in the Deer Creek watershed provide exceptional wildlife value. A continuous complex of riparian habitat is an important component, as are vernal pools. These seasonal pools located in the lower watershed are habitat for several federally-listed invertebrate species (tadpole shrimp, fairy shrimp, and California linderiella). Black-tail deer in this watershed are part of the large Tehama East herd that at one time numbered 100,000. As in other parts of northern California, deer numbers are in decline largely because of changes in forest habitat and forage conditions. Exotic species known to occur include feral pigs, brown-headed cowbirds, and bullfrogs.

Common mammal species in the Mill Creek watershed are black bear, mountain lion, coyote, bobcat, gray fox, raccoon, squirrels, and a number of other small mammals. The watershed is part of the East Tehama deer herd, historically the largest herd in the state. Special status species include northern goshawk, spotted owl, and willow flycatcher.

The continued presence of undeveloped land and habitat connectivity around Stillwater and Churn Creek are an important factor for the maintenance of wildlife populations in this watershed. There are numerous special-status species, including vernal pool shrimp, Shasta salamander, and foothill yellow-legged frog.

Feather River and Tributaries

The Plumas and Tahoe National Forests manage over 75 percent of the Feather River watershed, while the Sacramento Valley portions are predominantly privately owned and are agricultural. The Upper Feather River Watershed is a rural landscape and includes the small communities of Almanor, Quincy, Nevada City, and Grass Valley. The Lower Feather River Watershed is also predominantly rural, but does include the larger towns of Oroville, Yuba City, and Marysville.

Streambank and bottom degradation is lowering the water table in the valleys causing changes in riparian habitat as well as in adjacent grazing lands. Poor grazing management is suppressing the growth of riparian and upland vegetation. Streams in the upper watershed share the common characteristic of denuded streambanks. Headcutting exacerbates this condition; however, it is likely that longterm grazing and/or logging and water diversion began the decline of riparian vegetation before headcutting became the dominant force.

American River and Tributaries

The Lower American River and Bear River watersheds, wildlife including great blue heron, egret, mallards and other waterfowl, western rattlesnake, gray squirrel, river otter, beaver, turkey, mule deer, coyote, and mountain lion are frequently spotted.

The Upper American River Watershed supports a wide variety of wildlife. Typical bird and mammal species include mountain quail, mourning dove, Steller’s jay, western bluebird, warblers, squirrels, skunk, chipmunk, grey squirrel, coyote, mule deer, black bear, and mountain lion. Special species in the watershed include the American bald eagle, California red-legged frog, and valley elderberry longhorn beetle.

The Yuba River Watershed is home to a large number of bird species and a stopover point for migrating birds. Commonly seen mammals include mule deer, raccoons, skunks, opossum, and coyote. More elusive are the gray fox, bobcat, ringtail, mountain lion, and black bear.

Sacramento Valley

The Sacramento Valley is a unique landscape that includes state and national wildlife refuges, privately managed wetlands, rivers and streams that provides habitat for a wide variety of wildlife species. The river riparian corridor, the natural and managed wetland areas, and the nearly 2 million acres of agriculture lands all provide valuable habitat for wildlife species in the valley. Although specific management practices influence the value of rice lands, the mere presence of the approximately 500,000 acres of summer- and winterflooded area is highly important wetlands-like habitat to water-dependent bird species.

The seasonal and permanent wetlands of the Sacramento Valley are home to 60% of wintering and migrating waterfowl from the Pacific Flyway. There are six national wildlife refuges, more than 50 state wildlife areas, and large tracts of privately managed wetlands that support this migrating population. Winter fallow rice fields are also an important habitat component for ducks, geese, and other migrating waterfowl.

The cottonwood- and willow-dominated riparian forests along the Sacramento River have several characteristics that enable them to support an abundance and diversity of wildlife. Abundant food and cover, high structural diversity, and linear connectivity all contribute to making these riparian lands so important as wildlife habitat. Riparian forests in the area habitat for several special status species which are discussed further in Section 2.8.5.

Future Without-Project Conditions

The future of wildlife species related to the Sacramento River Watershed is likely closely related to condition of key habitats. Most notably affected by anthropogenic activities within the watershed are the quantity, quality and connectivity of riparian and wetland corridors and availability and quality of water in the system. Adjacent upland areas will likely be adversely affected as population growth and future development results in further encroachment. State and local planning efforts along with ESA requirements may provide limited protection and mitigation to help prevent impacts, but this may only help reduce and not prevent. However, with restoration and development of mitigation banks gains in habitat value and quantity may be made in the future, depending on the success of these efforts.

The future without project scenario is a continuation of the existing erosion processes and associated repairs under the various programs. Current bank and levee maintenance activities, such as mowing and application of herbicides, would continue, and any effects from these activities would not be different from current (baseline) conditions. Without erosion repairs, there is the continued risk of levee failure. A catastrophic levee failure would result in flooding and inundation that could adversely affect wildlife and its upland or wetland habitats through physical displacement, mortality, or destruction of habitat.

2.8.4 Fisheries

Fisheries in the CVIFMS study area have been greatly impacted by loss of suitable habitat. Structures, often referred to as fish passage barriers, reduce or eliminate longitudinal habitat connectivity; prevent or limit access to critical spawning, rearing, and refuge habitat; create migration delays; and create lethal or sublethal conditions for native anadromous species (California Department of Water Resources [DWR] 2012a, 2014; National Marine Fisheries Service [NMFS] 2014). Fish passage barriers associated with the Central Valley flood system trigger compliance requirements under the Federal and California Endangered Species Acts; necessitate recurring fish rescues; and impel additional permitting requirements, such as long-term mitigation (NMFS, 2009; Vogel, 2011; DWR, 2012b; Johnson and Vinci, 2012; Cannon, 2013; Heise, 2013; Hendrick and Swart, 2013).

As part of the State's CVFPP efforts, twenty-six structures were identified as fish passage barriers in the Sacramento River Basin of which fourteen structures were identified as priority barriers. Five priority barriers are located in the Upper Sacramento River, and four priority barriers (8 total structures) are located in the Lower Sacramento River. One priority barrier is located in the Feather River. Twelve other structures in the basin were not prioritized by CVFPP for various reasons but still obstruct fish passage. Figure 2-15 provides a map of known and potential barriers to fish passage in the Sacramento River Valley.

In addition to barriers, fish in the CVIFMS study area also face challenges due to loss of quality habitat, increasing water temperatures, changes in flow regimes, loss of riparian habitat, and increases in nonnative predator populations.

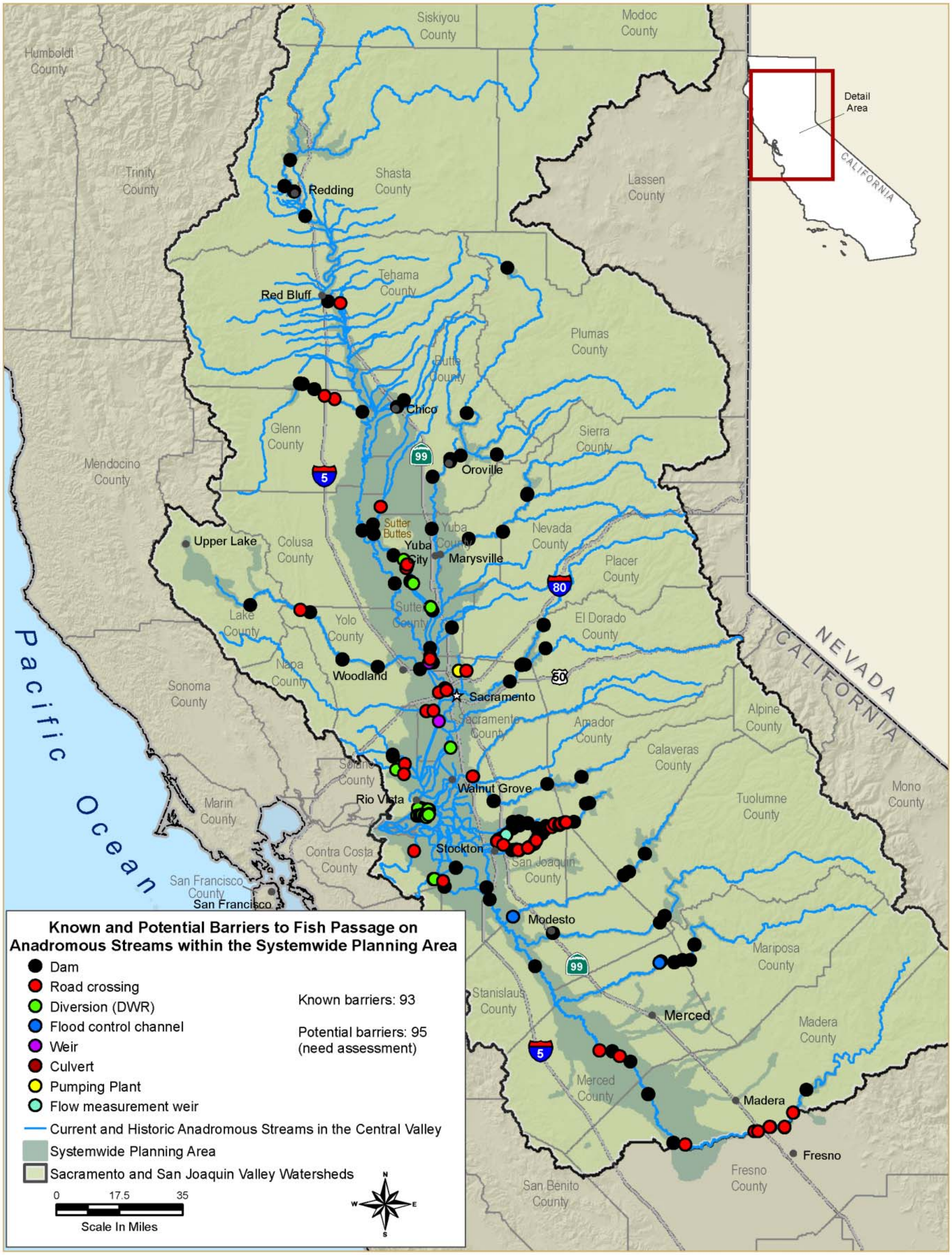

Figure 2-15 Known and Potential Barriers, Including DWR-Owned Diversions, in the Systemwide Planning Area

Upper Sacramento River and Tributaries

The Keswick and Shasta Dams on the Sacramento River are existing barriers to upstream passage of anadromous salmonids including Chinook salmon and steelhead. Prior to construction of Shasta dam in 1942, Chinook salmon and other anadromous fishes were able to travel up the rivers of the region. On the McCloud River, prior to construction of the McCloud Dam, they could travel as far as the 20-foot-high Lower Falls (FERC, 2011). In 1941 when Shasta Dam was under construction, it was estimated from studies of Chinook salmon runs that would be blocked by the dam that a total annual run of approximately 27,000 fish would be blocked when the dam was completed (Needham, et al., 1941).

Chinook salmon have been extirpated from the rivers in this region. In addition, the extirpation of Chinook populations had further impacts by affecting other species in the system, notably bull trout (originally identified as Dolly Varden) that fed on early life stages of the Chinook (FERC, 2011).

Downstream of the region, the population of Chinook salmon in the Sacramento River has significantly declined over the past 40 years (DFG, 2010). Numerous factors have contributed to this decline, including unstable water temperature, loss of historic spawning areas and suitable rearing habitat, water diversions from the Sacramento River, drought conditions, limited suitable spawning gravels, fluctuations in river flows, toxic acid mine drainage, high rates of predation, unsustainable fish harvests, and unsuitable ocean conditions. As a result, Sacramento River winter-run Chinook salmon have been listed as Endangered under the Federal Endangered Species Act, and spring-run Chinook salmon have been listed as Threatened, along with other anadromous fish species in the upper Sacramento River, including Central Valley steelhead and North American green sturgeon.

The McCloud River is known as a premier trout stream with an abundance of large rainbow and brown trout. DFG once estimated that trout abundance was approximately 8,500 fish per river mile. The abundance of large fish is a function not only of the excellent habitat quality, but also of strict fishing regulations and limited access to the largely private ownership in the lower stretch of the river. In addition to trout, the river is home to Sacramento sucker, Sacramento squawfish, carp, riffle sculpin, smallmouth bass, blackfish, golden shiner, and hardhead minnow. The Lower McCloud River is a CDFW-designated Wild Trout Stream from McCloud Reservoir Dam downstream to Lake Shasta.

There are eight native fishes of the Goose Lake Basin. Four of the species, Goose Lake redband trout, sucker, tui chub, and lamprey, are considered endemic to the area and known to spend at least part of their lives in the lake. During times of drought and low lake levels, tributary streams provide important refuge habitat for these species. The other four species are primarily stream-dwelling— the Pit-Klamath brook lamprey, speckled dace, Pit roach, and Pit sculpin. All of these fish are State and Federally listed as Species of Special Concern. Redband trout that spend part of their life cycle in Goose Lake are much larger than their stream-dwelling relatives and historically supported a commercial fishing operation at the mouth of Willow Creek. Populations have been highly variable from year to year, and no Goose Lake redband trout runs have been seen in Oregon since 1981 or in California streams since 1989.

The wild trout fishery of Fall River is important both ecologically and economically, and while CDFW fish survey records are inconclusive, many river users and fishing guides believe this valuable resource is in decline.

Hat Creek was designated as one of the State's first Wild Trout Streams by the Fish and Game Commission in 1972, following a restoration project that changed the stream from one overrun with suckers and other non-game fish to a highly productive wild trout fishery. In recent years, anglers and CDFW have seen a decline in the trophy trout status of Hat Creek. The suspected causes include damage from livestock grazing (now controlled), and increased erosion/ sedimentation from muskrat burrowing and other sources

Western Foothills and Tributaries

With the exception of Clear Creek and Cottonwood Creek, streams on the west side do not support significant runs of anadromous fish from the Sacramento River. This is largely because of the conditions of hydrology described above. There are resident fish populations in the upper stream reaches that sustain year-round flow, and the large, unpopulated areas of forest, brush, and grassland are important habitat for a variety of wildlife species.

In Lower Clear Creek, restoration of salmon and steelhead populations has been a major focus of fishery management agencies for the past 20 years. For the 50-year period from 1954 to 1994, fall-run Chinook salmon populations in Lower Clear Creek averaged around 2,000 fish annually, ranging from around 500 to as many as 10,000 depending on the individual year.

All three forks of Cottonwood Creek support fall-run salmon, and Beegum Creek, tributary to the Middle Fork, is important habitat for spring-run salmon and steelhead. CDFW estimates that on the average, 1,000 to 1,500 fall-run Chinook salmon enter the stream annually. Numbers have fallen in recent years, consistent with the overall decline of fall-run Chinook salmon in the Sacramento River. Warmwater species (e.g., carp, sucker, bass, pikeminnow) are common in the lower reach of Cottonwood Creek.

The physical characteristics of Tehama West drainages play an integral role in the status of fish populations and other aquatic life. Upper Coast Range stream reaches may be perennial with resident fish populations, mid-reach sections typically are dry for extended periods, and lowest reaches (near the Sacramento River) may have small amounts of water from irrigation and other sources that support fish that seasonally migrate from the river and occupy these lower reaches. In the upper perennial stream sections, common native species include rainbow trout, hardhead, and pikeminnow. Early stages of important anadromous species such as Chinook salmon and steelhead are believed to occupy habitat provided in streams near the Sacramento River.

Fish species common to the streams and reservoirs of Upper Stony Creek include rainbow trout, hardhead, bass, catfish, and carp. Black Butte Reservoir supports a popular sport fishery for bass, catfish, and crappie.

Barriers inhibit fall-run Chinook salmon, Pacific lampray, and steelhead from migrating up Cache Creek. Anecdotal evidence suggests that in wet years, when flows in Yolo Bypass and Cache Creek are high, some salmon may reach the spawning gravels of Lower Cache Creek from the Delta. However, in dry years no passable connection exists for salmon and steelhead between the Delta and mouth of Cache Creek. Cache Creek does support a variety of other fish species and above Capay Dam is perhaps one of the best native fisheries on the westside of the Valley. Because the water is typically warm and alkaline, the predominant fish resources are members of the minnow family such as pikeminnow, hitch, and California roach as well as Sacramento sucker, catfish, and largemouth and smallmouth bass.

Putah Creek contains a large number of fish species. While the majority of these are introduced game fish, the creek still supports remnants of the once abundant Central Valley native fish such as hitch, squawfish, and Sacramento suckers. Native rainbow trout still swim in the upper mountain reaches, and historically, Chinook salmon and steelhead spawned in the lower and middle portions of the creek. Putah Diversion Dam is now the upstream terminus of salmon and steelhead migration. Salmon attraction flows allow some spawning of anadromous fish even in years with limited runoff.

Eastern Tributaries

The Battle Creek Watershed is a focal area for restoring populations of Chinook salmon and steelhead in the Sacramento River Basin. Approximately 250 miles of stream are fish-bearing, and 87 miles historically were accessible to anadromous fish. Hydroelectric development began on Battle Creek in the early 1900s, and this substantially altered the available habitat for anadromous fish production. Today, natural spawning occurs mainly in the lower 6 miles of the creek downstream of the Coleman National Fish Hatchery. The Coleman Hatchery began operations in 1943 as mitigation for the loss of salmon spawning habitat caused by the construction of Shasta Dam on the mainstem of the Sacramento River north of Redding. As recently as 2005, 80,000 salmon entered Battle Creek to return to the hatchery. However, in recent years, because of the overall decline in Sacramento River salmon, that number has fallen below 10,000. The Battle Creek Salmon and Steelhead Restoration Project was initiated in 1995 as a multi-agency effort to improve fish passage and habitat conditions within the portion of the watershed encompassed by PG&E's Battle Creek Hydroelectric Project. The project includes removal of five diversion dams, placement of new screens and ladders on three other dams, and increased stream flow in both the north and south forks of Battle Creek, restoring approximately 42 miles of habitat in Battle Creek and an additional 6 miles of habitat in tributaries to Battle Creek.

Chinook salmon and steelhead are known to occur in the Bear Creek Watershed. Of the different runs of salmon that spawn in the Upper Sacramento River and tributaries, only fall-run Chinook salmon return in consistent numbers to spawn in Bear Creek. Estimated (CDFW) spawning runs in Bear Creek between 1949 and 2002 ranged from fewer than 10 fish up to 500. Counts in recent years have been very low, reflecting the overall decline in Sacramento River fall-run Chinook salmon. Anadromous fish restoration efforts in Bear Creek will target screening on diversions, increasing instream flows, and general habitat improvement work. State and Federal agencies have estimated that potential runs in Bear Creek would be in the range of 1,000 fish. Resident rainbow trout are common throughout the upper watershed and provide an important sport fishery for local residents. Nonnative, warmwater species (e.g., bass, bluegill, carp) are common in the Lower Bear Creek Watershed.

Butte Creek has historically had some exceptional features that made it one of the most important streams in the Sacramento Valley for fish, particularly spring-run Chinook. A natural barrier below the Centerville Powerhouse head dam limits most upstream access beyond this point. Population estimates in the mid-1950s to mid-1960s were generally less than 6,000. Beginning in 1966, the population crashed to less than 100 spawning individuals and ranged up to approximately 1,000 fish for the next 30 years. In 1995 the run was estimated at 7,500 fish, but the numbers fell off again dramatically the next year. In 1998 more than 20,000 salmon returned and in 2001, an estimated 18,000 spring-run Chinook salmon spawned in Butte Creek, with 2002, 2005, and 2008 also having good numbers. However, estimated 2009 figures are far lower at under 1,000 individuals. Steelhead trout populations fluctuate annually as well. Several other important native fish species including Pacific Lamprey and Sacramento Pikeminnow, plus numerous non-native species are also present in Butte Creek.

Three different groups of fish live in Cow Creek: anadromous, resident, and exotic. Anadromous species that migrate up the watershed to locations downstream of natural barriers include fall-run Chinook salmon and winter-run steelhead. Common resident species are rainbow trout (generally above 1,000 feet elevation), hardhead, pikeminnow, and sculpin. Exotic species known to occur in Cow Creek are large-mouth and smallmouth bass, carp, bluegill, brown trout, and brook trout. Fishery agencies have estimated that 9,000 female salmon potentially could use the 66 miles of Cow Creek streambed. Recent counts have been far below that potential, ranging from a few thousand to only a few hundred in the last couple of years. Cow Creek is a high-priority watershed in the basin-wide effort to increase anadromous fish populations, and restoration efforts will target concerns with instream flow, passage and screening of diversions, water temperature conditions, and habitat improvements.

The watershed has exceptional features that make Deer Creek one of the more important streams in the Sacramento Valley for anadromous fish. Species with consistent runs up Deer Creek include spring-run Chinook salmon, fall-run Chinook salmon, steelhead, and Pacific lamprey. The attributes of a steady supply of cold, clean water, no major storage dam, and the large acreage of private land make this watershed a high priority in the effort to restore populations of steelhead and spring-run salmon. Historically, spring-run populations in Deer Creek averaged around 2,800 fish, but numbers began to decline in the 1980s. In recent years runs have been variable from year to year but overall have averaged in the low hundreds. In elevations above 1,000 feet, resident rainbow trout are common in Deer Creek and its many tributaries.

At lower elevations near the valley floor, native and nonnative species such as hardhead, pikeminnow, and bass are dominant.

Mill Creek provides habitat for three types of anadromous salmonids: spring-run Chinook salmon, winter-run steelhead trout, and fall-run Chinook salmon. Historically, spring-run salmon numbered close to a million fish in the Sacramento Valley streams, but now only four tributaries support this run and Mill Creek is one of them. Population estimates for spring-run salmon in Mill Creek have been made since 1947. The estimated average run size from 1947 through the early 1990s is 1,200, while average run size over the past 20 years has been around 400. Fall-run salmon use mainly the lower 6 miles of Mill Creek, and when annual counts were made from 1952 through 1994, the average run size was about 2,000. With the recent decline in Sacramento River fall-run salmon, it can be assumed that the current numbers are much lower. Other common fish species in Mill Creek are rainbow trout, pikeminnow, suckers, and sculpin. In the high elevation meadow reaches, trout are a popular and plentiful game fish.

In the case of Battle Creek, Mill Creek, and Deer Creek, this streamflow is augmented by snow pack and subsequent runoff through the volcanic geology of the Mount Lassen area. This hydrology, in combination with the undammed, free-flowing state of these streams, makes this region a focal area for protection and enhancement of Sacramento River fall-run Chinook salmon, and the endangered spring-run Chinook salmon and steelhead trout.

In Stillwater and Churn Creeks, warmwater species such as sunfish and catfish are common along with native species like California roach, hardhead, and pikeminnow. There is increasing evidence that these intermittent tributaries provide important rearing habitat for juvenile Chinook salmon that migrate out of the Sacramento River. In good water years, adult fall-run salmon have been observed spawning in the upper reaches of Stillwater Creek, and agencies are looking at the potential for improving anadromous fish runs in these tributaries.

Several native fish species can be found in the relatively low-elevations of the East Tehama Watershed streams, including salmon and trout, suckers, sculpin, hardhead, pikeminnow, stickleback, and lamprey. Sacramento River Chinook salmon are known to use streams in which they were not spawned for early life history rearing habitat. This ‘non-natal rearing’ is common in the intermittent tributaries in the Tehama East Watershed. This intermittent tributary rearing offers significant advantages for young salmon, including faster growth and better condition. Nonnative species common to this watershed area are bass, sunfish, and bluegill. Special-status species include all four runs of Sacramento River Chinook salmon, steelhead, Sacramento splittail, and hardhead. Recommended actions for improving fish habitat and fish populations include restoring degraded stream channel and riparian zones, addressing impediments to migration, and establishing better population survey data.

Feather River and Tributaries

The Feather River drains 3,222 square miles of land base from the Sierra crest westward into the Sacramento River. The Feather River has a relatively large drainage basin along the Sierra foothills that receives input from several key tributaries, including Honcut Creek, the Yuba River, and the Bear River. Approximately 67 miles downstream of the City of Oroville, the Feather River flows into the Sacramento River, near the town of Verona, about 21 river miles upstream of Sacramento (DWR, 2007). The program area extends from the confluence of the Sacramento River (Feather River Mile 0) to river mile 61.

The Feather River watershed has been affected by 140 years of intense human use. Past mining, grazing and timber harvest practices, wildfire, and railroad and road construction have contributed to the degradation of more than 60% of the watershed, resulting in accelerated erosion, degraded water quality, decreased vegetation and soil productivity, and degraded terrestrial and aquatic habitats (Feather River Coordinated Resource Management 2009).

The lower Feather River from the Fish Barrier Dam to Honcut Creek supports a variety of anadromous and resident fish species. The Feather River maintains spawning, rearing, and migration habitat for four special-status species: fall-run Chinook salmon, spring-run Chinook salmon, Central Valley steelhead, and Sacramento splittail (DWR, 2001). The occasional capture of larval green sturgeon in outmigrant traps suggests that green sturgeon spawn in the Feather River (Moyle, 2002). However, Adams et. al (2002) report that evidence of green sturgeon spawning in the Feather River is unsubstantiated. The National Marine Fisheries Service (NMFS) (2008b) states that the presence of adult, and possibly subadult, green sturgeon within the lower Feather River has been confirmed by incidental sightings (DWR, 2005), photographs, anglers' descriptions of fish catches (P. Foley, pers. comm. cited in CDFG 2002, and occasional catches of green sturgeon reported by fishing guides (Beamesderfer et al. 2004).

The Middle Fork Feather River is a State-designated Wild and Scenic River, and the North Fork Feather River has been developed extensively for hydropower generation. Construction of the Oroville Dam built between 1962 and1967, blocked any passage of anadromous species into the upper watershed.

Bear River

The Bear River is the second largest tributary of the Feather River. The Bear River has been heavily affected by water imports and diversions, barriers, gravel mining, and municipal and residential effluent (Johnson, 2002).

Historically, the Bear River may have had a large fall-run Chinook salmon population (Johnson, 2002). Anadromous fish have access to 15 miles of the Bear River, but the habitat is of limited quality because of inadequate stream flow. As a result, there are no self-sustaining populations of salmon in the Bear River. However, during heavy rain events, salmon and steelhead will migrate up and spawn in the lower Bear River (NMFS, 2001).

The Bear River once supported substantial salmon and steelhead runs, but because of low flows in the lower river below the South Sutter Irrigation District Diversion Dam, no self-sustaining salmon runs presently exist, and the status of steelhead is unknown. However, the river does support a popular fishery for rainbow and brown trout, and flyfishing clubs are involved in an ongoing stream habitat improvement project.

American River and Tributaries

American River

The American River is the second largest tributary of the Sacramento River. The American River is designated as a recreational river in the State and Federal Wild and Scenic River systems. Below Nimbus Dam, the lower American River flows through a parkway, surrounded by urban development and is a major recreational area for the Sacramento region.

The lower American River provides a diversity of aquatic habitats, including shallow, fast-water riffles, glides, runs, pools, and off-channel backwater habitats. The lower American River from Nimbus Dam (RM 23) to approximately Goethe Park (RM 14) is primarily unrestricted by levees but is bordered by some developed areas. Natural bluffs contain this reach of the river and terraces cut into the side of the channel. The river reach downstream of Goethe Park, and extending to its confluence with the Sacramento River (RM 0), is bordered by levees. The construction of levees changed the channel geomorphology and has reduced river meanders and increased depth (USBR, 2003: 9-33).

The lower American River supports two special-status fish species: fall-run Chinook salmon and steelhead. The Central Valley fall-run Chinook salmon is currently designated a Species of Concern under the Federal Endangered Species Act. The Central Valley steelhead is listed as Threatened. The American River also supports a mixed run of hatchery and naturally produced fall-run Chinook salmon. On average, tens of thousands of hatchery or naturally produced Chinook salmon return each year to spawn.

The Lower American River Watershed supports more than 40 species of native and nonnative fish, including naturally spawning fall-run Chinook salmon, steelhead, and American shad. Several of these species are of primary management concern because of their declining numbers, or their importance to recreational/commercial fisheries. Recreationally and/or commercially important species include fall-run Chinook salmon (a Federal Species of Concern), steelhead (Federally listed as a Threatened species), and nonnative striped bass and American shad. Auburn Ravine in Placer County is also a Critical Habitat area for Chinook salmon (both spring- and fall-run) and steelhead.

With few exceptions, the high mountain lakes above 6,000 feet in the upper American River Watershed were historically fishless—dominated instead by amphibians, insects, and small aquatic invertebrates. It has been only within the last few decades that fish were introduced into the higher elevation lakes. The upper watershed streams provide high quality habitat for native fish, including trophy-sized rainbow trout. Anadromous fish species are found in the lower American River, but do not have access past Nimbus Dam.

Yuba River

The Yuba River joins the Feather River near the City of Marysville (DWR, 2007). The Yuba River Basin drains approximately 1,350 square miles of the western Sierra Nevada slope, including portions of Sierra, Placer, Yuba, and Nevada Counties (CALFED Bay-Delta Program, 1999). The primary watercourses of the upper watershed are the South, Middle, and North Yuba Rivers, which flow into Englebright Reservoir, which then releases water into the lower Yuba River. Both the upper and lower watersheds (above and below Englebright Dam, respectively) have been extensively developed for water supply, hydropower production, and flood protection.

The lower Yuba River consists of the approximately 24-mile stretch of river extending from Englebright Dam, the first impassible fish barrier along the river, downstream to the confluence of the Feather River near Marysville (USBR, 2003). Habitat near the confluence of the Feather River is deep, slow water and becomes more complex moving upstream. Riffles, pools, and runs are present up to Daguerre Dam, although water temperatures are warmer than upstream of Daguerre Dam. Most salmonid spawning and rearing occurs upstream of Daguerre Dam. Historically, the Yuba River supported as much as 15 percent of the annual fall-run Chinook salmon run in the Sacramento River Basin. Run sizes in the Yuba River have varied over the period of record, ranging from a low of 1,000 fish in 1957 to a high of 800,000 in 2002. Low flows and high temperatures on the South and Middle Yuba Rivers, along with the legacy of sediment from hydraulic mining, continue to contribute to problems for cold-water aquatic communities.

Sacramento Valley

Four runs of Chinook salmon occur in the Sacramento River with each run defined by a combination of adult migration timing, spawning period, and juvenile residency/migration periods. The presence of four seasonal runs in the Sacramento River (fall, late-fall, winter, and spring) lends it the uncommon distinction of having some salmon in its waters throughout the year.

Historically, large numbers of winter-run and spring-run Chinook salmon migrated through the Sacramento Valley to reach headwater areas with constant flow and cold water temperatures in the Upper Sacramento, McCloud, and Pit Rivers. Major water projects (e.g., Shasta Dam, Oroville Dam) blocked access to this part of the Sacramento watershed, and today only a few individual streams support spring-run salmon; the winter-run is restricted to the mainstem of the Sacramento River downstream of Shasta Dam. Winter-run salmon are Federally listed as Threatened and Endangered, and spring-run are listed as Threatened, as are Sacramento River steelhead trout. Currently, fall-run Chinook salmon are the dominant run; however, their numbers have dramatically declined, particularly in the last several years. As discussed in the Sacramento River Basin Overview section, there are major State and Federal programs currently underway to restore both resident and anadromous fish populations in the Sacramento River, most notably, the Anadromous Fish Restoration Program being implemented as part of the Central Valley Project Improvement Act, and the CDFW Salmon, Steelhead Trout, and Anadromous Fisheries Restoration Program. During the past two decades, water purveyors in the Sacramento Valley have been engaged in an aggressive effort to enhance the passage of anadromous fish along the Sacramento River and it's tributaries through the installation of fish screens on major diversions. This effort has led to the completion of state-of-the-art fish screens on almost all of the diversions that are larger than 200 cfs.

Sacramento River

In pre-settlement times, the Sacramento River's floodplain was occupied by dense riparian forest, likely extending a few miles from the river until wetland and marsh communities of the Natomas Basin prevailed to the east and Yolo Basin to the west. The remnant riparian forest above the bank protection sites generally supports the same species as were present in the pre-settlement period.

Because of clearing for agriculture, the riparian forest corridor along the Sacramento River is discontinuous and highly variable in width, species dominance, and ecological integrity. In reaches some distance upstream of the Fremont Weir, as well as through Sacramento and downstream through the Delta, forest gaps dominate over patches, and long lengths of the riverbank are nearly devoid of woody vegetation. Above Colusa a vast, dynamic riparian forest generally dominates the riverine landscape, although it is fragmented from place to place by agriculture.

The riparian corridor along the Sacramento River is generally continuous, narrow—but sufficiently wide to be considered a corridor rather than a strand—and dominated by diverse native woody species. Although narrow, it provides functional riparian habitat and undoubtedly serves as reproduction and foraging habitat and as a corridor for dispersal and migration for several species. This native riparian vegetation patch extends from the urban Sacramento limits to upstream riparian corridors along both the Sacramento and Feather Rivers at and above their confluence and the Fremont Weir overflow to the Yolo Basin.

The Sacramento River serves as an important migration and juvenile rearing corridor for anadromous fish species, which have been the focus of many restoration programs for the Sacramento River system. Anadromous steelhead and Chinook salmon, as well as resident green sturgeon, are endangered fish species known to use the program area. Habitat suitability for juveniles of these species is characterized by several variables, assessed for flow levels during seasons when juvenile salmonids pass through the sites: amount of near shore shallow-water zones, presence of instream vegetation and instream woody material (IWM) in these zones, amount of shading bank vegetation over these zones, substrate type, and amount of adjacent floodplain during frequent flood flows (i.e., 1.5- to 3-year return period).

The Sacramento River supports the following fish species listed under the Federal Endangered Species Act: Central Valley steelhead, Central Valley fall-, late fall–, and spring-run Chinook salmon, Sacramento winter-run salmon, delta smelt, and green sturgeon. Additional fish species protected under the California Endangered Species Act include longfin smelt, Sacramento splittail, hardhead, and river lamprey.

Yolo, Sacramento, Tisdale, and Sutter Bypasses

Seasonal high flows from the Sacramento River enter the Yolo Bypass via the Fremont Weir. To provide flood capacity, overflows at the Tisdale Weir are conveyed into the Tisdale Bypass, which routes the water into the Sutter Bypass. Upstream of the reach, floodwaters may overflow the left bank into Butte Basin via three locations near Chico Landing and through the Moulton and Colusa Weirs. At extremely high river stages, floodwaters may also overflow the right bank of the river and drain into the Colusa Basin, which eventually connects to the Sacramento River and Yolo Bypass via the Colusa Main Drain (U.S. Army Corps of Engineers 2007).

When inundated during high winter and spring flows, the Yolo and Sacramento Bypasses provide migratory and rearing habitat for emigrating juvenile salmonids, green sturgeon, and river lamprey. Sacramento splittail also use the Yolo and Sacramento Bypasses for spawning and juvenile rearing.

Sacramento-San Joaquin Delta

The major tidal sloughs within the program area are Threemile, Georgiana, Steamboat, Miner, Lindsay, Cache, Haas, and Sutter Sloughs. Sloughs and channels in this region are generally confined on both sides by natural levees enhanced by decades of man-made improvements. The individual channels and sloughs are moderately sinuous, of uniform width, and do not migrate.

The effects of seasonal flood events are much less in Delta sloughs than in the upper regions because of both tidal action and the diversion of flow through the upstream flood bypasses and outtakes (USFWS, 2001). Historically, channel and slough morphology actively adjusted throughout the Delta in response to seasonal variations in flow and sediment load. The decrease in flow velocities caused the deposition of a gradient of coarser to finer material from upstream to downstream (fine sand to clayey silt). The intertidal deposits that border the Delta channels and sloughs are typically characterized by shallow, alternating layers of fine sandy silt and clayey silt, with occasional peaty muds. Artificial fill from hydraulic dredge soils was placed after 1900 throughout the Delta along channel margins and upon various island surfaces (Atwater, 1982).

The riparian community in the Delta has been altered significantly since pre-European settlement times. Broad floodplains near the Delta that were once occupied by tule marshes and vernal pools have become isolated from the channel because of revetment along the levees. Several patches of tule habitat still occur at the mouths of sloughs and several areas downstream of Rio Vista (RM 12–13). However, riparian vegetation along the major sloughs is restricted to scattered narrow bands typically less than 30 feet wide on banks, berms, and levee faces (USACE, 2004).

The Delta provides habitat for all special-status fish species (listed as Threatened, Endangered or Species of Concern under Federal or State regulatory programs) known to occur in the program area. Adult fish species migrate through the Delta to upstream areas of the Sacramento River and its tributaries and spawn in the river. Delta smelt, longfin smelt, green sturgeon and juvenile salmonids rear in the Delta.

Future without Project Conditions

The future of key species in the Sacramento River Watershed is dependent on many conditions. Fish species that are listed under the Federal Endangered Species Act that utilize this watershed include Chinook salmon, steelhead, delta smelt and green sturgeon. The life cycles for these species is complex and highly affected by changes in the system. Their historic habitats have been degraded, blocked and continue to be impacted by human activities. In recent years, water management has included requirements that help to improve habitat conditions for these fish at critical life stages. In addition, there are restoration efforts underway in the watershed that expand available habitat and improve the quality and function. By 2070, a number of actions addressing recovery of listed species will have been completed based on NMFS recovery planning for listed salmonids and green sturgeon, which might result in beneficial changes to habitat for fish. Increased population growth between 2020 and 2070 is likely to affect water quality negatively and increase water demands in the study area. These increased stressors have the potential to affect riverine habitat utilized by these fisheries in the study area negatively.

There are also currently efforts underway to improve fish passage through the Yolo Bypass and perhaps also to improve habitat conditions for fisheries within the Bypass. Recent Biological Opinions have included requirements to develop and enhance habitats and make passage improvements that could purportedly improve the status of listed runs of Chinook salmon and green sturgeon. With the implementation of all of these efforts, it is still difficult to determine whether conditions will be improved for the fish species, versus just minimization of ongoing adverse impacts. Along with the variability of rainfall years and long-term weather trends, the future is still fairly uncertain. Since these fish have life stages in the ocean, changes in ocean conditions make it challenging to determine the level of success based on improvements/declines in populations. While there is a lot known about the upstream utilization of habitats by listed fish species, there are significant knowledge gaps about how these species move and utilize certain areas of the watershed and what optimal conditions for these fish in these regions.

Predicting the future of fisheries is very difficult given all of the considerations described above. It should be assumed that since there are no real "fixes" identified and/or proposed for these species, and the fact that there will likely be declines in riparian habitat and water quality, these fish species will likely face increased challenges in the future.

2.8.5 Migratory Corridors

Habitat Connectivity

The Sacramento River Valley is largely converted to agricultural and urban landcovers, with remaining natural communities severely reduced. For example, 99.9 percent of the region's historic native grasslands, 99 percent of valley oak savannah, 95 percent of wetlands, and 89 percent of riparian woodlands have been converted (Bunn et al. 2007). Due to the highest level of habitat conversion and fragmentation of any ecoregion, the Central Valley has a large number of very small natural landscape areas. The largest natural landscape areas are predominantly restricted to the foothill margins of the Valley proper. These foothill margins are dominated by annual grasslands.

There are also numerous vernal pools on remaining grasslands in the region, including large vernal pool complexes that are an important source of regional biodiversity and support numerous imperiled species. Restoring and enhancing connectivity for such species, as well as for aquatic and riparian species, is a high conservation priority in the region.

Large expanses of the Sacramento River Valley lack any significant blocks of natural habitat, and there are very few opportunities for maintaining or enhancing cross-Valley connectivity using natural upland vegetation. Consequently, the remaining riparian corridors play a critical role in helping connect remaining natural areas in the Sacramento River Valley. Figure 2-16 illustrates the remaining habitat areas in the watershed and the areas that would be the most beneficial to restore

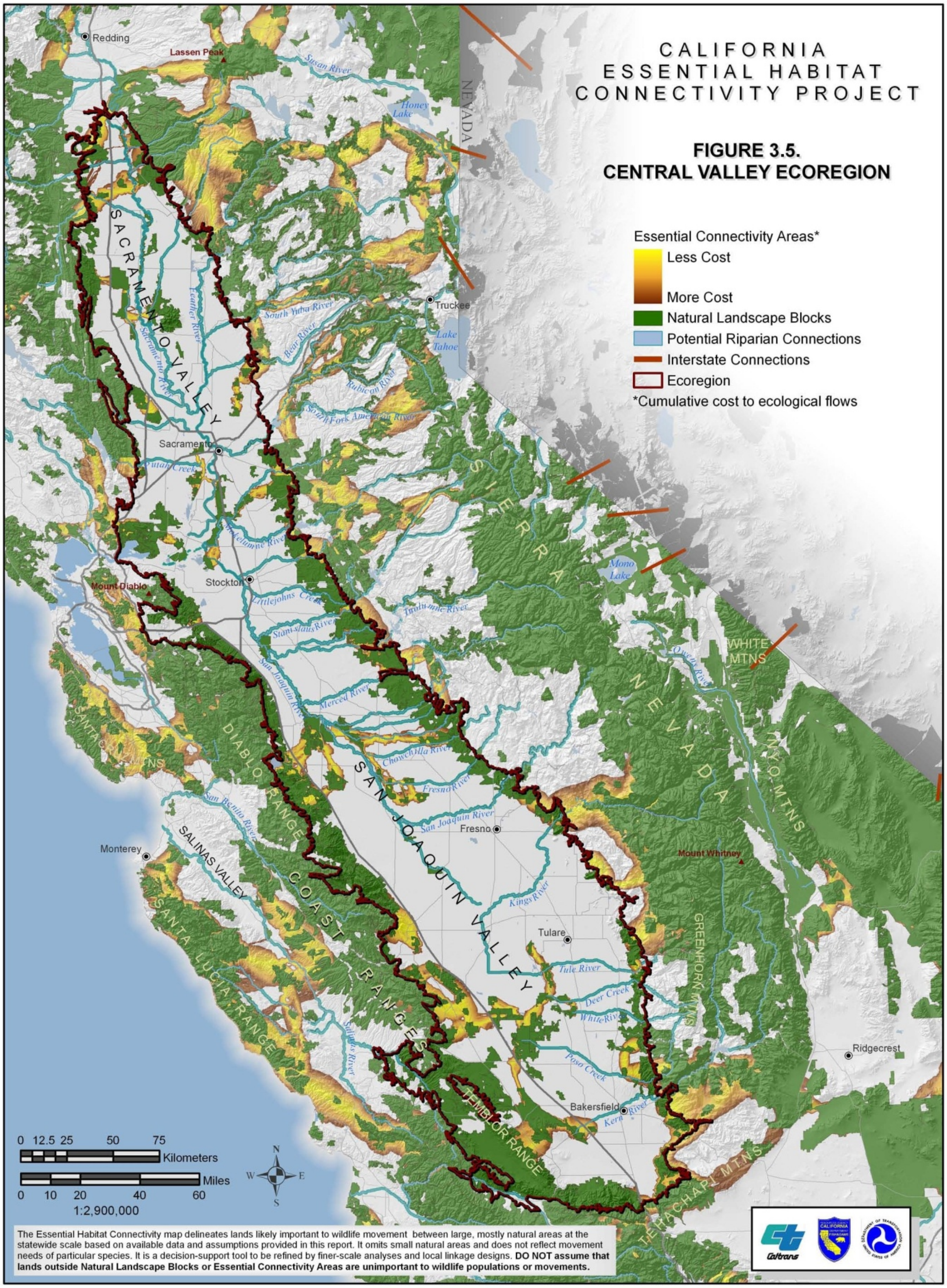

Figure 2-16 Essential Habitat Connectivity Corridors in the Central Valley.

Source: California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California. 2010. Prepared for California Department of Transportation, California Department of Fish and Game, and Federal Highways Administration

This connectivity function can and should be greatly enhanced by riparian and riverine restoration projects. Some local and regional connectivity planning and implementation has already been completed, or are currently being implemented in the region. A number of extensive restoration projects are planned or underway to improve aquatic flows, remove in-stream barriers, and increase the extent and continuity of riparian vegetation communities along major rivers and tributaries in the Sacramento River Valley. The focus on restoring ecological functionality in the Delta and the rivers that feed it has also spawned numerous restoration and enhancement projects under the CALFED Ecological Restoration Program and the Bay-Delta Conservation Plan. Finally, various other NCCPs in the Valley have focused on, or are currently focusing on, approaches for sustaining, restoring, and enhancing functional connectivity for diverse species and communities (e.g., NCCP/HCP plans in the Counties of Butte, Yolo, Yuba, Sutter, Contra Costa, and Placer).

Pacific Flyway

The Sacramento Valley provides critical habitat for migrating and resident species of waterfowl, geese, shorebirds and waterbirds. This habitat comprises an important part of the integrated water system in Northern California. The Sacramento Valley lies on the southerly end of the Pacific Flyway migratory route and is one the most prominent wintering sites for waterfowl in the world. Waterfowl migrate to the Sacramento Valley by the millions from as far away as Alaska, Canada, and Siberia. Sacramento Valley habitat supports approximately 44 percent of wintering waterfowl using the Pacific Flyway, attracting more than 1.5 million ducks and 750,000 geese to its seasonal marshes. The limited amount of natural wetlands in the area makes small-grain production fields (mostly rice) critical to the survivability of the large numbers of waterfowl wintering in California. Many water districts and companies in addition to providing water for the working agricultural landscapes and privately managed wetlands also provide water to federal wildlife refuges and state wildlife management areas (Northern California Water Association, 2015).

More than half of the Sacramento Valley’s wetlands are in private ownership, managed primarily for ducks and other waterfowl. The Sacramento Valley’s game refuges, rice fields, other wetlands, and agricultural properties provide exceptional habitat for wildlife, especially migratory waterfowl, shorebirds, waterbirds, and riparian songbirds. In total, these lands provide habitat for over 230 species of wildlife, including several listed species under the Federal Endangered Species Act and the California Endangered Species Act.

Where fields are flooded, as is the case on wildlife refuges and winter flooded rice fields, large numbers of geese, ducks, swans, and other waterfowl, as well as wintering shorebirds, can be observed. Waterfowl arriving in the Central Valley during annual migrations require a diet rich in carbohydrates. Agricultural crops are preferred by the many species of waterfowl because they are widespread, easily accessible, and provide the needed high levels of carbohydrates. Waterfowl also benefit greatly from the invertebrate populations that thrive in flooded fields, especially during the molt and egg-laying periods, when all species of waterfowl have increased protein requirements.

These areas also provide the necessary habitat and forage for wintering and breeding shorebirds and riparian songbirds.

The Sacramento River Valley represents the single most important wintering area for the waterfowl along the Pacific Flyway. Migrating waterfowl rely upon this region of the state to rest and feed during their annual migration. In addition to the multiple species of waterfowl, raptors, and shorebirds that seasonally inhabit the region, these lands provide habitat for a number of other species who rely upon this area year-round. The refuges in the region provide year-round habitat that compliments the efforts of landowners that also provide habitat. The winter rice decomposition/waterfowl habitat program, along with the refuges, provides hundreds of thousands of acres every winter for migrating waterfowl and other species. This program allows wildlife enhancement to occur along with continued agricultural production. The habitat goals for the Pacific Flyway in the Central Valley are compiled in the Central Valley Joint Venture Implementation Plan, which was published in 2006. These goals include water supply needs for the different basins located in the Central Valley, as well as conservation objectives for the six bird groups identified in the Plan (wintering waterfowl, breeding waterfowl, wintering shorebirds, breeding shorebirds, waterbirds, and riparian songbirds). These conservation objectives are also integrated in the plan to provide overall acreage and water supply objectives for seasonal wetland restoration, seasonal wetland enhancement, semi-permanent wetland restoration, riparian restoration, winter flooded rice, waterfowl-friendly agriculture, and agricultural easements (2006 Implementation Plan).

Anadromous Fish Migrations

Anadromous fish are freshwater fish that migrate to sea then return to spawn in freshwater. Central Valley migratory corridors are used at different times of the year by native anadromous fish species. Species type, life stage, and environmental conditions (e.g., flood pulses, water temperature, food supply, and predator presence), among other factors, determine the timing and duration of migrations and use of freshwater and estuarine habitat for reproduction and rearing (DWR, 2014). Water management features that adversely affect migration include those that totally impede upstream or downstream passage, delay fish migration, subject fish to lethal or sub-lethal conditions (e.g., by causing fish to become stranded in structures), or cause fish to stray into undesirable or dead-end waterways.

Many instream structures in the Central Valley adversely affect native anadromous fish migration and these are covered in Section 2.8.6.

2.8.6 Threatened, Endangered, and Sensitive Species

The designation of species as having “special status” can be applied to both plant and animal communities in the State, given slightly different criteria. Special-status fish and wildlife typically include:

- Species listed or proposed for listing as Threatened or Endangered under the Federal Endangered Species Act,

- Species listed or proposed for listing by the State as Threatened or Endangered under the California Endangered Species Act,
- Species designated as "Species of Special Concern" by the CDFW,
- Species designated as "Fully-Protected" by CDFW,
- Species considered sensitive or endemic by the USFS, or
- Birds designated as "Birds of Conservation Concern" by the USFWS.

California has the greatest number of Threatened and Endangered species in the continental U.S., representing nearly every taxonomic group, from plants and invertebrates to birds, mammals, fish, amphibians, and reptiles (Wilcove et al. 1998). In an analysis that identified "irreplaceable" places for preventing species extinctions (Stein et al. 2000), three out of six of the most important areas in the United States are in California, including the South Coast Ecoregion, San Francisco Bay Area, and Death Valley (along with Hawaii, Southern Appalachians, and the Florida Panhandle). The California Floristic Province, which covers roughly 69 percent of the State, is one of 25 global hotspots of biodiversity, and the only one in North America (Mittermeier et al. 1998, Mittermeier et al. 1999). As a consequence of habitat conversion to urban and agricultural uses, many areas in the state have become hotspots for species at risk of extinction.

As of December 2, 2009, there were 308 Federally species in California, including 129 animals and 179 plants (http://ecos.fws.gov). The USFWS has mapped essential habitat or designated Critical Habitat for 100 of these species, covering a total of 13.5 million acres in Critical Habitat and 1 million acres in essential habitat in California.

Assessments of potentially occurring special-status species typically include a search of the California Natural Diversity Database (CNDDB). The CNDDB is a database consisting of historical observations of special-status plant species, wildlife species, and natural communities. It is limited to reported sightings and is not a comprehensive list of special-status species that may occur in a particular area. Therefore, additional special-status plants may occur in the watershed, and CNDDB information may be supplemented by other assessments, such as the USFS Sensitive and Endemic Plants potentially occurring in the region.

Sacramento River Watershed Upstream of Shasta Dam

For the Upper Sacramento River Watershed CNDDB indicates 42 special-status plants known to occur in the watershed. Information on the habitat requirements of these species was obtained from the California Native Plant Society (CNPS) online Inventory of Rare and Endangered Plants, which features information on the habitats and statewide distribution of special-status plants in California.

The distribution and abundance of rare plants in the watershed is governed by a combination of: availability of suitable habitat; connectivity of habitat for dispersal and colonization; and losses of local populations from human impacts, climatic fluctuations, and other environmental events such as floods, fires, and diseases.

In the watershed upstream of Shasta Dam, 36 special-status wildlife species that are known to occur or may occur in the watershed were listed. The list of Federal- or State-listed Threatened and Endangered insect and wildlife species in the Upper Sacramento River Watershed Assessment includes special recognition of the following species (note: this list is not intended to indicate all Threatened and Endangered species that may be found in the region):

- Shasta Salamander (*Hydromantes shastae*): Known habitat consists primarily of limestone bluffs, cliffs, and outcrops near Shasta Lake Reservoir,
- American peregrine falcon (*Falco peregrines anatum*): Requires cliffs for nesting. Has been recorded nesting in the region,
- Bald Eagle (*Haliaeetus leucocephalus*): Although delisted as a Threatened species, the bald eagle continues to be protected under the Federal Bald and Golden Eagle Protection Act;
- Northern Spotted Owl (*Strix occidentalis caurina*): Associated with late-successional forest conditions. Critical habitat designation includes units within the region,
- Western Yellow-Billed Cuckoo (*Coccyzus americanus occidentalis*): Considered extremely rare in most areas and possibly extirpated from this region,
- Willow Flycatcher (*Empidonax traillii*): Nests in dense riparian thickets. Considered to be a rare spring and fall migrant in this area,
- Pacific Fisher (*Martes pennant pacifica*): This mammal has been recorded in numerous locations in the region, and
- Sierra Nevada Red Fox (*Vulpes vulpes nector*): Inhabits various habitats in alpine and subalpine zones. Sightings of this mammal have been recorded near Mount Shasta.

Other species that also warrant mention as special status species are: the Valley Elderberry Longhorn Beetle, golden eagle, northern goshawk, bank swallow, greater sandhill crane, American marten, California wolverine, ringtail, pallid bat, spotted bat, Townsend’s big-eared bat, western red bat, western mastiff bat, tailed frog, foothill yellow-legged frog, northwestern pond turtle, and 10 species of terrestrial mollusks — six of which are considered USFS-special status species.

Historically, two state Threatened mammals have occurred in the watershed, the Sierra Nevada red fox and California wolverine. The current distribution of these species in California, however, is not well known because they are difficult to locate when they occur in low numbers. Other special-status mammals that occur in the watershed include the American marten, pacific fisher, and Oregon snowshoehare. Two state Endangered fish are present in the upper portions of the watershed, the Modoc sucker and Goose Lake redband, and one State Threatened fish, the rough-skinned sculpin occurs in the lower portion of the watershed. In addition, one aquatic invertebrate, the Shasta crayfish, is State and Federally listed as endangered.

The McCloud Redband Trout is a former candidate species for protection under the Federal Endangered Species Act. Due to the enactment of a Candidate Conservation Agreement, the McCloud Redband Trout (or McCloud Redband) was removed from candidate status in October 2000. A series of conservation actions implemented by the Upper McCloud River Redband Trout Core Group have been designed to help recover this fish and reduce the need for listing under the Federal Endangered Species Act. Conservation of McCloud Redband Trout is ongoing under joint efforts of California Trout, the Shasta-Trinity National Forest, the California Department of Fish and Wildlife, and other partners in this effort. The forging of the Redband Trout Conservation Agreement in 2007 was an important step towards protecting these fish and their habitats.

Fish species in the region include several USFS-sensitive species as well as species listed as Threatened and Endangered under the Federal Endangered Species Act. While the anadromous species are no longer present, they may be reintroduced per the National Oceanic and Atmospheric Administration Fisheries Recovery Plan as is discussed below. Federal Endangered Species Act-listed species include Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley Steelhead, Southern DPS green sturgeon, delta smelt, Great Basin Redband trout, and rough sculpin. Most of these species are already at risk due to loss of habitat and habitat fragmentation. Additional stress to species is probable due to influences of warming on hydrologic processes. Periods of extended drought would also exacerbate the effects of drying on small aquatic habitats. Timing and volume of hydrographs are likely to shift. These increased stresses could result in loss of habitats and the species they support.

The Keswick and Shasta dams on the Sacramento River are existing barriers to upstream passage of anadromous salmonids including Chinook salmon and steelhead.

Chinook salmon have been extirpated from the rivers in this region. In addition, the extirpation of Chinook populations had further impacts by affecting other species in the system, notably bull trout (originally identified as Dolly Varden) that fed on early life stages of the Chinook (FERC, 2011).

Downstream of the region, the population of Chinook salmon in the Sacramento River has significantly declined over the past 40 years (DFG, 2010). Sacramento River winter-run Chinook salmon have been listed as Endangered under the Federal Endangered Species Act, and spring-run Chinook salmon have been listed as Threatened, along with other anadromous fish species in the upper Sacramento River, including Central Valley steelhead and North American green sturgeon.

Western Foothills and Tributaries

Special-status species of note in the Clear Creek watershed include northern spotted owl, bald eagle, and northern goshawk. In Lower Clear Creek, restoration of salmon and steelhead populations has been a major focus of fishery management agencies for the past 20 years. For the 50-year period from 1954 to 1994, fall-run Chinook salmon populations in Lower Clear Creek averaged around 2,000 fish annually, ranging from around 500 to as many as 10,000 depending on the individual year. In recent years, management efforts have focused on providing adequate instream flow, restoring channel and habitat conditions (gravel augmentation, channel realignment, riparian improvements), and removing impediments to migration.

All three forks of Cottonwood Creek support fall-run salmon, and Beegum Creek, tributary to the Middle Fork, is important habitat for spring-run salmon and steelhead. CDFW estimates that on the average, 1,000 to 1,500 fall-run Chinook salmon enter the stream annually. Numbers have fallen in recent years, consistent with the overall decline of fall-run Chinook salmon in the Sacramento River. Special-status species include northern spotted owl, red- and yellow-legged frog, Valley elderberry longhorn beetle (VELB), and vernal pool fairy shrimp.

A number of special-status fish, wildlife, and plant species can be found, or are known to have occurred historically, in the Elder Creek watershed. Special-status fish include Central Valley steelhead DPS, Chinook salmon, and hardead. Special-status wildlife include yellow-breasted chat, loggerhead shrike, tricolored blackbird, western yellow-billed cuckoo, Swainson's hawk, white-tailed kite, western red bat, pallid bat, Townsend' big-eared bat, western pond turtle, and VELB. Plants with the potential to occur in the watershed include Stony Creek spurge and silky cryptantha.

On the Stony Creek watershed, migratory species include steelhead trout, Chinook salmon, hardhead, and pikeminnow. Black Butte Dam blocks any upstream anadromous fish migration. The USFWS Anadromous Fish Restoration Program lists Stony Creek as high priority for increasing migratory salmonid populations that are currently adversely affected by temperature, hydrology, and channel habitat conditions. In addition to salmon and steelhead, special-status species in the Upper Stony Creek Watershed include VELB, western pond turtle, and foothill yellow-legged frog. The target and other sensitive species documented in the Foothill Landscape Units are VELB, western pond turtle, and greater sandhill crane. VELB has only been observed east of Black Butte Dam, between Stony Creek and Newville Road. Greater sandhill crane has only been recorded along Ash Creek and in the Ash Creek State Wildlife Area.

Target and other sensitive species documented within the Cache Creek watershed are VELB, western pond turtle, bank swallow, Swainson's hawk, colonies of tricolored blackbird, and western yellow-billed cuckoo. Wildlife resources in the Cache Creek Watershed also include the second largest wintering population of bald eagles in California and the golden eagle, osprey, red-tailed hawk, kestrel, prairie falcon, northern harrier, and several species of owls. Active bank swallow colonies have only been documented in natural banks and gravel pits along Cache Creek. Swainson's hawk nests have only been documented along Cache Creek, 2.5 miles southwest of Yolo. Western yellow-billed cuckoo was only documented in this area at the southern tip of Clear Lake. Barriers inhibit fall-run Chinook salmon, Pacific lampray, and steelhead from migrating up Cache Creek.

Putah Creek and its riparian vegetation are a refuge for wildlife that is otherwise rare or declining in the region, including the giant garter snake, the VELB, the northwestern pond turtle and Swainson's hawk. Putah Diversion Dam is now the upstream terminus of salmon and steelhead migration. Salmon attraction flows allow some spawning of anadromous fish even in years with limited runoff.

Eastern Tributaries

The eastern tributaries serve as important andromous fish habitat for Chinook salmon and steelhead. The Coleman National Fish Hatchery on battle creek supports large salmon and steelhead runs. Of the different runs of salmon that spawn in the eastern tributaries, only fall-run Chinook salmon return in consistent numbers to spawn in Bear Creek. Three different groups of fish live in Cow Creek: anadromous, resident, and exotic. Anadromous species that migrate up the watershed to locations downstream of natural barriers include fall-run Chinook salmon and winter-run steelhead. Cow Creek is a high-priority watershed in the basin-wide effort to increase anadromous fish populations, and restoration efforts will target concerns with instream flow, passage and screening of diversions, water temperature conditions, and habitat improvements.

The Big Chico Creek Watershed is another of the eastern tributaries to the Sacramento River with important anadromous fish habitat and, in particular, a valued spring-run Chinook salmon population. The watershed is also home to numerous state and/or federal special status species of amphibians, reptiles, birds, and invertebrates.

The Butte Creek watershed has historically had some exceptional features that made Butte Creek one of the most important streams in the Sacramento Valley for fish, particularly spring-run Chinook. It also contains important vernal pool habitat for listed plant and invertebrate species, and riparian areas provide habitat for important avian and other wildlife species.

Barriers to fish migration that have been identified as high priorities for remediation in this region include:

- One Mile Dam and Sycamore Pool in the lower Big Chico Creek
- Lindo Channel Diversion Structure at Lindo Channel

The target and other sensitive species documented in the eastern tributaries are woolly rose-mallow, VELB, giant garter snake, western pond turtle, colonies of bank swallows, greater sandhill crane, Swainson's hawk, colonies of tricolored blackbirds, western yellow-billed cuckoo, yellow-breasted chat, and yellow warbler. Active bank swallow colonies have been documented throughout the area in natural banks. The only documented occurrences of yellow-breasted chat and yellow warbler in this region have been observed on Todd Island in the Sacramento River, approximately 3 miles southeast of Red Bluff. The area contains critical habitat for steelhead, Chinook salmon, and green sturgeon.

Sacramento Valley

Historically, corridors of riparian vegetation lined the banks of the Sacramento River and American River, and extensive marshes existed in the Yolo and Natomas Basins and on Delta islands (see Section 2.8.2). Marsh and other wetlands were the predominant habitat of flood basins historically.

Although it is inundated less than 2 out of 3 years, the Yolo Bypass accounts for most floodplain inundation that now occurs in the lower Sacramento River Valley. Of the land within 1 mile of the lower Sacramento River and American River that could be inundated by a 50-percent-ACE event (2-year recurrence interval), only 9 percent remains connected to the rivers; the remainder is disconnected from these rivers by levees. As a result, the rearing habitat for Chinook salmon provided by inundated floodplains has been reduced by nearly 98 percent (not including the Yolo Bypass). Because of the presence of these levees and associated revetment, channel meander (although historically limited) has now essentially ceased. The Yolo Bypass provides extremely productive inundated floodplain habitat that benefits downstream ecosystems and provides rearing habitat for steelhead and Chinook salmon, as does the Sutter Bypass.

Substantial SRFCP-related constraints related to flood management complicate implementation of conservation plans. A particularly problematic constraint is the 112 miles of revetment present along major river reaches in the upper Sacramento River, much of it necessary to protect SRFCP and other levees. This revetment blocks the formation of cut banks, which are an attribute of SRA cover for salmonids and provide nesting habitat for bank swallows. Thus, revetment directly contributes to the decline of these species. Similarly, the flood management system and the need for flood protection currently constrain the establishment of continuous corridors of riparian vegetation along the upper Sacramento River.

Furthermore, several SRFCP and non-SRFCP structures have been impeding fish passage. In addition to dams at multipurpose reservoirs, these structures include:

- Tisdale Weir in the Tisdale Bypass
- Moulton Weir in the Butte Basin Overflow Area
- Weir No 1 (Parks Weir) in the West Canal of the Sutter Bypass
- Sacramento Weir in the Sacramento Bypass
- Fremont Weir in the Yolo Bypass
- Lisbon Weir in the Yolo Bypass
- Tule Canal crossings (five) in the Yolo Bypass

These alterations of ecosystem processes and habitats have contributed to the population declines of 22 sensitive species (CDFG, 2005 and DWR, 2011c):

- VELB
- Steelhead, California Central Valley distinct population segment (DPS)
- Chinook salmon, Central Valley fall-/late fall–run evolutionarily significant unit (ESU)
- Chinook salmon, Central Valley spring-run ESU
- Chinook salmon, Sacramento River winter-run ESU

- Green sturgeon, Southern DPS
- Giant garter snake
- Bank swallow
- Greater sandhill crane
- Swainson's hawk
- Western yellow-billed cuckoo
- Woolly rose-mallow
- Tricolored blackbird
- Longfin smelt
- Sacramento splittail
- California black rail
- Western pond turtle
- Sanford's arrowhead
- delta tule pea
- Mason's lilaeopsis
- Suisun Marsh aster
- yellow-headed blackbird

This area also contains critical habitat for steelhead, Chinook salmon, and green sturgeon, as discussed in Section 2.8.6 and shown in Figure 2-16.

Feather River and Tributaries

Riverine and floodplain ecosystems have been substantially degraded in the Feather River watershed and its main tributaries, the Yuba and Bear Rivers. Only a very small portion (less than 1 percent) of the floodplain experiences sustained winter or spring inundation, and the rearing habitat for Chinook salmon provided by inundated floodplains has been reduced by roughly 98 percent. Recently it has been found that steelhead and green sturgeon still utilize the Feather river for spawning during high water years.

These alterations of ecosystem processes and riparian habitat have contributed to the population declines of the following sensitive species (CDFG 2005 and DWR 2011c):

- VELB
- Steelhead, California Central Valley DPS
- Chinook salmon, Central Valley fall-/late fall-run ESU
- Chinook salmon, Central Valley spring-run ESU
- Green sturgeon, Southern DPS
- Giant garter snake
- Bank swallow
- Greater sandhill crane
- Swainson's hawk
- Western yellow-billed cuckoo
- Sanford's arrowhead
- Tricolored black bird

- Sanford's arrowhead,
- woolly rose-mallow
- western pond turtle,
- California black rail

This area also contains critical habitat for steelhead, Chinook salmon, and green sturgeon, as shown in Figure 2-16.

American River

Target and other sensitive species documented along the American River are Sanford's arrowhead, VELB, western pond turtle, bank swallow, and Swainson's hawk. The reach contains critical habitat for VELB. Active bank swallow colonies have been documented throughout the reach in steep eroding sandy bluffs and banks. This reach also provides habitat for migrating, holding, and rearing steelhead, and migrating, holding, spawning, and rearing fall-run Chinook salmon. The reach contains critical habitat for green sturgeon, steelhead, and Chinook salmon.

Sacramento-San Joaquin Delta

The Sacramento River Valley geomorphology transitions from a sinuous Sacramento River with a historically migrating channel to stable channels between delta islands bordered by natural levees of deposited sediment (see Section 2.7).

As discussed in Section 2.8, riverine and floodplain ecosystems have been substantially degraded by island subsidence, flow alteration by numerous upstream dams and diversions, bank protection with revetment, and disconnection of floodplains from rivers by levees.

These alterations of ecosystem processes and habitats have contributed to population declines of the following sensitive species (CDFG, 2005 and DWR, 2011c):

- VELB
- Steelhead, California Central Valley DPS
- Chinook salmon, Central Valley fall-/late fall–run ESU
- Chinook salmon, Central Valley spring-run ESU
- Chinook salmon, Sacramento River winter-run ESU
- Green sturgeon, Southern DPS
- delta smelt
- Giant garter snake
- Bank swallow
- California black rail
- Greater sandhill crane
- Swainson's hawk
- delta tule pea
- Mason's lilaeopsis
- Suisun Marsh aster
- woolly rose-mallow

- Sanford's arrowhead
- western pond turtle
- longfin smelt
- delta mudwort
- tricolored blackbirds

The area contains critical habitat for delta smelt, green sturgeon, steelhead, and Chinook salmon.

2.8.7 Invasive Species

Invasive plant, invertebrate, and vertebrate, species are found throughout the Sacramento River Watershed. Although invasive vertebrate and invertebrate species create costly impacts to the natural ecosystems of the Sacramento River watershed, DWR's Conservation Strategy recognizes invasive plants as a primary stressor on the habitats, species, and ecosystem processes that are the focus of conservation planning. Additionally, invasive plant species, specifically the giant reed (*Arundo donax*), have also been identified as stressors on the operation and maintenance (O&M) of SPFC facilities. Figure 2-17 provides a map showing the density of invasive plants throughout the Sacramento River Watershed emphasizing the degree of invasion. Pimentel et al. in 2005 determined that approximately 42 percent of the species listed as threatened or endangered by the Federal Endangered Species Act are at risk primarily because of the adverse effects of invasive species.

The following are examples of existing invasive species that, if not controlled, can have devastating impacts on the natural environment of the Sacramento River Watershed as well as high economic impacts on the State Plan of Flood Control.

Invertebrates
Invasive invertebrates such as the New Zealand mudsnail (*Potamopyrgus antipodarum*) are a problem within the Sacramento River Watershed due to its prodigious reproductive capacity, ability to outcompete with native mollusks for resources, and provides very little nutritional value to native aquatic predators.

Vertebrates
Vertebrate invaders include the North American bullfrog (*Rana catesbeiana*), which is a voracious predator that competes with the native red-legged frog (*Rana draytonii*). To make matters worse, the bullfrog has also been implicated as a leptospirosis vector and

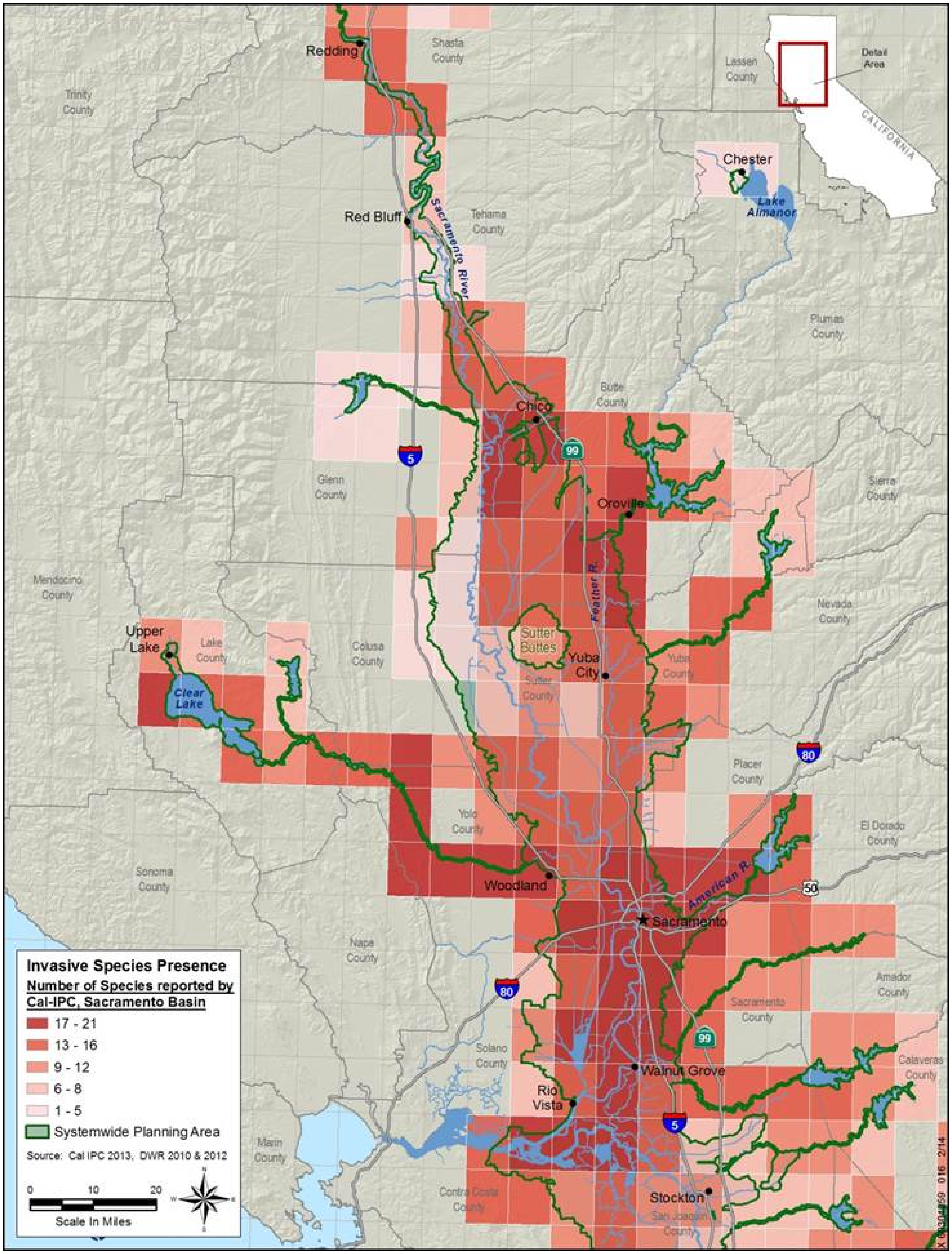

Figure 2-17 Invasive Species Presence

may therefore pose a threat to human health. Another vertebrate invader is the green sunfish (*Lepomis cyanellus*) that spawns in shallow waters and have enormous reproductive potential. They compete with native fishes by feeding on insects and small fish and are adaptable to varying lake conditions and climates.

Plant Species
The lands on which invasive plants occur are managed by a variety of entities, including DWR, Local Maintaining Agencies (i.e., levee districts and reclamation districts), the CDFW, the USFWS, and private landowners. The diverse entities involved in invasive plant management vary in their authorities and responsibilities making coordination between managing entities a challenge. The ability to implement the most effective system-wide invasive plant treatment methods is also hindered by a lack of common baseline information, shared priorities, and decreasing O&M resources. Regional factors such as upstream source populations may not be fully considered or addressed, and information characterizing the distribution of invasive plants is within the watershed, which could be used to prioritize specific infestations for treatment, is lacking.

A standardized system-wide approach to invasive plant management could improve collaboration among all maintenance entities in the watershed and could include prioritizing the infestations that pose a threat to Conservation Strategy targets, in addition to focusing on SPFC O&M needs.

The following subsections describe those species' natural history properties that have resulted in being problematic throughout the watershed.

Aquatic Plants

Brazilian Waterweed
Brazilian waterweed's (*Egeria densa*) dense underwater growth reduces water flow, which can adversely affect irrigation projects, hydroelectric utilities, and urban water supplies. Beds of this weed also accumulate sediment and reduce the abundance and diversity of native plant seeds in lake bottoms (De Winton and Clayton, 1996).

Water Primrose
Water primrose (*Ludwigia* sp.) forms dense mats above and below the water surface in shallow, stagnant, nutrient-rich pools and in areas with hydrological disturbance, such as flood protection channels, irrigation ditches, and irrigation ponds. Spreading very rapidly once established, heavy infestations of water primrose can alter water flow, cause sediments to accumulate, and diminish water quality. This weed can also outcompete native aquatic and wetland plant species, reducing species diversity and degrading waterfowl habitat. Areas that were once open water habitat become closed mats of water primrose (Verdone 2004).

Crisp-Leaved Pondweed
Crisp-leaved pondweed (*Potamogeton crispus*) forms vegetative propagules (turions) that lay dormant during summer and germinate when most native vegetation has died

back. It grows in dense mats that cover large areas and impede water flow, clog irrigation canals, and can deplete nutrients that are important for wildlife.

Water Hyacinth

Water hyacinth's (*Eichhornia crassipes*) rapid growth allows it to quickly dominate aquatic systems, displacing native aquatic plants, degrading habitat for waterfowl, and creating ideal breeding habitat for mosquitoes. Water hyacinth's high evapotranspiration rates increase water loss from aquatic systems.

Parrot's Feather

Parrot's feather (*Myriophyllum aquaticum*) outcompetes native aquatic plants, often eliminating or significantly reducing their numbers in infested sites and may significantly alter the physical and chemical characteristics of lakes and streams. The weed also forms dense mats that clog waterways, block irrigation pumps and water intakes, and cause similar adverse effects on agricultural and water management activities.

Terrestrial Plants

Tree of Heaven

Tree of heaven (*Ailanthus altissima*) is fast growing and produces long, lateral roots that grow suckers up to 50 feet from the adult tree. A single individual can produce dense clonal stands as large as approximately 1 acre. These large, dense stands degrade wildlife habitat and can adversely affect floodwater conveyance and SPFC maintenance.

Giant Reed

Giant reed (*Arundo donax*) displaces native plants and associated wildlife species because of the massive stands it forms, significantly increase water loss from underground aquifers due to its high evapotranspiration rate (up to three times greater than that of native riparian vegetation; Gaffney and Cushman, 1998; Bell, 2002). As giant reed replaces riparian vegetation, it reduces habitat and food supply, particularly insect populations, for several special-status species such as least Bell's vireo, southwestern willow flycatcher, and yellow-billed cuckoo (Frandsen and Jackson 1994; Dudley and Collins 1995).

Yellow Star-Thistle

Yellow star-thistle (*Centaurea solstitialis*) is highly competitive and can develop dense stands that displace native plants. Its long taproot effectively competes with native plants, particularly native perennials, for deep soil moisture during the dry summer months. Infestations reduce wildlife habitat quality and livestock forage value and decrease native plant and animal diversity.

Blue Gum

Blue gum (*Eucalyptus globulus*) groves of this species are highly combustible and increase the risk of fire because of its flammable plant compounds, dense growth habit, and copious leaf litter.

Edible Fig

Edible fig (*Ficus carica*) can form dense thickets that outcompete native trees and understory vegetation. Such thickets are difficult to control because cutting or injuring the tree typically stimulates the development of numerous root sprouts.

Perennial Pepperweed

Perennial pepperweed (*Lepidium latifolium*) can form large stands that exclude native plant species, decreasing plant diversity and structural complexity (Cal-IPC, 2013b) and giving it a competitive advantage over native plants for access to water and nutrients. Shifting plant composition to favor halophytes, perennial pepperweed may also transport salts from lower soil horizons, drawing the salts through its roots to its leaves, then exuding and depositing them on the soil surface (Renz 2000).

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*) can rapidly degrade wetlands, displace native vegetation, and adversely affect wildlife species that rely on wetlands for habitat and food. Purple loosestrife also clogs waterways and can alter the hydrologic and soil conditions of wetland pastures, meadows, and irrigation systems. Cut stems can reroot under certain conditions, and flooding can encourage the species to spread.

Himalayan Blackberry

Himalayan blackberry (*Rubus armeniacus*) spreads rapidly and dominate native species of blackberry. Periodic flooding can produce long-lived, early seral plant communities that are conducive to its growth and spread. This species is a strong competitor and rapidly displaces native plants by forming dense, impenetrable thickets that limit the growth of understory plants.

Milk Thistle

Milk thistle (*Silybum marianum*) often grows in dense, competitive stands, mainly on disturbed sites in pastures and fields, as well as along levees, roadsides, and similar disturbed areas. After it reproduces and dies, milk thistle skeletons can remain standing for months and preclude the regeneration of native plants.

Saltcedar

Saltcedar (*Tamarix* spp.) is tolerant of highly saline habitats, and it concentrates assimilated salt in its leaves. Over time, its surface soil can become highly saline and impede future colonization by native plant species (Carpenter 1998). Its roots can drastically reduce available surface and groundwater and the increase in salinity in the upper soil profile can inhibit the growth of native vegetation (DiTomaso and Healy, 2007). Saltcedar also traps and stabilizes alluvial sediments, narrowing stream channels and causing more frequent flooding (Bossard et al. 2000).

Barbed Goat Grass

Barbed goat grass (*Aegilops triuncialis*) successfully competes with native forbs and desirable annuals; its seeds are adept at germinating and can send roots down through thatch or bunch grasses. Once it is mature, the plant may cause livestock severe injury:

the disarticulated joints of the plant are sharp and can pierce the stomach linings of livestock when ingested.

Pampas Grass
Pampas grass (*Cortaderia selloana*) competes with native vegetation and, when it establishes in forests, with the seedlings of trees, ultimately slowing their establishment and growth. This species is also considered a fire hazard because it accumulates large quantities of dry leaves, leaf bases, and flowering stalks.

Scotch Broom
Scotch broom (*Cytisus scoparius*) is a strong competitor and displaces native plant and forage species by forming dense, monospecific stands. Seedlings are also shade-tolerant and can therefore outcompete trees, making reforestation difficult.

Stinkwort
Stinkwort (*Dittrichia graveolens*) seeds may remain viable in the soil for 2 to 3 years, and they are capable of germinating year-round, so the weed can quickly eliminate open spaces and pastureland. Seeds are likely spread by wind, mammals, birds, and human activity (Brownsey et al. 2012).

Medusa Head
Medusa head (*Elymus caput-medusae*) frequently outcompetes desirable nonnative annual grasses and native grasses and forbs. Once established, it can reach densities of nearly 200 plants per square foot. After seed set, the silica-rich dead plants persist as a dense litter layer for three or more growing seasons, encouraging further Medusa head dominance by preventing germination and survival of native species.

Fennel
Fennel (*Foeniculum vulgare*) is a competitive invader that can preclude the establishment of native plant species. It drastically alters the composition and structure of many plant communities by outcompeting native species for light, nutrients, and water, and can further outcompete other plants by forming dense, uniform stands.

French Broom
French broom (*Genista monspessulana*) is an aggressive invader that produces abundant seeds and will resprout from the root crown if it is cut, grazed, or burned. Seeds are dispersed by ants, birds, mammals, human activity, and water movement. French broom displaces native plant and forage species and can dominate plant communities by forming dense, monospecific stands.

Tree Tobacco
Tree tobacco (*Nicotiana glauca*) reproduces prolifically from seeds that are dispersed by water, soil movement, and human activities. All plant parts contain alkaloids that are highly toxic to humans and livestock when ingested. Tree tobacco competes with native plants, but its ability to outcompete native plants is not well documented.

Scotch Thistle
Scotch thistle (*Onopordum acanthium* ssp. *acanthium*) can form tall, dense, impenetrable stands that outcompete native plants for resources. The long taproot (1 foot long or more) may affect soil moisture levels and allow Scotch thistle to outcompete native grasses that rely on water close to the surface. Minimizing open gaps and bare ground can discourage invasion by this species.

Ravenna Grass
Ravenna grass (*Saccharum ravennae*) alters fire dynamics, light availability, soil moisture, and the nutrient content of soils, as well as accumulating sediment. Ravenna grass may also alter streambank erosion patterns and encourage flooding. It can grow on more exposed soils than many other riparian species, so it may add significant biomass to swift streams. In some areas, it has formed monospecific stands that may outcompete native vegetation.

Russian Thistle
Russian thistle (*Salsola tragus*) can be especially problematic during periods of drought when other annual vegetation does not germinate. Later stages of growth produce tough, spiny foliage that is often not eaten by grazing or browsing animals unless other forage species are unavailable. Also, the mature foliage contains high concentrations of oxalates, which can be toxic to livestock (DiTomaso and Healy, 2007).

Red Sesbania
Red sesbania (*Sesbania punicea*) is capable of producing thousands of viable seeds within a few months, leading to rapid spread of the species (DiTomaso and Healy, 2007). It can establish itself in the shade of other native riparian vegetation, allowing it to easily attain community dominance. This species displaces native plants, contributes to bank erosion and flooding, and diminishes wildlife habitat.

Chinese Tallowtree
Large stands of the Chinese tallowtree (*Triadica sebifera*) displace native vegetation and can significantly alter soil nutrients. When its leaf litter decomposes, levels of nitrogen, phosphorous, and other mineral nutrients increase while magnesium and sodium levels decrease.

2.9 Hazardous Materials

In this section, the term “hazardous materials” is used broadly to address hazardous substances and hazardous wastes that may be harmful to human health and safety or to environmental quality if released into the environment. The terms hazardous materials, substances, and wastes are not used here to refer to specific regulatory criteria.

The California Department of Toxic Substances Control (DTSC) maintains a comprehensive online database of hazardous material sites called EnviroStor. Although EnviroStor does not include all known sites regulated by agencies other than DTSC, it does indicate the general nature and distribution of hazardous material sites in the study area, including completed cleanup sites.

Most of the recorded hazardous material sites in the study area are located within urban areas. These sites have resulted from a wide range of activities typical of urban areas including, for example, industrial, waste disposal and utility sites, storage tank leaks, junkyards, and dry cleaners. Some of the recorded sites in urban areas are located near waterways and will need to be considered in planning water resource projects in those areas. Under existing conditions, flooding could upset stored hazardous materials and spread pesticides, oil, gasoline, sewage, and other hazardous materials in floodwaters, creating localized or widespread hazardous conditions for the public and environment, particularly in urban areas.

The study area has historically been and is currently being used largely for agricultural purposes. Agricultural land use typically involves the application of pesticides, the residues of which may remain in soils for many years, and the use of fuels, lubricants, and other fluids associated with the operation and maintenance of agricultural equipment. Other potential sources of hazardous materials in agricultural areas include aboveground and underground storage tanks and utility infrastructure, small waste disposal and burn sites, and gas wells. The DTSC EnviroStor data identifies relatively few recorded hazardous material sites within predominantly agricultural areas and very few sites near waterways in agricultural areas. In general, known hazardous material sites should not be a major constraint in planning water resource projects throughout most of the study area. Some minor hazardous material sites within agricultural areas may not be recorded and would need to be identified through site-specific assessments during the planning of future projects. Additionally, some portions of the study area suffer from poor water quality and contain harmful substances such as elevated levels of mercury or boron. Impaired waterbodies are discussed in more detail in Section 2.10.

2.10 Water Quality

2.10.1 Sacramento River Watershed Upstream of Shasta Dam

Water quality in the Sacramento River and its tributaries upstream of Shasta Dam is very good overall and supports a variety of diverse and abundant coldwater aquatic species. Existing water quality conditions are summarized as follows:

- Water temperature is generally desirable for trout and other coldwater species, but in low-flow, hot summer years it is likely stressful for trout in the lower river above Lake Shasta,
- Vegetation shading in the river and stream riparian zones is critical for preventing temperature increase,
- Suspended and settleable sediment levels are generally less than believed harmful to aquatic life; however, there are some localized erosion/sediment problems that should be addressed,

- Metals, nutrients, and other chemical parameters are indicative of unpolluted water and are at levels supportive of native aquatic life, and
- Effluent discharge from Mount Shasta and Dunsmuir wastewater treatment plants is generally in compliance with discharge requirements and not causing problems for water contact recreation or other beneficial uses.

Water quality in the McCloud River and tributaries is considered to be very good. The cumulative impacts of natural hillslope erosion, roads, timber management, and water storage/diversion exert the largest influence on water quality parameters. Changes in most water quality parameters occur in response to winter precipitation because the high flows during winter rains create an increase in suspended sediment and turbidity, this quickly drops to pre-storm levels following peak flow events. Mud Creek, also located in the upper watershed, carries glacial silt into McCloud Reservoir that, under certain conditions, gets resuspended and moves downstream through the McCloud River. The clarity of water in the McCloud River fluctuates from excellent during most of the year to highly turbid for short periods of time.

Water temperature in the McCloud River below McCloud Reservoir has increased as a result of hydropower operations. Before construction of the reservoir, water temperatures in the river largely were regulated by Big Springs, which provided a constant flow of 45°F water to the river, with temperatures in the lower river never exceeding 60°F. Following the completion of the reservoir, stream temperatures in the lower river have been recorded as high as 75°F.

Beneficial uses designated for the Pit River include support for cold- and warmwater aquatic life, recreation, and municipal, industrial, and agricultural supply. The mainstem of the Pit River (headwaters to McArthur) is listed on the Clean Water Act Section 303(d) listed as impaired for temperature, dissolved oxygen, and nutrients. In addition, several tributaries were recently listed as impaired for elevated levels of fecal coliform bacteria (E. coli). Water quality in the Pit River Watershed is influenced by a variety of current land and water use practices, past management practices, and natural geologic and climate conditions. The Pit River typically has relatively high levels of turbidity and suspended sediment, particularly during peak runoff events. Water quality improvement efforts in the watershed involve a combination of improved management practices and restoration projects to address legacy issues that have degraded channel and habitat conditions.

2.10.2 Western Foothills and Tributaries

In general, surface water quality in the western tributaries is good. DWR and USGS have recorded elevated levels of some constituents (dissolved metals, pH, and temperature), but these are considered the result of natural conditions, such as climate and geology. The principal issue is sediment loading and transport rates. Most westside streams carry high levels of suspended and bedload sediment, particularly during storm runoff events. These sediment loads cause changes in channel morphology and affect aquatic life and their habitat.

Water quality in Upper Clear Creek is generally good and supports a robust population of native rainbow trout. Willow Creek, a Clear Creek tributary just upstream of Whiskeytown Reservoir, is heavily affected by metals from the Greenhorn Mine, an abandoned copper mine operated in the early 1900s. Monitoring data have not shown significant impact on Clear Creek from the metal-contaminated Willow Creek drainage. Another potential water quality issue is elevated Escherichia coli (E. coli) levels downstream of the community of French Gulch, with the suspected source being individual waste disposal systems.

Both Lower Clear Creek and Whiskeytown Lake are 303(d) listed as impaired waterbodies for mercury. The source of this contamination is assumed to be mercury deposits in the expansive tailings piles that are a legacy of the dredging gold mining operations in the 1800s. Otherwise, water quality in Lower Clear Creek is considered very good and supportive of all aquatic life and recreational uses.

Physical and chemical constituents generally reflect good water quality for Cottonwood Creek that is supportive of aquatic life and other beneficial uses. Turbidity and suspended sediment are frequently elevated during high-flow events, and the largest source of this sediment turbidity is from landslide features in the South Fork drainage. Water temperatures in the lower reach of Cottonwood Creek are not supportive of coldwater species on a year-round basis. Because this watershed has a significant run of anadromous fish, maintaining adequate temperatures during times of both in- and out-migration is an important issue. Temperatures in Cottonwood Creek are influenced largely by ambient air temperature, flow, and channel conditions (e.g., streamside shade canopy).

On Upper Stony Creek, the principal water quality issue is mercury, which is known to be present in naturally occurring deposits in the upper watershed. Stony Gorge Reservoir is on the 303(d) list of impaired water bodies for mercury. There is also concern about metals from abandoned mines, elevated temperatures attributable to lack of riparian shade canopy, and high erosion/sediment discharge rates; however, mercury is the only documented impairment. Lower Stony Creek presents elevated levels of the pesticides diazinon and simazine, both used in agriculture. Escalating temperatures as you move downstream is also a concern. Temperatures are coldest at the outlet from Black Butte Dam and increase downstream as affected by air temperature, solar radiation, shading, and channel geometry. These issues aside, the principal management concern in Lower Stony Creek is accelerated channel erosion resulting from the modified hydrologic regime and from the persistent growths of invasive giant reed and saltcedar.

The Cache Creek Watershed was a primary source of mercury used for gold mining in the Sierra and one half of all the mercury entering the Sacramento River system flows from the watershed. It is estimated that over 40 abandoned mines are found in the drainage. The Sulphur Bank mine at Clearlake is a Superfund site undergoing clean-up and the Turkey Run-Abbott mine tailings have been restored. The BLM is currently working to clean up the Rathburn-Petrey Mine.

Lower Cache Creek is listed on the 303(d) list as impaired for mercury, boron and unknown toxicity. In 2007, the USEPA approved Total Maximum Daily Loads (TMDLs) for mercury and methylmercury in Cache Creek (and tributaries Bear Creek, Sulphur Creek, and Harley Gulch). The Cache Creek Settling Basin was designed solely to reduce heavy sediment discharges from the Cache Creek to the Yolo Bypass to preserve the flood capacity of the bypass. However, it is believed that the Basin also significantly reduces the total mercury load to the Yolo Bypass, Delta and San Francisco Bay. Changes to the Cache Creek Settling Basin that reduce trapping efficiency or increase mercury loading to the Yolo Bypass would be inconsistent with the TMDLs.

The Putah Creek Watershed is rich in mineral deposits, and prospecting for mercury and gold has taken place in the watershed since the mid- 1800s. Natural weathering, mining waste, and venting from natural geothermal springs all have contributed to the introduction of mercury in the area’s water bodies. Campus wastewater discharges from UC Davis and runoff from a U.S. Department of Energy Superfund site both contribute to the excessive mercury levels in Putah Creek. Putah Creek has been listed on the Clean Water Act Section 303(d) list of impaired water bodies for excessive mercury.

Lower Putah Creek also is affected by high turbidity from eroding tributary channels. The tributaries are adjusting to 20-feet-lower peak water surface elevations in the main channel compared with pre- Monticello Dam conditions. The cross-sectional area of tributary channels has increased approximately ten-fold in the post-dam era, and Lake Solano (7 miles below Monticello Dam) is filled to capacity with sediment. Loading of fine sediments degrades aquatic habitat by burying gravel substrate habitat.

2.10.3 Eastern Tributaries

Given the year-round, high-volume flow of water in Battle Creek, water quality is generally very good and supports a variety of coldwater aquatic species, including large runs of anadromous salmon and steelhead. Water quality issues in Battle Creek have centered on temperature and sediment conditions. In 2001, a watershed assessment was conducted to evaluate instream sediment conditions in the upper watershed. Fine sediment levels were found to be higher than favorable for salmonid production but similar to levels in other northern California streams. A 2006 repeat of this study found more favorable stream conditions indicating an improving trend. Temperature has been an ongoing concern, particularly in stream reaches where flow is substantially reduced by hydropower operations. Another potential concern has been nutrient enrichment from the large number of fall-run salmon carcasses in Battle Creek downstream of the Coleman Hatchery.

In Bear Creek, water temperature is the principal issue of concern, given its importance to resident coldwater species and migratory salmon and steelhead. In general, water temperatures in the upper watershed are supportive year-round for coldwater species. At lower elevations, summer temperatures exceed tolerance levels for these species, partially because of natural climate conditions and partly because of water diversions and low streamflow. Monitoring also has shown that fecal coliform bacteria concentrations occasionally exceed standards set for protection of contact recreation. Likely sources are domestic livestock and concentrations of wildlife.

Water quality generally meets State standards or designated beneficial uses in Big Chico Creek. Temperature is important, given the stream’s use by anadromous fish, as are bacteria loads because of water-contact recreational use. Potential sources of water quality impairment in the watershed include erosion from forest and rangeland roads, urban runoff in the Chico residential and commercial area, and agricultural chemicals runoff in the lower watershed reach. Big Chico Creek is 303(d) listed as impaired for mercury.

The overall water quality of Butte Creek is considered to be good to excellent, especially in the upper watershed. However, seasonal variability can occur related to weather patterns and reduced flow resulting from water diversions and other management activities. Increased water temperature is a definite concern, as it negatively impacts anadromous fish passage and survival. Sediment from surface erosion (roads, logging operations, etc.) is also a concern for the same reasons. Elevated bacteria levels downstream of populated areas from livestock grazing and natural sources also occur on a sporadic basis.

The primary water quality issues in the Cow Creek watershed relate to bacteria, temperature, and erosion/sediment discharge. There is one inactive, abandoned copper mine (Afterthought Mine); however, acid and metals draining from this site appear to have only localized impacts in North Fork Cow Creek. E. coli levels are a concern, given the extensive contact recreation use in this stream (swimming and tubing), and North Fork Cow, Clover, Oak Run, and South Fork Cow Creeks are all 303(d) listed as impaired waterbodies for bacteria. Likely sources include domestic livestock, faulty private septic systems, and concentrations of wildlife. Temperature is an important factor in successful spawning and rearing of salmon and steelhead and in some years may be a problem seasonally for in-migration of adults (October and November) and out-migration of juveniles (April, May, and June).

Water quality in Deer Creek is considered good with the exception of temperature conditions during times of low flow. Erosion in the upper watershed and its potential impact on aquatic habitat is another concern. SR 32 is a main transportation route that parallels Deer Creek through much of the upper watershed, and has caused concern over the possibility of a hazardous spill event that could have catastrophic results for the stream, surrounding habitat and aquatic life.

Mill Creek water quality is characterized by its high silt load and turbidity during the spring and early summer snowmelt periods. This silt originates from volcanic ash and glacial till in Lassen Volcanic National Park. Additional sediment load comes from land management activities in the watershed, including timber harvesting, roads, and cattle grazing. Water temperature in Mill Creek is an important parameter for species such as spring and fall-run Chinook salmon, trout, and steelhead. Concerns with temperature apply mainly in the lower reach of Mill Creek and are closely related to instream flow conditions.

2.10.4 Feather River and Tributaries

Within the Feather River Watershed water quality is considered good, but there are several water bodies currently on the Clean Water Act's 303(d) list of impaired waters (listed constituents include mercury, copper, temperature, and toxicity). Water quality constituents of general concern include temperature, dissolved oxygen, sediment, and bacteria, and the impacts are related to common land and water use practices in this watershed, (i.e., ranching, mining, timber harvest, road construction/maintenance, and rural residential development). Reducing peak streamflows and slowing currently accelerated erosion are principal management goals, as an estimated 1.1 million tons of sediment are transported annually out of the North Fork Feather River watershed.

Water quality in the Lower Feather River Watershed is heavily influenced by agricultural and municipal land and water use in the watershed. The Lower Feather River is listed on the Clean Water Act Section 303(d) list of impaired water bodies for temperature, chlorpyrifos, diazinon, mercury, and unknown toxicity. Constituents of concern for groundwater are TDS, nitrate, and several other individual chemical constituents. Surface and groundwater quality is a concern for both fisheries and agricultural supply use. In October 2003, the Central Valley RWQCB established TMDL regulations for diazinon in the Lower Feather River. That document recommended three strategies for reducing diazinon loading: (1) reducing diazinon use, (2) reducing surface water runoff from sprayed orchards, and (3) delaying and/or filtering orchard runoff containing diazinon. Recent monitoring (2006 and 2007) indicated diazinon loading to the Lower Feather has been reduced significantly.

Areas of the watershed have been severely degraded by historic hydraulic mining and mercury contamination. Five waterways within the watershed are listed under the Clean Water Act Section 303(d) list of impaired waterbodies for mercury contamination (Upper Bear River, Steephollow Creek, Lake Combie, Wolf Creek, French Ravine, Camp Far West); Wolf Creek and French Ravine are listed for fecal coliform and bacteria, respectively.

The Yuba River Watershed contains a significant amount of sediment and mercury as a result of hydraulic mining that occurred in the mid to late 1900s. Mercury is present in the bottoms of rivers and reservoirs and is transported by erosion processes, which can mobilize and convert mercury in sediments into methylmercury. As methylmercury accumulates in the food chain, it becomes concentrated, so that in larger predatory fish (e.g., trout and bass), concentrations can exceed levels of concern for human consumption. Findings in the most recent and comprehensive survey of fish in the Yuba River Watershed meet and exceed USEPA and Food and Drug Administration levels.

Sediment loads in the watershed can be attributed to historical mining as well as recent human activities such as road construction associated with rural housing development, logging, and recreation. Temperature is also a significant water quality concern in the Yuba River Watershed. Warming water temperatures can be attributed to dams, water diversions, inadequate shading due to limited riparian canopy, and low instream flows. Yuba River tributaries - Deer, Humbug, Kanaka, and Little Deer Creeks - are listed on the 303(d) list of impaired waterbodies, along with Englebright and Scotts Flat Reservoirs. Humbug Creek is also listed for copper, sediment, and zinc.

2.10.5 American River

In general, water quality in the American River is considered to be very good from the headwaters to the confluence with the Sacramento River. Streams in the upper watershed are typically clear, cold streams that are naturally highly oxygenated, low in dissolved ions and nutrients, and exhibit low instream plant or algal growth. However, erosion from land use activities (past and present), roads, and recreational use throughout the watershed contribute to instream sediment problems. The South Fork American River is listed on the 303(d) list of impaired water bodies for mercury because of historical mining activities.

American River water is generally characterized as high quality surface water that is low in alkalinity, mineral content, and organic contamination. Turbidity levels in the American River tend to be higher in the winter than summer because of higher flows associated with winter storms. However, the Lower American River is listed on the 303(d) list of impaired water bodies for mercury and unknown toxicity. Arcade Creek is listed for copper and chlorpyrifos/diazinon.

2.10.6 Sacramento Valley Surface Water

Surface water quality in the Sacramento Valley is affected by several factors: natural runoff, historical mining activities, agricultural return flows, operation of flow-regulating facilities, wastewater treatment effluent, construction, logging, grazing, urbanization, and recreation. In general, water quality in the Sacramento Valley is suitable for designated beneficial uses. However, there are concerns about possible water quality effects of metal contamination from abandoned mercury from hydraulic mining and other hard-rock mining activities. Other sources of pollutants in the Sacramento Valley and foothills include agricultural runoff that escalates after each irrigation season and runoff from dewatered rice fields. Additionally, wastewater treatment effluent and stormwater runoff contribute pollutants from urban areas.

Water quality protection for aquatic life, recreation, and domestic supply is a principal management issue in the Sacramento Valley. Use of agricultural chemicals on the almost 2 million acres of irrigated cropland in the Sacramento Valley is a concern with regard to potential aquatic life toxicity and impacts on domestic water supplies. Other Sacramento Valley water quality issues relate to abandoned mines, urban runoff, and water management operations that affect streamflow, aquatic habitat, and water temperature. Primary water quality issues in the Sacramento Valley include:

- Pesticide contamination of surface and groundwater from agricultural and urban sources,
- Nitrate contamination of groundwater
- Sediment binding to pesticides that subsequently are ingested and bioaccumulate through the food chain,
- Abandoned mines and discharge of heavy metals and mercury from legacy mining operations as well as some natural sources,
- Urban runoff, and
- Operation of dams and diversions that affect streamflow and water quality.

Water quality in the upper Sacramento River is generally acceptable for most designated beneficial uses. Only when stormwater-driven runoff is present are water quality objectives typically not met. Concentrations of metals and pesticides, in particular, tend to be highest during high-flow events (Domagalski et al., 2000).

Metals are a key water quality concern in much of the upper Sacramento River and its tributaries. A major source of metals in this geographic area is drainage from inactive mines in the Iron Mountain area of the West Shasta mining district. During mining and smelting activities that occurred from the 1880s to the 1960s, Iron Mountain's acid mine drainage discharged directly to Spring Creek, a Sacramento River tributary upstream from Redding (Alpers et al., 2000). Springtime methylmercury concentrations have been observed to be higher during flood events (Domagalski et al., 2000). Water quality enhancement actions at mines in the upper Sacramento River area and improved coordination of Spring Creek and Keswick reservoirs have resulted in a notable decrease in the number of water quality targets exceeded in the past 10 years.

Elevated mercury concentrations in the upper Sacramento River correlate with high concentrations of suspended sediment and high flows because much of the mercury transported is bound to suspended sediments (Domagalski et al., 2000). Rates of loading and discharges of suspended sediment in the upper Sacramento River watershed have been altered by activities such as mining, agriculture, urbanization, and dam construction. Storing and diverting reservoir water to produce hydroelectric power or for other purposes can affect sediment yield, downstream sediment levels, and transport characteristics.

Historical hydraulic gold mining has had a considerable effect on sediment yield in the Sacramento River watershed (Wright and Schoellhamer 2004). During the late 1800s, such mining introduced mass quantities of silt, sand, and gravel into the Sacramento River system. Suspended sediment was washed downstream into the Delta. Peak-flow events are primary drivers of sediment mobilization, bed scour, and bank erosion in the Sacramento River. However, the rates at which sediment is supplied upstream and the distribution of sediment loads also affect loadings of suspended sediment (CALFED, 2003). The upper Sacramento River contributes little coarse sediment from erosion because these sediments are bound by erosion-resistant bedrock and terrace deposits (The Nature Conservancy 2006). Substantial quantities of sediment are detained behind dams on the Sacramento River and its tributaries. As a result, the amount of suspended sediment and correlated mercury levels in the Sacramento River is trending down (Wright and Schoellhamer 2004).

2.10.7 Sacramento-San Joaquin Delta

Although the Delta is an exceptionally productive agricultural area, its unique value to the rest of the State is as a source of freshwater. The Delta receives runoff from about 40 percent of the land area of California and about 50 percent of the State’s total streamflow. It is the heart of a massive north-to-south water-delivery system with giant engineered arterials transport water southward. State and Federal contracts call for export of up to 7.5 MAF per year from two huge pumping stations in the southern Delta near the Clifton Court Forebay. About 83 percent of this water is used for agriculture and the remainder for various urban uses in central and southern California. Two-thirds of California’s population, more than 20 million people, get at least part of their drinking water from the Delta.

The Delta always has been at the mercy of river flows and brackish tides. While the Delta ecosystem evolved around this fresh/salty cycle, the need to keep the Bay’s brackish water away from the rich Delta soils and local farms was seen as essential. The discussion of Delta salinity often invokes “X2,” the distance in kilometers from the Golden Gate Bridge to the point where the salinity about one meter (3.3 feet) from the bottom is about 2 parts per thousand (ppt) and is the basis for standards to protect aquatic life (seawater salinity is about 35 ppt).

In addition, EPA assessed the progress of implementing 14 TMDLs in the San Francisco Bay Delta Estuary (the Delta) to determine if the actions called for in the TMDL were being accomplished and water quality was improving. TMDL implementation refers to completing required TMDL actions, achieving load limits, and removing water quality impairments. These TMDL implementation assessments were called for in the EPA San Francisco Bay Delta Action Plan (August 2012) to "…improve accountability and help align grant and program activities to ensure timely achievement of load limits and removal of impairments."

TMDLs chosen for evaluation address several aquatic life stressors including low dissolved oxygen, pesticides, selenium, and mercury. The first three of these contaminants and stressors are considered potential contributors to sharp declines in resident and migratory fish populations observed early in the 21st century and low population numbers observed today. Mercury TMDLs were also evaluated because minimizing methylmercury production is essential for protecting public health, aquatic life, and aquatic-dependent wildlife.

All 14 TMDLs are being actively implemented and many milestones are being achieved. Eight of the TMDLs evaluated show that water quality conditions are improving or targets have been achieved. However, aquatic life beneficial uses continue to be impaired by contaminants and stressors despite these important water quality improvements. In general:

- Concentrations of two pesticides (diazinon and chlorpyrifos) have been substantially reduced in the Delta Watershed; however, newer classes of pesticides are causing aquatic toxicity in these waterways.
- Selenium load reductions have resulted in selenium concentrations that meet either final or interim TMDL targets in Salt Slough and the lower San Joaquin River while selenium concentrations continue to exceed the water quality objective in the Grasslands Marsh.
- Dissolved oxygen conditions have improved in the Stockton Deep Water Ship Channel, but are not yet consistently meeting water quality goals for protecting migratory fish.
- Mercury TMDLs are being implemented, however mine remediation actions and developing new methylation reduction technologies are solutions that require decades before mercury concentrations in fish tissue would achieve water quality goals.

2.11 Air Quality

2.11.1 Sacramento Valley Air Basin

The Sacramento Valley Air Basin (SVAB) is located within both the Sacramento and San Joaquin Valleys and portions of the Sierra Nevada foothills. With respect to water resources, the SVAB encompasses the Sacramento and San Joaquin Valley Watersheds. The SVAB is relatively flat, bordered by the North Coast Ranges to the west and the northern Sierra Nevada to the east. Air flows into the SVAB through the Carquinez Strait, the only breach in the western mountain barrier, and moves across the Delta from the San Francisco Bay Area Air .

Summer high temperatures are hot, often exceeding 100 degrees Fahrenheit . Winter temperatures are cool to cold, with minimum temperatures often dropping into the high 30s. Most of the precipitation occurs as rainfall during winter storms. Also characteristic of the SVAB are winters with periods of dense and persistent low-level fog that are most prevalent between storms. Prevailing wind speeds are moderate. The mountains surrounding the SVAB create a barrier to airflow, which leads to the entrapment of air pollutants when meteorological conditions are unfavorable for transport and dilution. Poor air movement occurs most frequently in fall and winter when high-pressure cells are present over the SVAB. The lack of surface wind during these periods, combined with the reduced vertical flow because of less surface heating, reduces the influx of air. Surface concentrations of air pollutants are highest when these conditions combine with agricultural burning activities or temperature inversions, which hamper dispersion by creating a ceiling over the area and trapping air pollutants near the ground.

May through October is ozone season in the SVAB. This period is characterized by poor air movement in the mornings and the arrival of the Delta sea breeze from the southwest in the afternoons. Typically, the Delta breeze transports air pollutants northward out of the SVAB; however, a phenomenon known as the Schultz Eddy prevents this from occurring during approximately half of the time between July and September. The Schultz Eddy causes the wind pattern to shift southward, causing air pollutants that have moved to the northern end of the Sacramento Valley to be blown back toward the south before leaving the valley. This phenomenon exacerbates concentrations of air pollutants in the area and contributes to violations of the ambient air quality standards (Solano County 2008:4.2-1 through 4.2-2).

Air quality within the SVAB is regulated by the Shasta County, Butte County, Feather River, Sacramento Metropolitan, and Yolo-Solano air quality management districts; and by the Tehama County, Glenn County, and Colusa County air pollution control districts.

2.11.2 Lake County Air Basin

The Lake County Air Basin (LCAB) is located within the North Coast Ranges. Like the SVAB, the LCAB includes portions of the Sacramento and San Joaquin valleys and Sierra Nevada foothills. Winds are generally light because of the sheltering effect of surrounding mountains with predominant winds from the northwest, particularly in summer (Lake County 2010:5.3-1). Air quality within the LCAB is regulated by the Lake County Air Quality Management District.

2.11.3 Mountain Counties Air Basin

The Mountain Counties Air Basin (MCAB) is located within both the Sacramento and San Joaquin Valley and foothills and the Sacramento and San Joaquin Valley Watersheds. The MCAB is an area of approximately 11,000 square miles that encompasses Amador, Calaveras, Mariposa, Nevada, Plumas, Sierra, and Tuolumne counties, as well as portions of El Dorado and Placer counties. Most of the MCAB is located in the northern Sierra Nevada, although the western boundary of the MCAB extends into the Sacramento Valley. The temperature variations have a substantial influence on wind flow, dispersion along mountain ridges, vertical mixing, and photochemistry within the MCAB. Air quality within the MCAB is regulated by the Northern Sierra, El Dorado, and Calaveras County air quality management districts; and by the Placer County, Amador County, Tuolumne County, and Mariposa County air pollution control districts.

2.12 Cultural Resources

2.12.1 Existing Conditions

“Cultural resources” describe several different types of properties: prehistoric and historic archaeological sites; architectural properties such as buildings, bridges, and infrastructure; or traditional cultural properties and sacred sites. “Artifacts” include any objects manufactured or altered by humans.

Prehistoric archaeological sites date to the time before recorded history, and in this area of the United States, sites are primarily associated with Native American use before the arrival of European explorers and settlers. Archaeological sites dating to the time when these initial Native American-European contacts occurred are referred to as *protohistoric*. Historic archaeological sites can be associated with Native Americans, Europeans, or any other ethnic group. In the project area and surrounding area, these sites could include the remains of historic structures and buildings.

National Register of Historic Places Evaluation Criteria

Structures and buildings are considered historic when they are more than 50 years old or when they are exceptionally significant. Exceptional significance can be attributed if the properties are integral parts of districts that meet the criteria for eligibility for listing in the National Register of Historic Places (NRHP) or if they meet special criteria considerations.

The criteria applied to evaluate properties for listing in the NRHP (36 C.F.R. § 60.4) are outlined below:

The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and

a) *That are associated with events that have made a significant contribution to the broad patterns of our history; or*

b) *That are associated with the lives of persons significant in our past; or*

c) *That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or*

d) *That have yielded, or may be likely to yield, information important in prehistory or history.*

Meeting one or more of the criteria for eligibility is not enough to determine a resource as eligible for listing in the NRHP. In order to meet eligibility, a resource must have also retained a majority of the integrity considerations.

Prehistory Sacramento Valley Residents

In late prehistoric times, no fewer than five ethnic groups occupied parts of the Sacramento Valley. The Patwin held the southern end of the Valley, mostly west of the river, from the area of Princeton south to San Pablo and Suisan Bays. The eastern Valley between modern Sacramento and Marysville was the domain of Valley Nisenan. North of the Nisenan on the eastern valley floor and in the foothills east of Chico and Oroville were the Konkow, and the River Nomlaki lived to the west between Cottonwood and Toomes Creeks. The upper Sacramento drainage north of Cottonwood Creek was inhabited by the Wintu (Moratto, 1984).

2.12.2 Cultural Resource Types

The Historic Property Treatment Plan developed for the Sacramento River Bank Protection Project, Phase II, Post Authorization Change (Sac Bank) neatly outlines the potential site types likely to be encountered within the project area (ICF 2012, Chapter 3). This information has been excerpted and adapted for use in this CVIFMS Watershed Report.

Prehistoric Archaeological Property Types

Previous studies in the vicinity provide reasonable expectations of the range of prehistoric archaeological property types relevant to CVIFMS. Five prehistoric archaeological site types have been identified and are defined below by their constituents and features.

Midden Sites

Middens in the Sacramento Valley were generally occupation sites, although some may have been used only on a seasonal basis. When deaths occurred, they were often used as burial sites. Midden sites are anticipated to be the most structurally complex and to have the greatest artifact diversity of all the prehistoric property types. They are usually distinguished by a high organic content that causes soil to be noticeably darker, and they can vary greatly in size. This is because they form where people ate and processed shellfish and other invertebrates, fish, birds, sea mammals, ungulates, small mammals, acorns, seeds, tubers, and other food resources. These food sources leave a large amount of debris, which customarily was piled up where the food was processed and eaten. Constituents may include flaked stone debitage, bedrock mortars, ground stone tools, marine shell, vertebrate remains, charcoal, baked clay, charred floral remains, and fire affected rock. Non-utilitarian artifacts also may include charmstones, shell ornaments, and beads. Discrete features, including house floors, hearths, and human burials, also may be located within these deposits (Moratto, 1984; Raven et al., 1984)

Isolated Burials and Burial Complexes

Burial features can range in complexity from a simple isolated inhumation to more elaborate interments containing numerous bodies. These features may represent specially designated interment areas or remnants of larger archaeological sites. Burial associations often include Olivella beads, Haliotis ornaments, and ground and polished stone artifacts, such as charmstones and plummets.

Lithic Scatters

Lithic Scatters are collections of flaked and/or ground stone debris, including tools and debitage that relate to post-quarry reduction and tool manufacturing efforts. They are perceived primarily as daily or overnight task oriented camps where a limited range of activities was conducted. These sites may or may not contain chronological information, depending on the presence and quantity of diagnostic items such as projectile points and pottery, or dateable materials such as obsidian. Lithic scatters can be perceived as simple, containing only flaked stone debitage and tools, or complex, having primarily flaked stone but some ground stone as well.

Bedrock Milling Features

Bedrock Milling Features are typically bedrock mortars and/or milling slicks. Milling features can be isolated or can be grouped together in a cluster. These features were used for processing vegetal resources such as acorns and other seeds. Because of a dearth of exposed bedrock in the Central Valley, milling features are typically associated with the Sierra Nevada foothills, where exposed bedrock is more common. These features often have associated artifacts such as pestles and manos. Flotation analysis of adjacent soils can often identify plant types that were processed at these sites.

Isolated Artifacts

Isolated finds are three or fewer artifacts that occur within a restricted spatial context, generally within an area 10 meters (~33 feet) in diameter. Information potential is usually limited to location, material type, style, and function of the individual artifact, but chronological information may also be available.

Native American Property Types

Native American property types, or traditional cultural properties (TCP), within the Sacramento River watershed are typically associated with resource procurement activities along the waterways of the Central Valley. Such properties derive their significance not from the property itself, but from the social group. Examples of TCPs range from expansive geographic areas such as the Sutter Buttes to individual locations associated with beliefs or practices that are of traditional cultural significance. Examples of TCP types are described under separate headings below.

Plant Gathering

Many Native American Groups gather the same plant resources that have been used by their people for centuries. Some gathered resources are used for subsistence or medicine, but Native Americans and those who currently practice traditional plant gathering focus more on materials for producing baskets and other items. Typical resources gathered for food include acorns, buckeye nuts, wild onion, and wild sweet potato. Resources gathered for other uses include tule, willow, and various native grasses.

Fishing

Fishing played an important role in the lives of Native Americans within the watershed. Some Native American groups still procure fish (particularly salmon) using traditional methods, including weirs, nets, harpoons, and traps. There may be areas where Native American groups still practice these traditional procurement methods within the watershed.

Ceremonial and Sacred Sites

Some areas regarded as sacred by Native American groups are still used for ceremonial purposes. These areas are typically associated with an event or a viewshed of particular importance. Often these are ancient village sites or meeting sites where tribal leaders from the region would gather or sites with views of areas important to their religious beliefs.

Historical Archaeological Property Types

Previous studies in the watershed provide reasonable expectations of the range of historical archaeological property types relevant to the study. These property types are classified here in terms of function. Intensive historic-era use of waterways within the watershed coincides with the discovery of gold in 1848. The sudden influx of fortune seekers resulted in heavy use of waterways within the watershed for transportation of individuals and supplies. To accommodate the surge, cities and towns were established along the rivers. Both small and large scale mining endeavors were carried out within the watershed along the Feather, Bear, Yuba, and American rivers. Agricultural endeavors followed quickly, and overland transportation routes were developed that often paralleled waterways within the watershed. Historical archeological resources within the watershed are mostly related to these events. Five categories of historical archaeological property types have been identified within the watershed and are described below.

Mining Sites

This property type is typically found in the Sierra Nevada foothills and consists of features associated with placer mining, including prospect pits, tailing piles, ditches and adits. There are often associated mining camps of varying size, which can include tent pads and domestic refuse deposits. Large scale hydraulic mining occurred along many rivers and the resulting features form identified historic mining districts.

Building Foundations

Building foundations are typically related to either commercial or residential structures that have been demolished or otherwise destroyed. Foundation materials can include stacked rock, wood, brick and mortar, and concrete. There are often associated structural remains such as plate glass, nails and subterranean wells and privy pits.

Refuse Scatters/Dumps

Refuse scatters can range from a single dumping episode to an established community dump. They may also represent an ephemeral occupation of an area. Associated artifacts include glass bottles and jars, ceramics, metal cans, and other domestic items.

Transportation Related Features

Transportation related features include roads, railroads, and landings for water vessels. Roads and railroad lines were often established on the crown of levees that parallel waterways within the watershed. Public landings were often established for towns, but many were associated with private properties. Landings associated with private property were typically used for loading and unloading of materials and livestock associated with agricultural endeavors.

Water Conveyance Systems

Water conveyance systems consist of both small scale systems, such as ditches, canals, and pumphouse foundations, and large scale systems, such as levees, sloughs, and weirs. Small-scale water conveyance systems are typically associated with irrigation for agricultural endeavors, but they can also be associated with placer mining, particularly in the foothills.

Historic Structure Property Types

Historic structures include several different property types best classified as buildings, structures, and sites. Property types within these classifications can also be classified as a district. A district would contain a high concentration of buildings, structures, and sites united historically or aesthetically. Cultural landscapes include a combination of property types and are typically classified either as a site or district. Previous studies within the watershed indicate a high concentration of historic structure property types.

Buildings

Buildings are defined as being constructed primarily to shelter any form of human activity. Therefore, this property type can include residential, commercial, agricultural, civic, or social buildings. Residential buildings will include single and multifamily residences. Agricultural buildings will include ranch complexes, sheds, barns, and associated outbuildings. Civic buildings may include government buildings such as a city hall or firehouse. Buildings that serve a social purpose can include fraternal/social halls or libraries. Typically these buildings will be associated with the settlement and development of the particular regions.

Structures

Flood protection and irrigation played an important role in the development of each region of the watershed. Structures related to these contexts include levees, weirs, slips, canals/ditches, pumping stations, water towers, and related water conveyance systems. Other possible property types within this category may include roads and bridges.

Sites

Sites are associated with significant historic events or activities. Most often, sites are places that have archaeological or cultural associations. Sites, however, can include natural features and landscapes. Within the watershed, potential sites may include orchards, natural groves of tree, tree allées, and vernacular and rural landscapes.

Cultural Landscapes

Cultural landscapes are classified most often as sites or districts. Within CVIFMS, historic vernacular landscapes or rural landscapes are likely present. Property types that contribute to a cultural landscape may include ranch complexes with a farmhouse, associated outbuildings and circulation paths. Under the context of flood protection and irrigation, it is also possible to have a cultural landscape that includes levees weirs, canals, levee roads, bridges, and agricultural fields/orchards.

Submerged Property Types

Previous studies in the watershed provide reasonable expectations of the range of submerged property types relevant to CVIFMS. These property types are classified here in terms of function because of the wide variation in form. Submerged resources are typically associated with historic-era activities, although there is a small possibility for submerged prehistoric resources. Use of the waterways within the Sacramento River watershed for commercial, military and recreational endeavors has been intensive since the 1840s, resulting, for various reasons, in numerous submerged properties. Previous cultural resources studies within the watershed have identified several submerged property types. Submerged property types include the remains of landings, pilings, and modern and historic vessels (Panamerican Consultants, 2010). Each property type is described below.

Landings

Landings include wooden structures used for docking vessels for loading and unloading people, livestock, and materials. Public landings were often established for towns, but many landings were associated with private property. Landings associated with private property were typically used for loading and unloading materials associated with agricultural endeavors. As overland transportation became more common, use of the waterways declined and landings fell into disrepair, often resulting in their collapse into the water. In many places, only the pilings remain as described next.

Pilings

Pilings were often associated with landings or structures build along the riverfront. Pilings are wood or concrete poles driven into the river bottom to provide support to the associated structure, but they were also sometimes used individually for the mooring of the vessels. Many pilings within the watershed have fallen into disrepair and sunk, although some are still intact and being used for mooring.

Vessels

A wide range of submerged vessels dating from the 1840s to the present can be found within the watershed. The earliest vessel types were typically wooden hulls with metal hardware and included small and large sailing vessels and barges. These vessels were usually associated with commercial endeavors because recreational boating was not common until the 1930s. Wooden barges within the watershed were typically ‘dumb’ barges (i.e., no built in means of propulsion) and were used for transporting produce while tethered to a wind or steam powered vessel (Lydecker, 2010). Steel hulls became more prominent after the 1860s and are typically steamboats, barges, fishing vessels, or military vessels. Modern vessels are most often recreational and are made of fiberglass and wood or steel composite.

2.12.3 The SacBank Project

As the SacBank Project covers a large portion of the watershed, information concerning sites reported for that project is used here to provide illustrations of the number of known sites and the likelihood of encountering sites within the watershed during implementation of the CVIFMS Project. These results and detailed methodologies can be found in *Historic Properties Treatment Plan, Sacramento River Bank Protection Project* prepared for the USACE by ICF International in 2012.

Identified Sites within Sac Bank Project

A total of 642 known cultural resources were identified within the SacBank project area as a result of the records search. Of these, 418 are historic structures and 224 are archaeological sites. Of the 224 archaeological sites, 127 are prehistoric archaeological sites, 67 are historical archaeological sites, and 30 sites contain both historic and prehistoric components (some examples are included in the descriptions of cultural resource types above).

The American River Common Features Project

As part of on-going efforts to clarify and understand cultural resources risk prior to conducting full coverage surveys, the Corps is currently engaged in the creation of a formal model of archaeological site sensitivity for the American River Common Features Project (ARCF). The ARCF project area falls within the larger SacBank and CVIFMS watershed areas. Part of this effort has involved quantifying the specific likelihood that archaeological sites will occur at increasing distances from sources of permanent water.

The working model indicates that archaeological sensitivity drops quickly with increasing distance from water. Though the ARCF data were compiled for a smaller part of the Sacramento River watershed, it is reasonable to expect a generally similar pattern of land use throughout the overall system. The spectrum of linguistic and cultural variability throughout prehistoric California was broad and vibrant, but patterns of adaptation were remarkably consistent between culturally distinct groups, especially in the Central Valley. If we assume that the Area of Potential Effect (APE) for the proposed project would extend no more than 100 meters (~330 feet) from either side of the river, we can divide the total length of proposed project by 70 and multiply that by the probability of encountering a site within 100 meters of the waterway (approximately 0.035). Considering just the SacBank project, with a total proposed length of approximately 20,800 meters (approximately 13 miles), the model predicts that at least 11 prehistoric sites likely would be encountered within the course of the program within construction APEs and that there is a 17% chance of encountering a prehistoric site within any given erosion site. This model does not include the likelihood of encountering historic sites or structures.

The Sacramento River Levee System

Due to hydraulic mining in the Sierra Nevada foothills, severe flooding became commonplace in the Central Valley beginning in the 1850s. In response, private landowners began to construct small levees near their farms along the Sacramento River. These 3- to 4-foot-high levees proved to be ineffective and regularly failed during catastrophic floods. The Federal Swamp Land Act of 1850 allowed for the State to reclaim wetlands through construction of levees. The program, however, was ineffective due to corruption and other problems. In 1864, the state legislature enhanced the power of local levee districts in order to spur more levee construction, though political battles were still being waged over who would control these districts. Through the 1880's and 1890's, local levee districts continued to build levees piecemeal. The Flood Control Act was passed by Congress in 1917. The act required the Corps to work with state governments and local levee districts to construct flood control facilities along the Sacramento River and also authorized the SRFCP, which provided for construction of more levees as well as the Yolo and Sutter Bypasses. The SRFCP resulted in construction of about 1,000 miles of levees, which are part of the Sacramento River Levee System. The program area encompasses part of this system.

The Sacramento River Levee System as a whole has not been formally evaluated. The system is widely recognized by the Federal, State, and local professional cultural resources and historic preservation community as being eligible for listing in the NRHP under Criterion A for the system's role in flood protection of the Central Valley, which led to the expansion of early settlements.

Underwater

Initial analysis of the data collected during dive investigations conducted for SacBank indicates that three sites examined are likely eligible for NRHP status. Additionally, several additional submerged resources may meet eligibility criteria.

2.12.4 Future Without-Project Conditions

As has been discussed above, the waterways of the Sacramento River watershed have a high potential for historic and prehistoric sites alike, and the potential for any single project to adversely affect any of these historic properties is high. Of the 13 individual projects reviewed for the CVIFMS project, five have programmatic agreements in draft or final form to continue compliance under Section 106 of the National Historic Preservation Act; three additional projects have at least one Memorandum of Agreement to resolve adverse effects to specific historic properties; three did not identify an adverse effect to cultural resources, therefore an agreement document was unnecessary; and two are still too early in the feasibility phase to have identified the necessity of an agreement. It can be assumed that a good faith effort has been or will be made to identify historic properties within their respective APE's and that the terms of any agreement document will be completed, including any mitigation to resolve adverse effects resulting from the respective project. The resolution of adverse effects due to one of these projects does not necessarily absolve future projects from additional mitigation from new effects.

Historic properties may also be subject to non-project related effects. These are generally incurred because of natural disasters such as flood, ongoing natural erosive forces, or neglect of the resource. Historic-era property types are more likely to be affected by events that breach the integrity of the levee system such as overtopping, failure of the levees, and underseepage or boils because, for the most part, they are located on the landside of the levee system. These events could completely destroy buildings and structures, as well as undermine foundations. The integrity of prehistoric property types may be directly affected by erosion of the riverbank, overtopping or failure of levees, neglect, flood, underseepage/boils, vandalism, and slumping. Native American property types may be impacted by the above factors as well as ongoing development and loss of natural landscapes. Submerged vessels are likely to be the least impacted by natural events, but routine operations and maintenance as well as dredging and recreational activities may contribute to the degradation of these resources.

In the absence of a project, the likelihood of destruction or degradation of historic property types is likely to be higher when considering effects from flood events including overtopping, failure of levees, slumping, and underseepage. Ongoing erosion due to the nature of the constructed works (e.g., levees and associated features) within the watershed that may be halted or remedied through a project, further endanger archaeological sites. Other effects such as neglect and vandalism would likely occur with or without the project, unless solutions to these problems would be part of a specific project's mitigation of effects.

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3.0 Conceptual Alternatives

3.1 Conceptual Plan Formulation

In a typical feasibility-level study, the six-step planning process would be used to formulate alternatives, evaluate them, compare them against each other and select a single recommended plan for implementation using an existing or proposed USACE authority. In this watershed study, a number of plans were developed at a more conceptual level; but a single, feasibility-level plan will not be selected for implementation. Instead, a prioritized list of potential plans will be compiled and a list of general recommendations will be made to address the watershed-wide issues, which led to the specific planning objectives. The plans identified in this watershed study will not necessarily all be studied further or implemented via a USACE authority.

3.1.1 Development of Management Measures

A management measure is a specific structural or non-structural action that could contribute to the goals of this watershed study, thereby reducing or eliminating of the identified flood risk management, ecosystem and water supply problems identified in the Sacramento River Watershed by the project sponsors (see Section 1.4 *Watershed Problems and Project Goals, Objectives and Constraints*). Per USACE guidance, management measures may address one or more study objectives and are the “building blocks” for conceptual alternatives.

An initial array of management measures was identified during the Federal and non-Federal sponsors’ December 2012 re-scoping Charette #2; the list went through further review and refinement during the USACE plan formulation process over Winter/Spring 2014-2015 at public meetings held in Colusa and Natomas in March 2015 and at a plan formulation public workshop held in Sacramento in August 2015. Table 3-1 lists those measures that have been retained as part of the project, grouped by project purpose.

Table 3-1 CVIFMS Management Measures by Project Purpose

Flood Risk Management	
Bypass upgrades	Widen bypasses
	Create new bypasses
Flow upgrades	Modify weirs
	Optimize operation of weirs
	Automate weir operations
	Remove/modify obstructions
Levee upgrades	Raise/strengthen existing levees
	Build new levees
	Build setback levees
Floodplains improvements	Create/enlarge floodplain storage

	Purchase flowage easements
Dams and reservoirs upgrades	Raise/upgrade existing dams
	Construct new dams
	Re-operate/optimize reservoirs
	Forecast-informed reservoir operations
	Re-allocate storage in reservoirs
Non-structural measures	Coordinated emergency response plans
	Flood recovery plan
	Floodplain management plan
Ecosystem Restoration	
Habitat improvements	Increase shaded riverine aquatic habitat
	Increase riverine aquatic habitat
	Increase riparian habitat
	Increase perennial marsh habitat
	Restore wetlands
	Restore natural bank habitat
In-channel improvements	Recreate channel meanders
	Remove barriers to channel migration
	Remove barriers to fish passage
	Notch weirs
	Low flow channel in bypasses
Floodplains improvements	Reduce slope of banks to connect with floodplain
	Terrace floodplains
	Re-contour floodway
	Extend floodplains/expand floodway
	Set back levees
Other types of improvements	Screen pump diversions
	Remove non-native species
	Re-operate reservoirs
Water Supply	
Dams and reservoirs upgrades	New dams with WS purpose
	Re-operate existing dams to conserve
	Reallocate storage in reservoirs
Other types of improvements	Enhance/increase GW percolation
	Improve existing water conveyance

Flood Risk Management Measures

Following is a brief description of each of the flood risk management measures included in CVIFMS.

Widen Bypasses

This management measure could include widening or expanding the footprint of existing bypasses to increase flood conveyance capacity. It may also require the re-construction and/or re-operation of existing flow control weirs that direct flood flows into the bypasses. This management action could also include sediment removal or vegetation control. Increasing the capacity of certain bypasses could provide opportunities for ecosystem restoration, recreation and agricultural activities.

Create New Bypasses

New bypasses could be created to redirect damaging flood flows away from the existing channels and facilities that currently lack sufficient conveyance. Siting for new bypass construction would take into consideration various parameters such as the topography, local magnitude of the flow that is to be redirected, and potential downstream hydraulic impacts. Creating a new bypass could provide opportunities for ecosystem restoration, recreation, and agricultural uses, and satisfy right-of-way requirements.

Modify Weirs

Aspects of the flood management system are controlled or operated via weirs (both with and without gates) and overflows (such as lowered segments of levees designed to permit overflows at certain stages) to divert flood flows to the bypasses and for irrigation during non-flood season. Weirs could be modified in several ways (e.g., raised, lowered, lengthened; changing the weir sill elevation) depending upon the operation and desired effect. For example, a weir crest could be raised to prevent flows from entering a storage area too early in a flood event, thereby reserving storage space for the storm peak. Alternatively, weirs could be lengthened to pass more flow into a bypass at the same stage, or lowered to divert flow at lower stages. Other modifications could include removal of sediment or debris to improve the intended performance of the weir. Weir modifications could also be designed to provide opportunities to restore ecosystem functions or habitats, reduce operations and maintenance, and improve safety. For example, improvements to weirs could allow greater fish passage, change the flow split, manage sediment deposition or increase the safety of weir operations (floodgates).

Optimize Operation of Weirs

Weir operation could be studied and optimized for maximum operational efficiency resulting in benefits to flood risk management and ecosystem restoration.

Automate Weir Operations

Weirs with gates could be modified to automate the gate operation, which would increase operational efficiency and increase safety by removing the need to open and close the gates physically.

Remove/Modify Obstructions

Increase channel or bypass flood conveyance capacity and efficiency by removing or reducing impedance to flood flows. Removal, modification, or relocation of flow constrictions and hard points can increase overall channel capacity and/or reduce flooding upstream. This could also improve operational flexibility of reservoirs. Specific actions or treatments would depend on the type of flow constriction or hard point. For example, existing bridges that impede flood flows could be removed, replaced, or modified/raised to improve conveyance; new bridges within designated floodways could be constructed to standards that prohibit constraints on conveyance capacity and reduce backwater effects. Dredging and sediment removal could be used to reduce other types of flow constrictions. Marinas or other flow impediments could be modified or relocated to prevent accumulation of debris during floods. Changing the physical features of the conveyance system to reduce flow constrictions could also provide opportunities to restore ecosystem functions or habitats. For example, removing rock revetment, dikes, or other structures in the channel in conjunction with setback levee construction could promote natural erosion and deposition processes and provide opportunities for riparian habitat restoration; wetland, shallow water, or terrestrial habitats could also be established in conjunction with projects to reduce flow constrictions and improve flood flow capacity.

Raise/Strengthen Existing Levees

Levees can be raised by the addition of earthen material or by constructing floodwalls. Raising levees could allow greater flows to pass without resulting in flood damages. Specific actions would take into consideration various factors, including the need to perform a geotechnical evaluation of the structural integrity of the levee for stability and seepage; and land use and corresponding level of safety needs on either side of the levee. Any modification of non-project levees that provide significant benefits or are essential to management of the system would require adoption of these structures as part of the SPFC by the CVFPB and/or the USACE. Levees can be strengthened to improve their integrity by improving the embankment soil properties and geometry to resist slope and seepage failures. Improving a levee’s resistance to slope failure is achieved by enlarging it with new material to widen the top width, flatten steep slopes, or both. Material can be added on the landside of a levee to increase stability by widening the crown and/or decreasing the side slopes. Additionally, material on the waterside can be used in some situations, but is not desired, because of constriction to the waterway. Methods to address seepage include seepage berms, impermeable barrier curtains (slurry cutoff wall) in the levee and/or its foundation, and relief wells and toe drains. Armoring of the landside of the levees is required to improve levee resiliency during overtopping episodes.

Build New Levees

New levees could be constructed along river or bypass reaches to increase the carrying capacity of the existing river channel and to modulate peak flows. By modifying the flow regime, new levees can reduce flood risk. New levees could also be ring levees constructed around small communities and critical infrastructure at risk of flooding. A ring levee is constructed around the area to be protected, isolating it from potential flood waters.

Build Setback Levees

Expanding channel capacity by setting levees back from the main river, tributary or bypass could provide a sustainable approach by increasing flood system performance and reducing levee erosion over the longer term. Assessing setback levees would take into consideration various factors, including existing flood easements; willingness of landowners to participate in the action; site geology and topography, ground foundation; existing transportation features and infrastructure; hydraulic modeling. Setting back levees could provide opportunities for ecosystem restoration, recreation, and agricultural activities, and has the potential to reduce erosion.

Create/Enlarge Floodplain Storage

Floodplain or transitory storage occurs when peak flows in the river are diverted to adjacent, off-stream floodplain areas. Once flow in the river decreases, water in the transitory storage/floodplain area may flow or be pumped back into the river channel. Transitory storage could be attained by flows at certain stages being allowed to overtop a bank and flowing onto adjacent lands (e.g., the project could reduce or notch a levee to the desired overtopping level), by removal of a section of levee to allow flows to flow onto adjacent lands, or could be engineered using weirs and bypasses to direct flows onto adjacent lands. Enlargement of existing transitory storage areas may involve new or modified outfall structures and weirs, or modifications to berms or training dikes to increase the available storage area. Other existing structures may also be suitable for use as transitory storage, such as irrigation canals, which are usually dry during the winter months. There may also be opportunities to establish new transitory storage in existing floodplains or areas that experience frequent flooding. Wildlife refuges and certain types of rural or agricultural lands may be suitable for use as transitory storage. This may necessitate acquisition of flowage or other private or public easements. Transitory storage areas may also be built into multi-stage setback levees or widened levee corridors. This new, likely temporary, storage could also provide opportunities to restore ecosystem functions and habitats. For example, allowing overland flows could: provide water to areas that may not currently receive enough water to sustain quality aquatic habitat; promote natural erosion and deposition processes; and provide opportunities for restoration in riparian, wetland, shallow water or terrestrial habitats. New transitory storage would likely include control facilities such as weirs to control the stage in the river at which the storage begins to operate, and also control the flow rate into the storage area. Existing infrastructure in a new transitory storage area would need to be protected (2010 CVFPP Management Actions Report available here: http://www.water.ca.gov/cvfmp/docs/ManagementActionsReportAppendixA.pdf).

Purchase Flowage Easements

Flowage easements could be purchased on private and/or public lands adjacent to channels to accommodate flood waters, preserve agricultural land and provide water to floodplain habitats. This measure would likely be combined with other measures like removal/reduction of levees or levee setbacks.

Raise/Upgrade Existing Dams

This could include retrofitting a dam to include a new spillway, raising the top of the dam and/or upgrading facility gates and outlet works. These modifications could provide additional flood risk management storage, improve operations and optimize flows. At the same time, it could maintain or increase water conservation storage. The additional storage in the reservoir could be divided between flood risk management and conservation storage, where feasible.

Construct New Dams

A new flood risk management reservoir could be constructed on a stream in a subwatershed that already contains a flood management reservoir; it could be constructed upstream or downstream from an existing flood risk management reservoir; or it could be constructed in a watershed that has no existing flood risk management reservoirs. Constructing a new flood risk management reservoir in any of these locations would provide additional flood management storage to allow better management of flood flows to decrease the probability of releasing damaging flows downstream. The new reservoir could also be designed to provide multipurpose benefits, as applicable.

Re-Operate/Optimize Reservoirs

Changes to the prescribed operation of reservoirs (where feasible) could reduce the frequency, magnitude and impacts of downstream flooding and could enhance the ability to coordinate with Federal, State and local agencies and modify operations to better manage floods, while serving multiple beneficial uses of the system. Objective release schedules could be reviewed and revised, if needed, based on recent data, current watershed conditions, and the latest science. Modifications to increase objective releases could provide more system flexibility and safety systemwide and could decrease the rate and quantity of required reservoir flood allocation for the same design frequency. Decreasing the objective release would have the opposite effect, reducing downstream effects of facilities, but also requiring a larger flood risk management reservation. Climate change, water supply conjunctive use and transitory storage, if not already considered in reservoir operations, could be considered in updated operations and water control manuals. Pre-storage of water would likely be required, as groundwater banks are not able to take water in sufficient quantity to be used during flood operations, and are often already taking water during floods and might not be able to accept additional inflow. With the water stored in a groundwater bank, some of the shortfalls that might result from the increase in flood management storage allocation at a given reservoir could be replaced with water withdrawn from the groundwater bank.

Forecast-Informed Reservoir Operations

Increased flexibility of operations at flood control reservoirs in the Sacramento River Valley could be achieved using advanced forecasting information based on snow accumulations in the basin, basin wetness, runoff forecasts, quantitative precipitation forecasts and climate change information. Implementation would require (1) developing weather forecasting and hydrologic models, and (2) coordinating with reservoir operators, and (3) may require updating existing forecasting technologies. Forecast-informed operations would provide operators with information on potential future reservoir inflows and would allow them to better save the flood management storage for the peak of the storm to help minimize the risk of exceeding river channel capacity. Knowledge of potential future flows and reservoir releases would increase the warning times to communities along the rivers and downstream from flood control reservoirs. Forecast-informed operations could also prevent releases from being made unnecessarily if there is no forecast of rain in the immediate future (i.e., 3-5 days), which could help to conserve water for water supply, where applicable. When levees are removed , the O&M for that section of levee can be eliminated or reduced , lowering the lifecycle costs. Flowage eassements can be written to allow for transitory storage (long residence times) facilitating more groundwater recharge, and the ability to limit the amount of water that is in the main channel during a peak flow.

Re-Allocate Storage in Reservoirs

In cases where a reservoir has dedicated storage for multiple purposes, storage could be reallocated from a given purpose to flood risk management (i.e., reallocate storage space from water conservation to flood risk management). This would have direct negative impacts on the purpose from which the storage space had previously been allocated. Trade-offs between purposes would have to be assessed.

Coordinated Emergency Response Plans

Create updated or new coordinated emergency response plans to ensure coordinated efforts across all agencies with emergency response functions, including USACE, California Emergency Management Agency (CalEMA), FEMA, local agencies or organizations and tribes, to promote the highest level of response possible to the effected communities.

Flood Recovery Plans

Work with USACE, CalEMA, FEMA, local agencies and/or organizations, tribes, and others to: identify all responsible people, agencies, and organizations with disaster recovery roles and responsibilities; detail relevant recovery activities, including levee repair, flood water evacuation, property and infrastructure rehabilitation and recovery of floodplain habitats; establish or describe timelines and protocols for accomplishing recovery activities; and identify all Federal, State, and non-governmental sources of potential disaster assistance funding, both general and flood-specific.

Floodplain Management Plans

Updated or new floodplain management plans could be created, and could include floodplain mapping and delineation. Updated mapping would facilitate pre-planning response options to foreseeable breach scenarios, or typical levee problem scenarios, which would expedite response at the time of the flood.

Ecosystem Restoration Measures

Increase Shaded Riverine Aquatic Habitat

Restore appropriate areas with shaded riverine aquatic cover defined as follows (USFWS, 1992):

> *"...the unique near-shore aquatic area occurring at the interface between a river (or stream) and adjacent woody riparian habitat. Key attributes of this aquatic area include (a) the adjacent bank being composed of natural, eroding substrates supporting riparian vegetation that either overhangs or protrudes into the water, and (b) the water containing variable amounts of woody debris, such as leaves, logs, branches and roots, often substantial detritus, and variable velocities, depths, and flows."*

Increase Riverine Aquatic Habitat
Restore in stream habitat for native species. This measure refers to actions such as placement of large woody materials, creation of run and riffle complexes or gravel placement (https://www.grad.unizg.hr/_download/repository/Management_and_rehabilitation_of_reparion_land.pdf).

Increase Riparian Habitat
Restore appropriate lands between riverbanks or streambanks and adjacent uplands to riparian habitats, generally in frequently inundated floodplains. Vegetation for this measure would include to forest, woodland and scrub vegetation which are characteristic of riparian areas in the Sacramento River Valley (Sawyer et. al 2009 and Vaghti and Greco, 2007).

Increase Perennial Marsh Habitat
Restore appropriate areas with perennial marsh habitat, which consists of vegetation that generally occurs in perennially and intermittently flowing reaches of a channel. Freshwater emergent marshes are dominated by large, perennial herbaceous plants, particularly tules and cattails (Draft Conservation Strategy, 2015).

Restore Wetlands
Restore appropriate areas with wetlands. Seasonal wetlands are generally located in the ephemerally flowing reaches of the channel. Floodplains often support extensive areas for seasonal wetlands that dominated by herbaceous plants (Draft Conservation Strategy 2015). The bypass system of the lower Sacramento River offers extensive opportunity for wetland habitat improvements.

Restore Natural Bank Habitat
Restore appropriate river bank areas with riparian vegetation that provides terrestrial and aquatic fauna habitat, food, access to water, and refuge from predators and extreme weather and can act as a corridor for wildlife to pass from one area to another. Natural bank habitat can also provide habitat for in-stream life (flora and fauna). For example, exposed roots on undercut banks can be used as spawning habitat for fish (https://www.grad.unizg.hr/_download/repository/Management_and_rehabilitation_of_reparion_land.pdf).

Re-Create Channel Meanders
Re-create channel meanders that have been straightened to increase natural meanders and lateral bed and bank of the channel. This will provide additional aquatic habitat and additional flood storage capacity. Typically, re-creating channel meanders requires an increased footprint to provide the channel room to meander. Thus, potential conflicts with existing land uses, local zoning regulations, local economies, private property rights and water rights must be considered.

Remove Barriers to Channel Migration
This measure could include reconnecting historical floodplains by removal or modification of embankments, levees, or other features that prevent flood flows from

entering adjacent floodplains (e.g., lowering levee crowns to permit overflows at certain flood stages, constructing weirs or other features to control the passage of flood flows into adjoining floodplains, or removing embankments completely).

Remove Barriers to Fish Passage

This measure could include installation of fish ladders at existing obstructions (e.g., weirs) or removal of the structures that act as barriers.

Notch Weirs

Modify weirs by adding a notch, such as a low flow notch that would concentrate flows, usually at low flows. This type of fish easement produces a concentrated plume of water and is particularly suitable for salmonids. The notch will allow the upstream river bed to re-align itself gradually (http://www.wildtrout.org/sites/default/files/library/Obstructions%20information%20paper%2020082013.pdf).

Low-Flow Channel in Bypasses

Bypasses could include a low-flow channel to allow passage and egress of entrained fish.

Reduce Slope of Banks to Connect Within Adjacent Floodplains

This measure could include grading banks to gentler slopes to allow for restored hydrologic connections and to create shallow water habitat, reduce erosion, stabilize banks and to allow riparian and aquatic habitats to form more naturally.

Terrace Floodplains

Recreate fluvial terraces that flank the sides of the channel and/or floodplain.

Re-contour Floodway

Re-contour land within the floodway to increase the frequency of inundation for floodplain habitats such as wetlands.

Extend Floodplains/Expand Floodway

This measure would include expansion of a channel for conveyance in times of flood and for restoration of floodplain habitat.

Set Back Levees

Construct a new levee(s) set back from the channel and/or from the existing levee(s) to allow more area for the river to meander and for flood flows to pass. This would allow more area for riverine and floodplain habitats to establish, while at the same time improve flood risk management.

Screen Pump Diversions

Place on-stream fish screen structure(s) at stream diversions to prevent fish entrainment and mortality.

Remove Non-Native Species

Restore natural habitats by active means such as planting native trees and shrubs and removing invasive/exotic plants and animals. Active restoration is necessary as a measure to reduce the potential for the spread of invasive species, reduce the seed predation and girdling of young trees by rodents, reduce browse pressure from herbivores (plant eaters), and reduce the amount of erosion from exposed areas. This measure would likely also include padding or improving existing O&M activities to employ best management practices for invasive species management and allows for adaptive management.

Re-Operate Reservoirs

Coordinate with ecosystem managers to discern ways in which ecosystem processes can be better supported by non-emergency reservoir operations, while still managing storage space for necessary water supply and flood risk management. The releases could be planned to optimize the duration, timing, magnitude and frequency of flows needed to sustain viable ecosystems and the inundation of floodplain habitat connected to streams within the flood system. Changes in releases would also accommodate necessary flood maintenance requirements. Channel maintenance may benefit from flushing flows, which could assist with vegetation management and snag removal, while also serving ecosystem needs. State and Federal recovery goals for fish species in plans for altering flow regimes could be integrated into updated operations.

Water Supply Measures

New Dams That Includes Water Supply Purpose

Construction of a new dam(s) would also include water supply as an approved purpose.

Re-Operate Existing Dams to Conserve More Water

Water supply conjunctive use and transitory storage, if not already considered in reservoir operations, could be considered in updated operations and water control manuals. Pre-storing of water will likely be required, because groundwater banks are not able to take water in sufficient quantity to be used during flood operations and are often already taking water during floods and might not be able to accept additional inflow.

Re-Allocation of Storage in Reservoirs

Space in reservoirs could be re-allocated to water supply if the space is no longer needed for its original purpose or if water supply is found to be a higher and better purpose. For example, space can be re-allocated from hydropower or flood risk management to water supply.

Enhance/Increase Groundwater Percolation

Increase the surface flows available from storms that can be percolated into groundwater basins by means such as slowing flows that can be captured by off-takes to spreading basins or injections wells or by increasing retention time of water over floodplain areas that have permeable soils over groundwater basins to promote infiltration.

Improve Water Conveyance System
The existing water conveyance system could be enlarged and/or improved; this could include levee earthwork, set back levees, and channel dredging as well as intake, siphon and operable gate components, etc. (California Water Plan Update, 2009)

3.1.2 Opportunity Areas and Screening Criteria

The large watershed planning area was divided into 50 opportunity areas within which measures could be applied and would have independent benefits and costs (Figure 3-1, and Attachment C. CVIFMS Map Book) 49 of the 50 opportunity areas are within the Sacramento River valley, while the 50th area encompasses the entire outer watershed area. These opportunity areas are consistent with the State's planning areas and the planning areas used in Comp Study.

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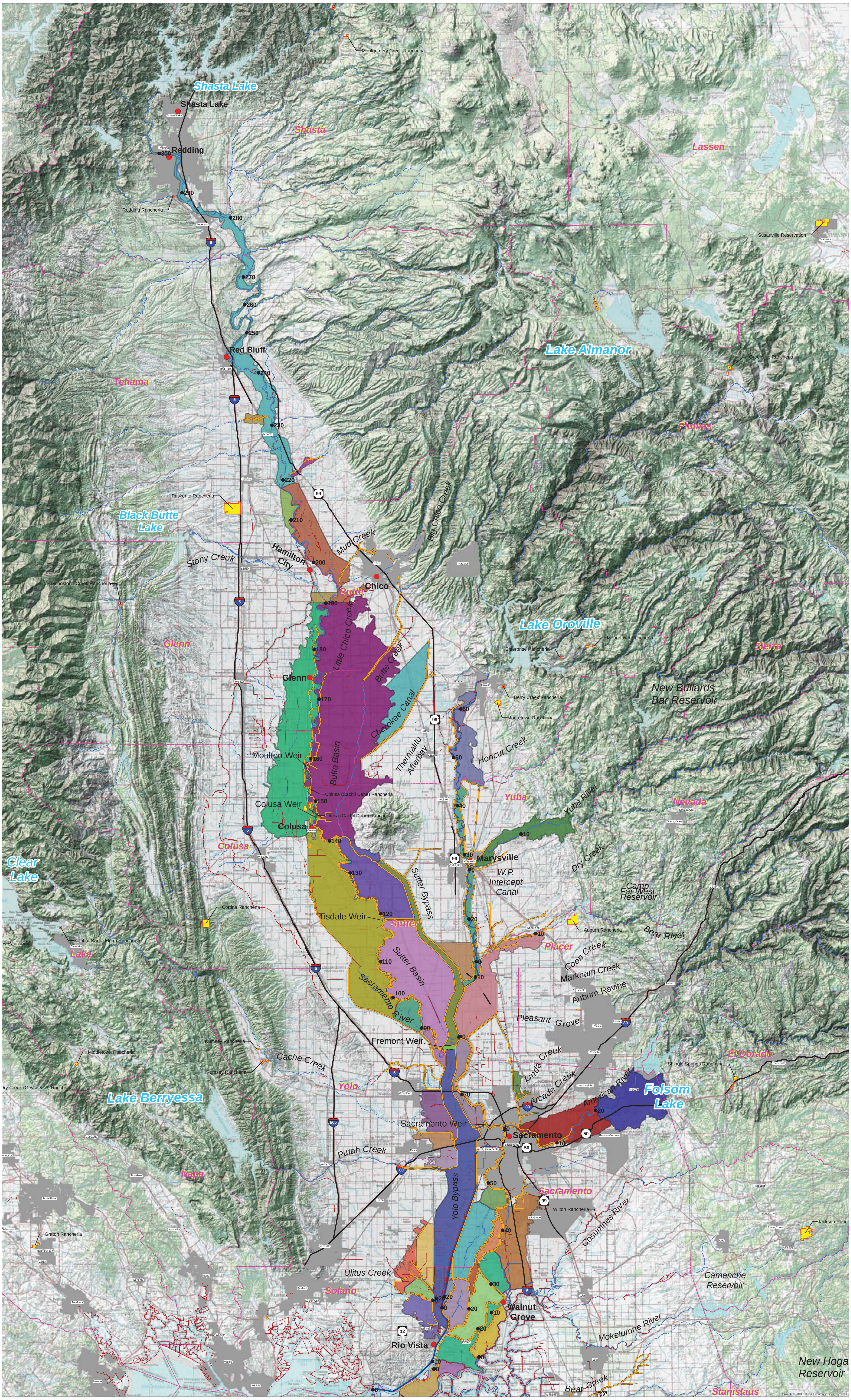

Legend
- River Miles 10 Markers
- Federal Levees
- Non Federal Levees
- Weirs
- SacramentoDWSC
- SAC Riversystem
- Cities
- Tribal Lands
- CA Counties

Figure 3-1

CVIFMS PROJECT

Opportunity Areas

0 2.5 5 10 15 20 Miles

N

US Army Corps of Engineers
Sacramento District

Coordinate System: Datum: NAD 1983 CA State Plane II Feet

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Each potential feature (i.e., a measure applied in a specific opportunity area) was scored for effectiveness with a qualitative ranking of high, medium, low or zero based on expert knowledge and judgment. The effectiveness criteria included:

Flood Risk Management

- How well the feature could reduce risks to life safety from flooding,
- How well the feature could reduce the consequences associated with flood risk (with an emphasis on improving system resiliency and increasing the integrity of the flood system),
- How well the feature could reduce risks to critical infrastructure from flooding, and
- How well the feature could encourage wise use of the floodplain.

Water Supply

- How well the feature could increase the availability and reliability of water supply (both groundwater and surface water).

Ecosystem Restoration

- How well the feature could increase the area, quality, connectivity and diversity of significant native aquatic and related habitats,
- How well the feature could reduce barriers to fish passage,
- How well the feature could increase natural dynamic hydrologic and geomorphic processes, and
- Which types of species the feature could benefit: 1) aquatic, 2) avian, 3) terrestrial or 4) all types (zero = no benefit; low = one type could benefit; medium = two types could benefit; high = all types could benefit).

Each feature was also scored for magnitude of cost, with a qualitative ranking of high, medium, low or zero based on expert knowledge and judgment. The cost criteria included:

- The order of magnitude of costs for the feature, and
- The order of magnitude of mitigation that would likely be required for the feature

3.1.3 Screening and Evaluation

Each feature was evaluated against the effectiveness (benefits) and cost magnitude criteria discussed in the previous section. For each criterion, the feature was given a score of high, medium, low or zero. After this was completed and validated through SPK and DWR quality review and input was solicited from stakeholders, the qualitative scores were assigned numerical values as follows (values are the same for Effectiveness and Cost Magnitude Criteria): high=3; medium=2; low=1; zero=0. The effectiveness and cost scores were then combined to provide a relative indicator of efficiency. Once this was complete, each feature had a numerical score “total” by which it could be evaluated and compared to other features. Any features that were found to be technically infeasible or that had costs that were very likely to outweigh their benefits were screened out from consideration in the formulation of conceptual alternatives.

Additionally, a quantitative assessment of federal interest was done for flood risk management. The analysis applied annual exceedance probabilities and equivalent annual damages from the CVFPP without-project condition for all areas except the Sacramento metropolitan area, West Sacramento and Natomas where the CVFPP baseline existing condition is different from the USACE baseline existing condition. The CVFPP models were used in the without-project condition models where possible and logical assumptions and expert judgment were used for the other exception areas (mentioned above). The existing condition damages represent the maximum potential benefit that a FRM project could attain if it were to eliminate all flood risk in a given area. That maximum potential benefit was compared to a range of historic levee costs to build a levee on either one or both sides of the polygon, depending upon the alignment of flood sources with the polygon. The difference between existing conditions damages (potential benefits) and costs was examined to determine the potential for federal interest in FRM. Four scenarios were analyzed, high and low cost for both baseline existing condition and future without-project conditions. See Appendix E for more details.

3.1.4 USACE Formulation Strategies

After the measures for each opportunity area were screened, the retained measures for all opportunity areas were grouped into conceptual alternatives based on several formulation strategies. First, a non-structural flood risk management alternative was formulated. Second, separate single purpose alternatives were formulated for flood risk management and ecosystem restoration.

Single purpose conceptual alternatives fit into one of the following categories:

- Non-structural flood risk management,
- Structural flood risk management,
- Ecosystem Restoration.

Although there are significant water supply problems and opportunities in the watershed, a single purpose water supply alternative was not formulated because water supply is not a main USACE mission. In the western United States, a single purpose water supply mission resides with the USBR. As such, future single purpose water supply projects with a federal nexus should be pursued in partnership with the USBR. USACE could play a supporting role, or could be a joint Federal partner in future projects, if requested by the USBR.

After conceptual single purpose alternatives were formulated, multiple purpose alternatives were formulated by combining the single purpose alternatives.

Multiple purpose conceptual alternatives fit into one of the following categories:

- Flood risk management and ecosystem restoration,
- Flood risk management and water supply, or
- Flood risk management, ecosystem restoration and water supply.

In addition, a locally developed plan (LDP) for flood risk management and ecosystem restoration was included in the conceptual alternatives (including the No Action Alternative). The resulting seven conceptual alternatives are:

0) No Action Alternative,

1) Non- Structural Flood Risk Management (FRM) Alternative includes flood risk management plans and flood recovery plans that include economic and environmental recovery after flood events,

2) Ecosystem Restoration (ER) Alternative includes all of the ER features that remained post-screening,

3) Structural FRM Alternative includes all of the FRM features that remained post-screening,

4) ER and FRM Alternative – This is a combination of Alternatives (2) and (3) above.

4a) CVFPP and the Draft Conservation Strategy (CS) – This is the LDP as submitted by the sponsors, the CVFPB and DWR. It is a combination of the FRM and ER features that were included in the 2012 CVFPP and the Draft Conservation Strategy,

5) FRM and Water Supply (WS) Alternative – This is a combination of alternative (3) and the remaining WS features that remained post-screening, and

(6) FRM, ER and WS Alternative – This is a combination of alternative (4) and the remaining WS features that remained post-screening.

These conceptual alternatives could be pursued at a scale of one opportunity area (smallest scale) or at a scale of the entire watershed (largest scale). For the purposes of this watershed plan, the maximum possible combined score was used (i.e. the largest scale) for comparison of the conceptual alternatives.

Based on the normalized scores for the features, a *benefits value index, a costs and mitigation value index,* and *net value index* (benefits value minus costs/mitigation) were calculated for each opportunity area under all conceptual alternatives. A net relative value score and a ratio of benefit value index to cost magnitude index were also calculated for each conceptual alternative in order to compare alternatives to each other.

Once the relative benefit and cost indices were calculated, a net value index was determined for each conceptual alternative (Table 3-2). It should be noted that the net value index provides only an approximate indication of the relative net benefits for the various opportunity areas and conceptual alternatives. Because the various types of benefits and costs used to calculate the net value index were evaluated qualitatively and comparatively, and were not calibrated to the same monetary scale (i.e., a unit of benefit is not necessarily equivalent in magnitude to a unit of cost), a positive net value index does not necessarily indicate that an alternative would have positive net benefits. Table 3-2 below shows the net value index for all conceptual alternatives.

Table 3-2 Net Value Index

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Opportunity Areas:	***Notes: 1) Any of the alternatives can be done on a scale ranging from 1 opportunity area to ALL opportunity areas; 2) All scores below are raw scores from the features screening, scoring & ranking table**							
Feather River Upper Honcut	0.0	2.9	14.9	12.0	17.8	16.3	12.0	17.8
Feather River Lower Honcut	0.0	2.9	30.9	28.5	35.5	33.5	28.5	35.5
Upper Sacramento	0.0	2.9	5.1	13.2	14.1	5.1	13.2	14.1
Elder Creek Opportunity Area	0.0	2.9	5.3	6.9	8.2	8.2	6.9	8.2
Deer Creek	0.0	2.9	4.5	5.9	7.4	6.0	5.9	7.4
Woodson Bridge West	0.0	2.9	7.7	7.6	10.6	9.2	9.3	10.6
Woodson Bridge East	0.0	2.9	14.5	13.8	17.4	16.0	13.9	17.4
Capay	0.0	0.0	8.0	2.9	8.0	8.0	6.7	8.0
Chico Area	0.0	2.9	7.2	5.8	10.1	10.1	8.4	10.1
Colusa Basin North	0.0	2.9	16.0	9.1	18.9	17.4	16.7	18.9
Butte Basin	0.0	2.9	23.6	21.5	26.5	23.6	23.3	26.5
Cherokee Canal	0.0	2.9	5.2	9.4	9.4	6.7	9.4	9.4
Colusa Basin South	0.0	2.9	20.1	18.1	23.0	21.5	21.9	23.0
Rec District 70-1660	0.0	2.9	13.1	12.9	16.0	14.6	15.2	16.0
Sutter Bypass	0.0	2.9	15.3	12.6	18.2	16.7	17.2	18.2
Tisdale Bypass	0.0	0.0	6.2	5.7	6.2	6.2	5.7	6.2
Rec District 1500	0.0	2.9	16.6	17.0	19.5	18.0	17.0	19.5
Levee District 1	0.0	0.0	13.1	10.4	13.1	13.1	10.4	13.1
Sycamore Slough	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Ditrict 1001	0.0	2.9	8.8	8.6	11.7	8.8	10.5	11.7
Ridge Cut (North)	0.0	0.0	13.7	8.0	13.7	13.7	12.1	13.7

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Elkhorn	0.0	0.0	22.8	18.9	22.8	22.8	18.9	22.8
Rio Linda	0.0	0.0	9.2	6.2	9.2	9.2	7.5	9.2
Rec District 2035	0.0	0.0	14.5	14.3	14.5	14.5	14.3	14.5
East of Davis - North	0.0	0.0	8.1	5.8	8.1	8.1	8.1	8.1
East of Davis - South	0.0	0.0	7.3	5.4	7.3	7.3	7.3	7.3
Putah Creek	0.0	0.0	6.1	2.9	6.1	6.1	5.2	6.1
Yolo Bypass	0.0	0.0	17.8	9.5	17.8	17.8	11.8	17.8
Stone Lake	0.0	0.0	5.2	2.9	5.2	5.2	5.2	5.2
Rec Dist 302	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 999	0.0	2.9	6.6	5.6	10.3	8.1	10.0	10.3
Merritt Island	0.0	0.0	3.8	2.5	4.3	3.4	2.5	4.3
Cache Slough	0.0	0.0	2.7	2.7	2.7	2.7	2.7	2.7
Hastings	0.0	0.0	2.9	3.5	3.5	3.5	3.5	3.5
Lindsey Slough	0.0	2.9	2.9	6.4	6.4	4.9	6.4	6.4
Moore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 551	0.0	1.5	0.0	1.5	1.5	0.0	1.5	1.5
Sutter Island	0.0	0.0	4.3	2.9	4.3	4.3	2.9	4.3
Prospect Island	0.0	0.0	3.2	2.9	3.2	3.2	2.9	3.2
Ryer Island	0.0	0.0	3.2	2.9	3.2	3.2	2.9	3.2
Grand Island	0.0	2.9	1.2	4.5	4.5	3.1	4.5	4.5
Andrus Island	0.0	0.0	2.5	1.3	2.6	2.6	1.3	2.6
Tyler Island	0.0	0.0	2.0	1.2	2.0	2.0	1.2	2.0
Twitchell Island	0.0	0.0	5.9	3.6	5.9	5.9	3.6	5.9
Sherman Island	0.0	0.0	5.2	2.9	5.2	5.2	2.9	5.2
Area between pocket & deep water ship channel (Rec District 302)	0.0	0.0	8.2	8.2	8.2	8.2	8.2	8.2
American River (North Fork)	0.0	0.0	0.0	2.3	2.3	0.0	2.3	2.3
American River (South Fork)	0.0	0.0	4.3	4.8	6.8	0.0	6.8	6.8
Lake Oroville	0.0	0.0	0.0	8.3	8.3	4.3	8.3	8.3
Systemwide Surface Storage	0.0	0.0	0.0	7.8	-28.3	0.0	7.8	7.8
Sacramento River Basin Systemwide Reoperation	0.0	0.0	0.0	2.8	2.8	0.0	2.8	2.8

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Total net value index per alternative at largest scale (all opportunity areas)	**0.0**	**56.6**	**398.7**	**373.6**	**454.8**	**427.1**	**426.3**	**490.8**

Table 3-3 and 3-4 summarize the results; first with all indices results for each alternative, then shown ranked by net value. It should be noted that the value ratio provides only an approximate indication of the relative cost efficiency for the various opportunity areas and conceptual alternatives. Because the various types of benefits and costs used to calculate the value ratio were initially evaluated qualitatively and comparatively, and were not calibrated to the same monetary scale (i.e., a unit of benefit is not necessarily equivalent in magnitude to a unit of cost), a value ratio that is greater than 1.0 does not necessarily indicate that an alternative would be justified.

Table 3-3 Alternatives Scoring Indices Results

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Total benefit index per alternative at largest scale (all opportunity areas)	0	76.1	569.2	598.6	745.5	610.6	667.5	781.5
Total costs index, including mitigation, per alternative at largest scale (all opportunity areas)	0	-19.5	-170.5	-225.0	-290.8	-183.5	-241.3	-290.8
Total net value index per alternative at largest scale (all opportunity areas)	0	56.6	398.7	373.6	454.8	427.1	426.3	490.8
Value Ratio (Benefits index to Costs Index)	0	3.9	3.3	2.7	2.6	3.3	2.8	2.7

Table 3-4 Alternatives Ranked by Net Value Index with Value Ratios

	(0) No Action	(1) Non-Structural	(3) FRM	(2) ER	(5) FRM + WS	(4a) CVFPP + CS (LDP)	(4) ER + FRM	(6) FRM + ER + WS
Net Value Index	NA	56.6	373.6	398.7	426.3	427.1	454.8	490.8
Value Ratio (Benefit Index to Cost Index)	NA	3.9	2.7	3.3	2.8	3.3	2.6	2.7

Alternative 6, which combines FRM, ER and WS measures across the entire watershed, has the highest net value, while Alternative 1, the non-structural alternative, has the highest value ratio. Figure 3-2 provides a graphic illustration of the alternatives' ranking by net value; Figure 3-3 provides a graph of alternatives' ranking by value ratio.

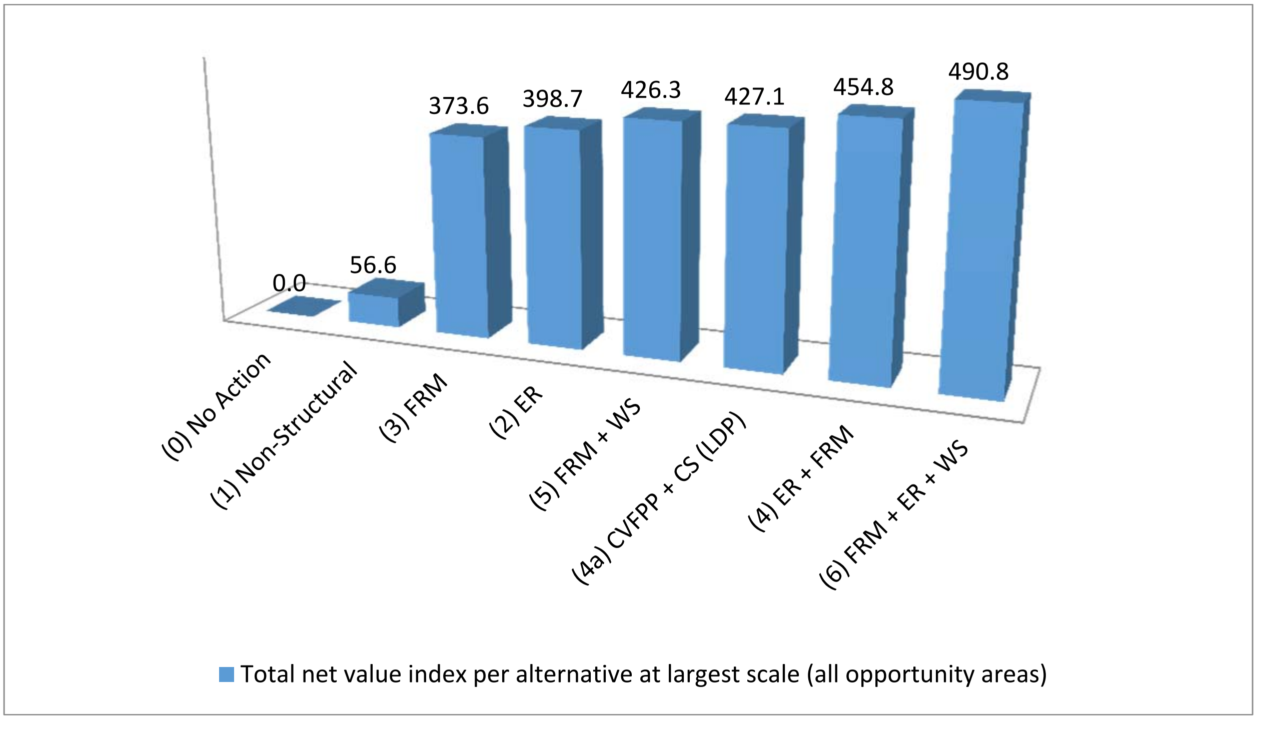

Figure 3-2 Alternatives Ranked by Net Value Index

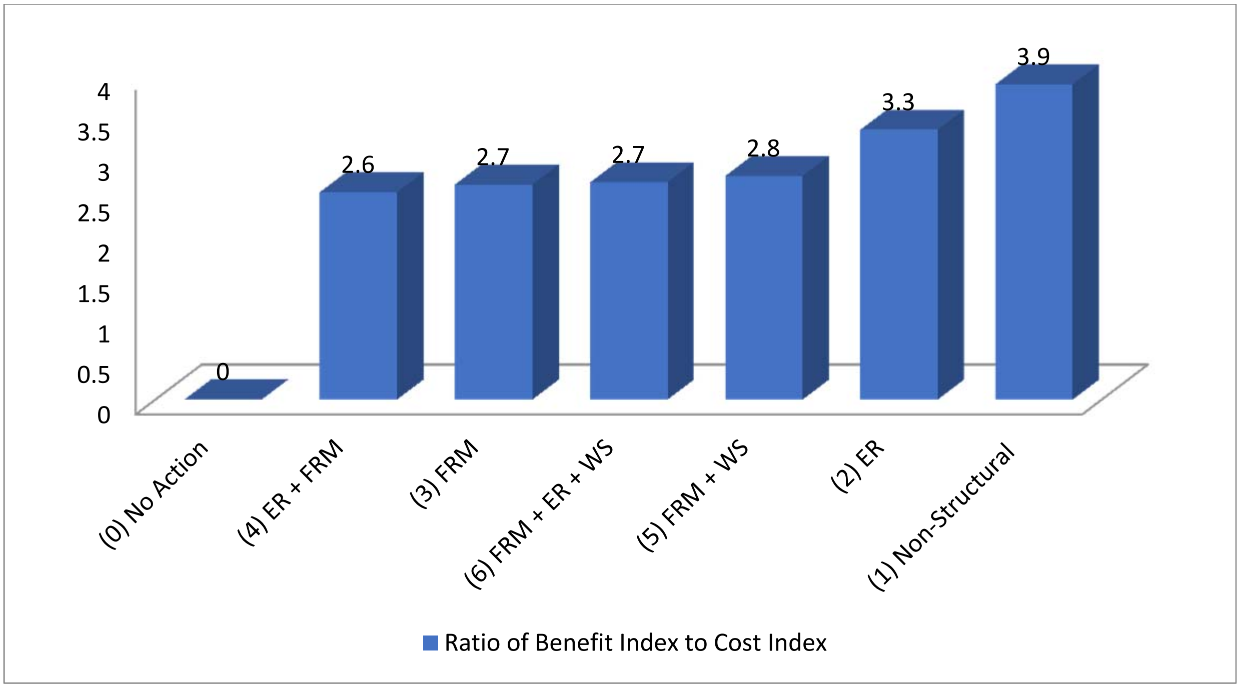

Figure 3-3 Ranking of Alternatives by Value Ratio

No conceptual alternatives were screened out as they all appear to have potential for Federal interest (i.e., had some potential to provide benefits to the nation's economy and/or to nationally significant ecosystems).

See Attachment D *Conceptual Plan Formulation* for more detailed tables and figures from the detailed plan formulation process.

3.2 Implementation/Investment Strategy

The State estimates that between $14 and 17 billion in investments need to be made in the Sacramento River Valley to address the water resources problems and opportunities discussed in Section 1.7 of this report, with between $12 and 14.6 billion of those investments occurring in the Sacramento River Watershed (CVFPP 2012; see Table 3-5 below). Due to the challenges of studying, planning and implementing a suite of projects of that magnitude, projects will need to be implemented in phases, based on where the needs are most urgent and where there is consensus and support for implementation among local groups, regional groups, the State, Tribes and, as applicable, the Federal government.

The State is committed, in partnership with local groups, regional groups, Tribes and the Federal government to continue to make investments in water resources infrastructure and innovation. The most recently approved water bond, the Water Quality, Supply and Infrastructure Improvement Act of 2014, was approved overwhelmingly by California voters to provide $7.545 billion for regional, local and Tribal water resources projects (http://www.acwa.com/spotlight/2014-water-bond). See Figure 3-4 below for a more detailed breakdown of the 2014 water bond.

It is critical that local, regional, Tribal, State and Federal entities work together to strategically plan and implement the needed projects in order to promote efficiency and effectiveness, and to take advantage of synergies, where possible.

Table 3-5 Estimated Costs of State Systemwide Investment Approach ($ Millions)

Region	System Improvements Low High	Urban Improvements Low High	Rural Agricultural Improvements Low High	Residual Risk Management Low High	Total Cost Low High
1 – Upper Sacramento	$109 - $180	$120 - $144	$154 - $168	$95 - $114	$480 – 610
2 – Mid-Sacramento	$234 - $340	$ 0 - $0	$360 - $379	$261 - $333	$860 - $1,050
3 – Feather River	$1,695 - $2,139	$891 - $1,048	$282 - $289	$170 - $212	$3,040 - $3,690
4 – Lower Sacramento	$1,627 - $1,962	$3,549 - $4,283	$77 - $88	$138 - $169	$5,390 - $6,500
5 – Delta North[1]	$754 - $924	$144 - $192	$604 - $634	$266 - $311	$1,770 - $2,060
6 – Delta South[1]	$427 - $549	$0 - $0	$47 - $52	$110 - $135	$580 - $740
7 – Lower San Joaquin	$7 - $8	$626 - $809	$17 - $19	$82 - $97	$730 - $930
8 – Mid-San Joaquin	$60 - $102	$0 - $0	$48 - $55	$81 - $96	$190 - $250
9 – Upper San Joaquin	$229 - $297	$166-$199	$183 - $189	$308 - $396	$890 - $1,080
TOTAL	$5,140 to $6,500	$5,500 to $6,680	$1,770 to $1,870	$1,510 to $1,860	$13,920 to $16,910

Source: [DWR] Central Valley Flood Protection Plan. 2012. Table 3-5. Available at: http://www.water.ca.gov/cvfmp/docs/2012%20CVFPP%20FINAL%20lowres.pdf

Key: SPFC = State Plan of Flood Control

Notes:

1 SPFC Facility costs only

Costs in $ millions. All estimates in 2011 dollars.

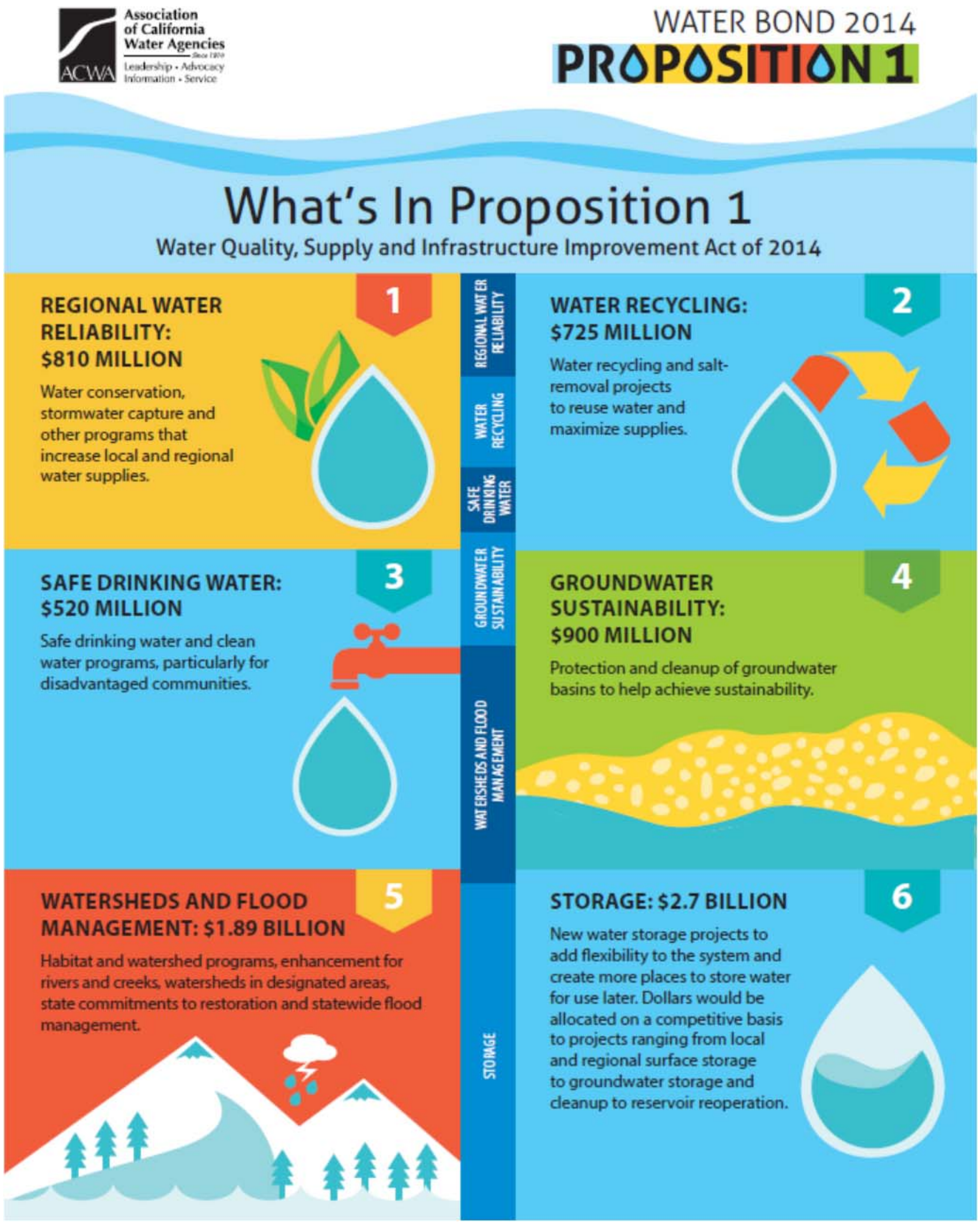

Figure 3-4 Water Bond 2014

Source: http://www.acwa.com/sites/default/files/post/2014-water-bond/2014/09/whats-2014-waterbond_infographic.pdf

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4.0 Other Potential Projects Within the Sacramento River Watershed

This section outlines other project areas within the geographic range and compatible with the conceptual alternatives detailed in Section 3.0. Many of these projects or studies compliment the scope and intent of this watershed study and should be considered for partnering where mission areas are common and other agencies are willing to costshare.

This chapter examines both ongoing studies and proposed studies, as well as projects planned for implementation within the next 5 years. Projects that are likely to be implemented have been identified as part of the without-project future condition described in Section 2.

4.1 Central Valley Flood Protection Plan

As noted earlier, the CVFPP has developed a conceptual system-wide plan to address FRM issues in the Central Valley of California, which includes the Sacramento and San Joaquin River Basins. The CVFPP is a long-range management program to reduce the flood risk within the Sacramento and San Joaquin River Basins, while restoring and protecting riparian and floodplain ecosystems. The CVFPP provides a framework for a management plan that can be effectively implemented and supported by local, State, and Federal agencies. The CVFPP was approved in 2012 and two basin-wide feasibility studies; one for the Sacramento River Basin and the second for the San Joaquin River Basin were initiated to identify specific measures in the State Strategic Investment Approach (the Preferred Alternative). Both basin-wide feasibility studies are to be completed in 2016. The primary recommendation of the 2012 CVFPP was a State System-wide Investment Approach that included a combination of system-wide and regional elements. System elements provide cross-regional benefits and improve the overall system’s function and performance. Regional elements address local and regional needs. The system elements of the Sacramento Basin focused on expansion of the weir and bypass system. The State-led BWFS was initiated to refine the scale and location of the system improvements, integrate environmental conservation with system improvements, and inform the 2017 CVFPP update. The primary focus of the Sac BWFS is of the system elements (e.g., Yolo and Sutter Bypass expansions), and regional elements are only included as part of the future without-project condition. Sac BWFS alternatives (or options) include a variety of sizes, alignments, and magnitudes of these bypass and weir expansions.

The 2017 CVFPP Update will include a recommended investment portfolio of management actions with potential State interest. It will include management actions of all scales (not just the system elements). All projects identified in the six Regional Flood

Management Plans (RFMPs; see discussion in next section) are currently being assessed for potential State interest against multi-objective evaluation criteria and consistency with the State Systemwide Investment Approach. Only a subset of RFMP projects will be included in the recommended investment portfolio, which is currently being determined through a process of assessment and stakeholder engagement. There will not be an alternatives analysis in the 2017 CVFPP Update because the CVFPP alternatives were already described in the 2012 CVFPP and the team is only refining/updating that recommended plan. Once approved by the California Legislature, a design phase will be initiated to finalize the plans.

The State will continue to update the CVFPP towards a 2022 Update. This 5-year cycle will produce updates recommending a portfolio of actions to be financed and implemented. These portfolios will be a combination of local, regional, and systemwide improvements-each with different schedules for design, funding, and construction.

4.2 Regional Plans

As part of the stakeholder outreach for the 2012 CVFPP discussed above, DWR made a call for regional planning groups to assess watershed level issues within nine regions in the Central Valley so as to provide a list of projects that the region would support. Six locally-led RFMPs were developed to identify and refine regional projects and develop a financing plan (See Figure 4-1). DWR provided funding with the intent of assessing if those regional projects would be compatible with the CVFPP and could be incorporated into the State's recommended plan.

The Mid and Upper Sacramento River Regional Flood Management Plan (MUSR RFPM) is a locally-driven assessment of regional flood management issues within the Mid Sacramento River and the Upper Sacramento River Regions (collectively referred to as the Planning Area or Regions). The Mid and Upper Sacramento River regions comprises portions of Butte, Colusa, Glenn, Lake, Sutter, Tehama, and Yolo counties and contain a diverse set of stakeholder groups in urban cities, small communities, and rural areas. The MUSR RFMP is intended to provide the framework for the Regions' vision for managing flood risk, and was developed using local experience, knowledge and expertise. It provides a reconnaissance-level assessment of regional flood risks, and presents a list of short-term and long-term flood risk reduction projects and actions for the Regions.

The Yuba County Water Agency, Three Rivers Levee Improvement Authority, Marysville Levee Commission, and Sutter Butte Flood Control Agency have partnered to develop the Feather River Regional Flood Management Plan. The Plan reflects the flood management priorities of the Feather River Region. The regional plan elements described in this Plan are focused on urban and urbanizing area improvements, small community improvements, rural agricultural improvements, and ecosystem restoration improvements that will achieve regional objectives in a way that will be consistent with DWR and the CVFPB's probable system-wide improvements.

The Lower Sacramento/Delta North planning group focused on a geographic area that includes portions of Solano, Yolo, Sacramento, and Sutter Counties, was developed by FloodProtect, a regional working group comprised of the counties, cities, flood management agencies, local maintaining agencies, water agencies, emergency response agencies, citizen groups, tribes, and other interested stakeholders in the Region.

The three regional planning groups in the Sacramento River Basin submitted an initial list of projects in 2014. DWR has performed an assessment of proposed projects submitted by the regional planning teams within both the Sacramento and San Joaquin River Basins. The hydraulic impacts from such projects may then affect assumptions used to develop both BWFS configurations. The assessment methodology provided a basis upon which RFMP projects can be assessed for their potential to impact basin-wide system hydraulic performance. The criteria used were sufficient definition of the project, capability to model effects of the project, hydraulic significance, and consistency with the SSIA.

The assessment process will be applied equally to all proposed projects. If a project did not meet the criteria at any step in the process, it will be eliminated from being advanced for further assessment. For example, if it was determined that the hydraulic model was not capable of modeling a project, that project would not be assessed for hydraulic significance or SSIA consistency.

Each planning group finalized their Regional Flood Management Plans in late 2014 and contained substantially more projects than can be listed here. However, some of the recommended regional plans may provide additional opportunities for the Corps and non-federal interests to partner in studies outside of the CVFPP/CVIFMS. Figure 4-1 shows the nine regional planning areas.

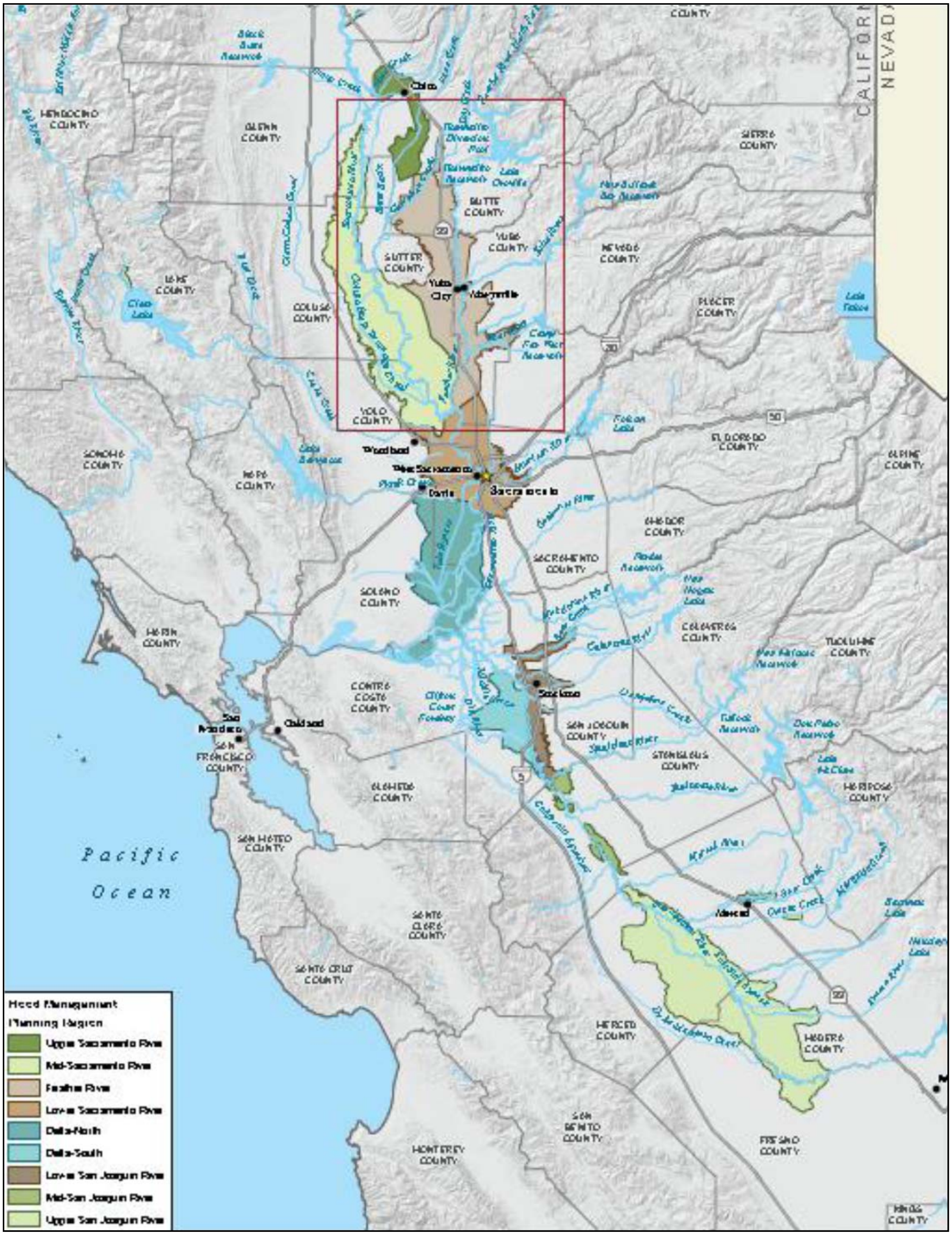

Figure 4-1 Regional Planning Areas

4.3 Bureau of Reclamation

The Sacramento and San Joaquin Basins Study (SSJBS) is a partnership between Reclamation, California Department of Water Resources, California Partnership for the San Joaquin Valley, Stockton East Water District, El Dorado County Water Agency, and the Madera County Resources Management Agency. The Friant Water Authority and the Mountain Counties Water Resources Association have recently joined in the Basins Study process. This stakeholder involvement in the Study will assist in identifying mitigation or adaptation strategies to address negative impacts of climate change.

The Study will assess potential climate change impacts to the Basins' water supplies and demands and will specifically evaluate potential changes to agriculture and urban water supplies, flood protection, hydroelectric power generation, recreation, fisheries, wildlife and wildlife habitats, water quality, and water-dependent ecological systems.

The Study encompasses the entire Central Valley of California with an area of more than 22,500 square miles from the Tehachapi Range in the South to the Klamath Mountains in the north. The Study area includes three major basins which are the Sacramento on the north, the San Joaquin in the central portion, and the Tulare Lake Basin on the south. A portion of the Trinity River Basin in Northern California is also included, due to exports of water from the Trinity River to the Central Valley Project.

No potential projects have been identified at this point in the study.

4.3.1 Central Valley Project Biological Opinions

On June 4, 2009, NOAA's National Marine Fisheries Service issued a biological and conference opinion on the long-term operations of the Central Valley Project (CVP) and State Water Project

(SWP) (NMFS Opinion). The NMFS Opinion concluded that the CVP/SWP operations were likely to jeopardize the continued existence of several federally listed species under NMFS' jurisdiction, and to destroy or adversely modify designated critical habitat.

Since receiving the NMFS Opinion, the Bureau of Reclamation has undertaken studies to assess reasonable and prudent alternatives contained within. The Yolo Bypass Project is evaluating fish passage issues and potential modification of the Fremont Weir. It is also evaluating alternatives for increasing floodplain habitat for salmonids.

USBR and DWR operating under NOAA OCAP BO are conducting evaluation studies to plan and study options to implement fish passage over Shasta Dam. These studies will continue for the forseeable future with a goal of developing a long term solution to providing passage over Shast Dam for winter run salmon. The OCAP Biological Opinion also identifies the RPA to evaluate and study fish passage at Folsom Dam and on the Stanislaus River lead by USBR at their dam facilities. These studies are yet to be initiated by USBR.

The NMFS BO concluded that, as proposed, CVP and SWP operations were likely to jeopardize the continued existence of four federally- listed anadromous fish species: Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the Southern distinct population segment of the North American green sturgeon. The BO set forth a Reasonable and Prudent Alternative (RPA) that allows continued operation of the CVP and SWP in compliance with the federal Endangered Species Act (ESA).

The NMFS RPA includes a Fish Passage Program (Action V) to evaluate the reintroduction of winter-run and spring-run Chinook salmon and steelhead. Action V of the RPA applies to three dams operated by Reclamation: Shasta, Folsom, and New Melones. The near-term goal for Action V is to increase the geographic distribution and abundance of the listed fish. The long-term goal is to increase abundance, productivity, and spatial distribution, and to improve the life history, health, and genetic diversity of the target species.

4.3.2 Central Valley Project Improvement Act

On October 30, 1992, President George Bush signed into law the Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102-575) that included Title 34, the Central Valley Project Improvement Act (CVPIA). The CVPIA amends the previous authorizations of the California Central Valley Project to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses and fish and wildlife enhancement as a project purpose equal to power generation. The CVPIA identifies a number of specific measures to meet these new purposes.

CVPIA's general purposes are to:

- Protect, restore, and enhance fish, wildlife, and asociated habitats in California's Central Valley and Trinity river basins
- Address the Central Valley Project's impacts on fish, wildlife, and associated habitat
- Improve the Central Valley Project's operational flexibility
- Increase water-related benefits provided through expanded use of voluntary water transfers and improved water conservation
- Contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
- Achieve a reasonable balance among competing demands for project water, including requirements for fish and wildlife, agriculture, municipal and industrial and power contractors.

Current projects in the Sacramento River Basin includes fish screens, gravel augmentation, dedicated water flows, and increased fish populations. Nearly 50% of the program goals have been met since initiating restoration actions.

4.4 Bay-Delta Conservation Plan

DWR and several state and federal water contractors, in coordination with Reclamation, have proposed a strategy for restoring ecological functions in the Delta while improving water supply reliability in California. These agencies' initial approach, going back as far as 2006, focused on the development of an extensive conservation plan known as the Bay Delta Conservation Plan, or BDCP, which would add new intakes in the north Delta while at the same time pursuing a very large-scale long-term habitat restoration program within the greater Delta. Under this potential approach, DWR would achieve compliance with the federal Endangered Species Act (ESA) through a habitat conservation plan (HCP) approved by both USFWS and NMFS under Section 10 of the ESA, and would achieve compliance with state endangered species laws through approval by CDFW of a natural community conservation plan (NCCP) prepared under the California Natural Community Conservation Plan Act (NCCPA). Both the HCP and NCCP would provide incidental take authorization for a period of 50 years. Reclamation would achieve compliance with ESA through Section 7 of that Act.

In December 2013, after several years of preparation, DWR, Reclamation, USFWS, and NMFS, acting as joint Lead Agencies, published a Draft Environmental Impact Report/Environmental Impact Statement (Draft EIR/EIS) on the proposed BDCP. This document contained a total of 15 action alternatives, including Alternative 4, which was identified as DWR's preferred alternative. The 14 other action alternatives varied from Alternative 4 with respect to factors such as the number of proposed North Delta intakes, the types of conveyance facilities (e.g., surface canals versus underground pipelines), operational rules, and amounts of proposed habitat restoration. Alternative 4 included three new intakes located in the North Delta and two parallel underground pipelines conveying diverted water to the existing export facilities in the South Delta. The proposed operations for Alternative 4 reflected many years of negotiations between DWR, Reclamation, the water contractors, USFWS, NMFS, and CDFW.

By July 2014, at the end of the public review period, the Lead Agencies had received numerous comments on the proposed BDCP from other agencies and members of the public. Many of these comments included concrete suggestions regarding how, from the commenters' perspectives, the project (i.e., Alternative 4, the BDCP) could be improved. For example, some people urged the Lead Agencies to reduce the level and scope of the construction activities, as well as the sheer size of the proposed facilities, as means of reducing air quality and noise impacts. Other commenters noted that Alternative 4 as then envisioned included substantial amounts of construction activity within Staten Island, which is prime habitat for the greater sandhill crane. Many commenters argued that, because the proposed project would lead to significant, unavoidable water quality effects, DWR could not obtain various approvals needed for the project to succeed (e.g., approval by the State Water Resources Control Board of new points of diversion for north Delta intakes). Yet others suggested that DWR should pursue a permit term shorter than 50 years due to the levels of uncertainty regarding both the future effects of climate change and the long-term effectiveness of habitat restoration in recovering fish populations. Still other comments suggested that the proposed conveyance facilities should be separated from the habitat restoration components of the BDCP, with the latter to be pursued separately.

Consistent with this public input, the Lead Agencies have substantially modified Alternative 4 to reduce its environmental impacts and have formulated new sub-alternatives that would seek incidental take authorization for a period of far less than 50 years, and would include only limited amounts of habitat restoration.

In April 2015 State and Federal agencies announced a new sub-alternative—Alternative 4A (California WaterFix) —which would replace Alternative 4 (the proposed BDCP) as the State's proposed project. Alternative 4A reflects the State's proposal to separate the conveyance facility and habitat restoration measures into two separate efforts: California WaterFix and California EcoRestore. These two efforts are a direct reflection of public comments and fulfill the requirement of the 2009 Delta Reform Act to meet co-equal goals. The comment period for the revised document ends in October 2015.

4.5 Integrated Regional Water Management Planning Program

IRWM is the application of integrated water management (IWM) principles on a regional scale. IWM is a comprehensive and collaborative approach for managing water to concurrently achieve social, environmental, and economic objectives. IRWM was officially embraced by the State of California in 2002 with the passage of the Integrated Regional Water Management Planning Act (SB 1672).

There are 48 IRWM regions across the State, which collectively cover about 87 percent of the State's geographic area and 99 percent of the State's population. As of December 2014, 45 of those regions had adopted IRWM plans that identify regional water management issues; establish water management goals, objectives, and performance measures; define regional governance for IRWM; describe the stakeholder participation processes; and identify projects that provide, or work toward, regional water management solutions.

A corresponding grant funding program has helped local groups with their planning and resulting implementation projects. Through funding from Proposition 50 and 84, DWR has funded 700 implementation projects since 2002. Nine IRWM regions are within the study area. Figure 4-2 depicts the area covered by the specific IRWM plans.

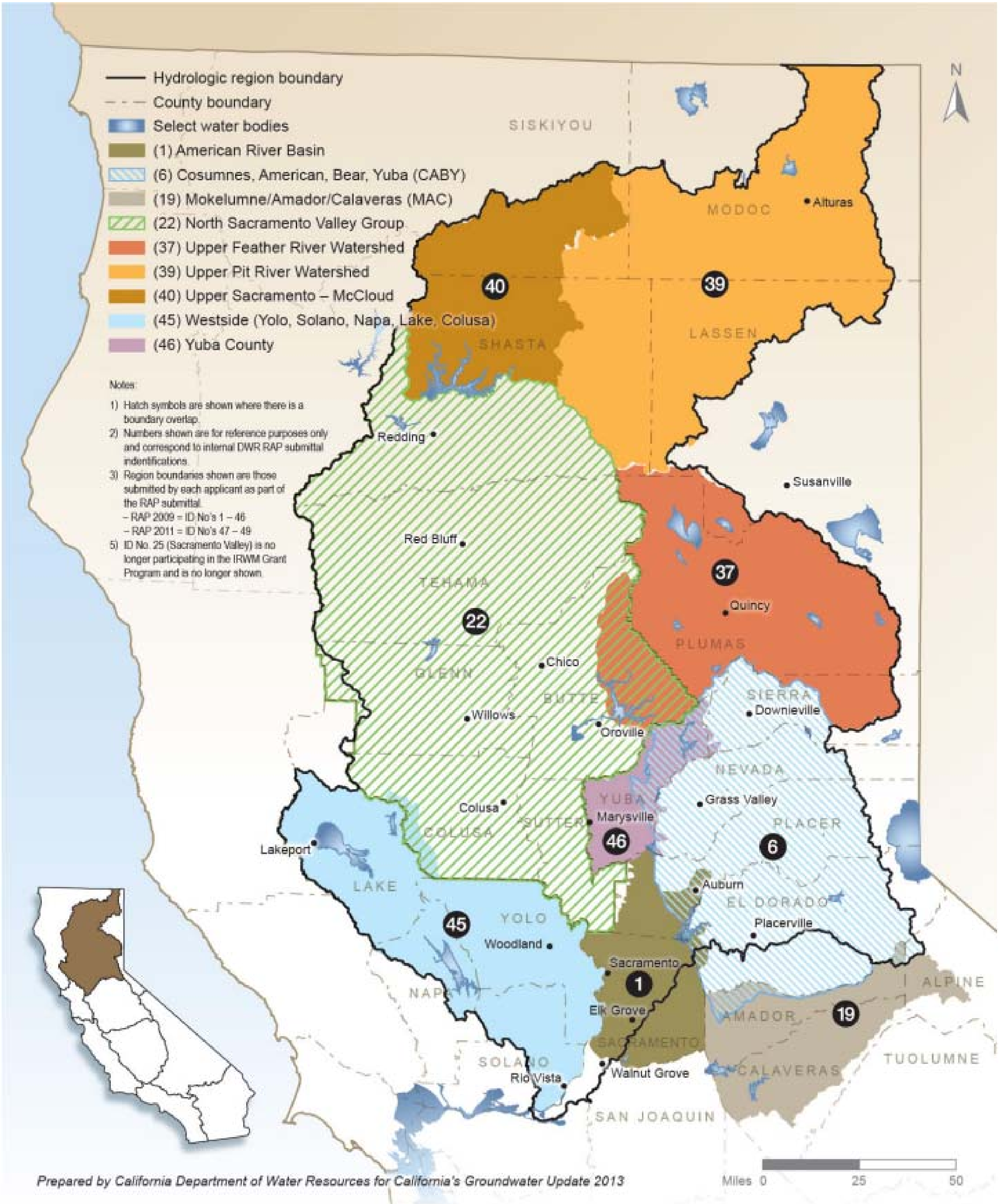

Figure 4-2 Integrated Regional Water Management Plans in the Sacramento River

Source:
http://www.waterplan.water.ca.gov/docs/groundwater/update2013/content/hydrologic_region/GWU2013_Ch7_SacramentoRiver_Final.pdf

4.6 Other Local Plans

The dynamic nature of water management within the Sacramento River Basin makes comprehensive tracking of individual plans and projects extremely challenging. Many actions identified within the Regional Plans noted above may be carried forward even if they are not included as part of the CVFPP 2017 update.

- The Yolo Bypass is currently under investigation by multiple agencies for modifications to increase flood risk management efficiencies and ecosystem restoration opportunities. In addition to those mentioned above, Yolo County has proposed the replacement of the Wallace Weir, an earthen and concrete structure at the mouth of the Knights Landing Ridge Cut and the western levee of the Yolo Bypass, to reduce the need for replacing the earthen portion of the structure on a yearly basis with a modern structure that would allow for more flexible water management.

5.0 Conclusions and Recommendations

5.1 Shared Vision

The Federal and State governments share a vision for an integrated flood management system in the Central Valley to provide for safe, healthy and thriving communities while protecting and restoring the environment. The problem is so overwhelming that achievement of this shared vision can only be through pursuit of mutual priorities. The State's flood risk management priorities of public safety, environmental stewardship and economic stability align with the Federal administration's priorities of protecting the American people, restoring and protecting the environment and improving the nation's economy.

5.2 General Recommendations

There are significant water resources challenges that need to be met over the near and mid-term in the Sacramento River Watershed. The Sacramento River Flood Control Project, which was originally authorized by Congress in 1917 is now being asked to meet the multi-purpose needs and values of today's modern society, including an increased demand for flood risk management benefits to large and small communities as well as agricultural areas, an increased demand on water supply, a changing climate and an increased societal value on protecting and restoring the ecosystem. As such, it is necessary to reinvestigate the existing system to optimize its operation and functionality where possible, and to remove, repair, replace, rehabilitate or upgrade the facilities to reduce the risks and provide benefits to society, as needed. It is also necessary to revise the system to account for the demand and need for integrated water resources management, and to provide benefits of flood risk management, ecosystem restoration and water supply.

Recent flood risk management studies and projects in the watershed delt with localized, critical flood risk issues in areas such as the lower American River and Marysville as interim responses to various existing authorities, but the residual flood risks remaining in the watershed are still potentially catastrophic. Many of the remaining benefits are system benefits that can be accumulated over a wide area by addressing needs with multiple features located across broad areas within the watershed. At the same time, there are needs to improve habitat quality, quantity, connectivity and complexity for nationally significant habitats and species and to meet current and future demand for water supply. With California currently entering its fifth year of a severe drought, water supply for municipal, industrial, agricultural and ecosystem uses is an important issue.

This watershed plan investigates the FRM, ER and WS problems and opportunities in the Sacrament River Watershed. Seven conceptual alternatives were formulated to address the problems and opportunities. They are as follows:

(0) No Action Alternative

(1) Non- Structural FRM Alternative

(2) ER Alternative

(3) Structural FRM Alternative

(4) ER and FRM Alternative

(4a) CVFPP and the Draft CS Alternative

(5) FRM and WS Alternative

(6) FRM, ER and WS Alternative

Based on a qualitative assessment of the relative benefits and costs of the alternatives, it was determined that there is a potential for Federal interest in future projects within any of these conceptual alternatives. In other words, they warrant future study.

5.3 Potential for Federal Interest

As described in more detail in Attachment E, the potential for federal interest in risk reduction measures that benefits a single impact area are limited to a few impact areas in the delta, namely: Andrus (54), Sherman (58) and Grand (50) islands; 2 small communities: Knights Landing (13) and Colusa (08); as well as one urban area, Rio Linda (37). This is largely due to the unpopulated nature of much of the watershed, as well as ongoing FRM studies in most of the urban areas. The potential for federal interest in risk reduction measures benefiting a single impact area is further complicated by 'wise' use of floodplain policies and executive orders that guide FRM plan formulation. Risk reduction measures in the delta islands would likely be contingent upon the planning delivery team demonstrating that any flood risk reduction measure would not lead to land use changes in the historic floodplain. Anticident delta water surface elevation conditions in the without project CVFPP models further mitigates against the without project delta area EADs presented in this report.

The potential for federal interest in risk reduction measures benefiting multiple areas is more promising. The addition or expansion of storage, modifications to weirs and bypasses as well as the reoperation of existing storage and diversion structures may have the ability to reduce peak stages in multiple impact areas resulting in much larger FRM benefits. These benefits may be obtainable in areas where levee improvements and other less systematic projects have been built or are being considered, particularly in the greater Sacramento area where substantial residual flood risks remain.

The potential for federal interest in multi-purpose projects is also substantial. The water supply and ecosystem related water resource problems exist throughout the watershed.

Projects that solve these issues while providing FRM benefits may generate federal interest by defraying the costs associated with each individual project purpose.

5.4 Spin-Off and Off-Shoot Studies

5.4.1 Early Off-Shoot Study

The watershed analysis completed for this plan influenced the recently started Sacramento River General Reevaluation study. Based on recommendations from the watershed assessment, the Sacramento River General Reevaluation will re-vision the flood protection system within the Lower Sacramento River and Sacramento-San Joaquin Delta-North area for improved flood risk management and ecosystem restoration.

5.4.1 Spin-Off Studies

Near-term recommended spin-off studies (under the same authority as this plan) and off-shoot studies (under other authorities) include:

- <u>Climate Change Assessment under USACE Floodplain Management Services authority</u> – USACE should partner with the State, the Institute for Water Resources and potentially other Districts in the region and climate change experts to develop a standard approach for assessing the impact of inland climate change on decision criteria in future studies and projects in this region. The approach is likely to follow the cost-effective, interagency “bottom-up” stepwise process being piloted internationally and by other Federal agencies.
- <u>San Joaquin River Watershed Study (CVIFMS Part II) under General Investigations</u> – The Sacramento River Watershed is only half of the Central Valley; the other half is the San Joaquin River Watershed. The two watersheds meet in the Delta. Originally, both of these watersheds were included in this study, but during a re-scoping of this effort, the San Joaquin River Watershed was recommended to be assessed in a second phase. To come up with a comprehensive plan for water resources management in the Central Valley, it is necessary to complete a watershed assessment for the San Joaquin River Watershed to complement this plan and the CVFPP and Draft CS.
- <u>Central Valley Reoperation Study under General or Special Investigations</u> – The reservoirs in the Sacramento and San Joaquin Watersheds work as and are operated as a system. This study would investigate what more can be done with the existing water infrastructure by taking advantage of the physical interconnections (and enhancing them) while also operating the system in a coordinated manner to optimize the benefits. The current focus of the State’s Systemwide Reoperation Program is the Central Valley, because this region has the highest integration of water supply and flood management facilities. Additionally, the greatest potential for ER through infrastructure reoperation is found in the Central Valley because the existing infrastructure has had a profound effect on aquatic ecosystems. As a first increment, it is important to

determine what FRM, WS and ER benefits can be provided by the existing flood system before recommending construction of new features. The reoperation study would be a comprehensive investigation of reservoirs within both the Sacramento and San Joaquin River Basins (USACE, State, and USBR as partners) to optimize operations for FRM, ER and WS across the system of reservoirs, incorporating weather forecasts and climate change analysis. This is a logical and necessary next step to DWR's Phase I and II reoperation studies (http://www.water.ca.gov/system_reop/). System reoperation has the potential to produce benefits with little to no construction costs.

- <u>Middle and Upper Sacramento River Basin Study under General Investigations</u> - Multi-purpose ER, FRM and WS/conservation study to restore impaired aquatic ecosystems, reduce flood risk to residential and commercial structures and to improve availability and reliability of water supply for ecosystem function, groundwater recharge and municipal and industrial uses. The study will consider sites located within the Middle and Upper Sacramento River Watershed for ER, FRM and WS. The Middle and Upper Sacramento River Basin Comprehensive Study would be a continuation of the Sacramento and San Joaquin River Basins, California Comp Study. In the 1998 House Report 105-190 of Public Law 105-62, Congress provided funding for the study in response to the devastating floods of 1997, directing a comprehensive evaluation of both the Sacramento River and San Joaquin River Basins within the existing study authorities: the Flood Control Act of 1962 (P.L. 87-874), and the San Joaquin River and Tributaries authority (1964 Resolution of the House Committee on Public Works). (Authorization legacy of the House Resolution is the Flood Control Act of 1936 (P.L. 74-738), Section 2 and Section 6; and House Document No. 367, dated October 13, 1949, a Letter from the Secretary of the Army on the Sacramento – San Joaquin Basin Streams, California dated July 27, 1948. The study would complement the Middle and Upper Sacramento Regional Plan and provide an opportunity to partner with both the State and the regional group. The study area would include the Sacramento and Feather Rivers and their tributaries (The Lower Sacramento River-Delta North area is not included in this recommendation as it is being investigated under separate authorities in the Delta Islands and Levees Study and the recently initiated Sacramento River General Reevaluation Study).

Mid- to long-term spin-off and off-shoot studies include:

- <u>Non-Structural Floodplain Management Services Studies</u> – If near term efforts do not include non-structural floodplain management, local sponsors can approach the USACE for projects under the Floodplain Management Services authority. These small-scale, non-structural projects can provide floodplain mapping, floodplain management plans, emergency plans and flood recovery plans. These non-structural actions could provide significant benefits to the affected areas for low cost and effort. Studies such as this may be critical for small communities, agricultural areas and Tribal communities within the watershed where structural flood risk management projects may not be justified.
- <u>Upper American River and Tributaries under General Investigations</u> - Multi-

purpose FRM, WS and ER study (USACE, DWR, and USBR as partners) to reduce flood risk to residential and commercial structures and to improve availability and reliability of water supply for ecosystem function, groundwater recharge and municipal and industrial uses. The study would consider sites along the American River and its tributaries (above Folsom Dam and Reservoir).

- Single-Purpose Ecosystem Restoration Projects under Continuing Authorities Program or General Investigations or Tribal Partnership Program – To restore ecosystem in more localized areas, including on Tribal lands, smaller-scale projects could be pursued in areas such as Clear Lake/Upper Cache Creek, Elder Creek and Deer Creek, among others. These could complement restoration efforts addressed in the larger, near-term projects.

5.5 Other Potential Partnerships

Aside from partnering with local sponsors on civil works feasibility studies, the USACE can also provide inter-agency support to sister Federal agencies, like the USBR or Department of the Interior to assist with water resource projects for which the USACE has an expertise, but is not the appropriate lead agency, as needed and requested. These support projects would be coordinated through the Inter-Agency and International Support program.

Under the Planning Assistance to States authority provided by Section 22 of the WRDA 1974 (P.L. 93-251), as amended, the USACE can provide states, local governments, other non-Federal entities and eligible Tribes assistance in the preparation of comprehensive plans for the development, utilization and conservation of water and related land resources. Studies could include: water supply/demand, water conservation, water quality, ecosystem restoration and dam safety/failure.

5.6 Other Projects and Considerations

The Regional Plans developed as a component of the overall planning effort for the State's CVFPP contain a number of potential actions and projects that are outside the USACE's primary mission areas. However, there are some potential projects that could take advantage of the USACE Continuing Authorities Program (CAP) for study and implementation.

Although the Bureau of Reclamation has a number for studies ongoing as part of the Biological Opinion on the CVP, the USACE has successfully partnered with them as part of the Joint Federal Project at Folsom Dam. If additional alterations to the CVP are warranted outside the requirements of the Biological Opinion, there is some potential for partnering with the USBR in further actions within the system.

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Attachment B. Stakeholder and Sponsor Viewpoints

STAKEHOLDER VIEWPOINTS

Key Takeaways from the public meetings, stakeholder workshops and comments received include:

- "Don't reinvent the wheel." - Over and over again during the early stages of the watershed planning process, the stakeholders made it clear that they did not want this study to do new analyses. A substantial amount of work has been done in this watershed to study the problems and opportunities, and the stakeholders expressed a strong desire that this study use the existing data, analyses, studies and planning documents, including the 2012 CVFPP, the Integrated Regional Water Management Plans, the Regional Plans, the 2013 California Water Plan, the Basin-wide Feasibility Studies, etc.
- Preservation of cultural resources – The Central Valley has many known and unknown sites of cultural and historical significance. Many parts of the flood control system are greater than 50 years old and are listed on the National Register of Historic Places. Tribes and other stakeholders expressed the need for those resources to be preserved and for adverse impacts to them to be avoided, if and when potential water resources projects are implemented in the future.
- Preservation of agriculture – Agriculture has a significant role in the economy and way-of-life of the Central Valley. The agricultural community strongly expressed the desire to preserve agriculture in the Central Valley by providing flood risk management to rural and agricultural areas, by increasing the availability and reliability of water and by ensuring that ecosystem restoration is not placed above or in opposition to agriculture.
- USACE economic calculations - Stakeholders from rural and agricultural communities expressed a concern that the USACE calculations for National Economic Development (NED) are unfair to rural and agricultural communities as they make it very difficult for flood risk management projects to be justified in those areas. There is a desire for the policy on NED calculations to be revised.
- USACE "needs to be at the table more" - Many local and regional stakeholders expressed a desire for the USACE to participate more in local and regional planning groups and meetings. This would require funding for outreach, coordination and collaboration separate from project-specific funds.
- Climate change – Broad sets of stakeholder groups are concerned about climate change and the impacts it is having and will continue to have on the Central Valley and on all of California. California is currently entering the fifth year of a

severe drought in which the snow pack in the Sierra Nevada Mountains has been historically low and in which groundwater wells in several communities in the Central Valley have dried up. Groundwater basins are not being recharged sufficiently, are being overdrawn and related subsidence is occurring. According to NASA's 2015 Groundwater study (Accessible at: http://water.ca.gov/groundwater/docs/NASA_REPORT.pdf):

> "Sinking land, known as subsidence, has occurred for decades in California because of excessive groundwater pumping during drought conditions, but the new NASA data show the sinking is happening faster, putting infrastructure on the surface at growing risk of damage." (Source: http://www.jpl.nasa.gov/news/news.php?feature=4693)

Snow is melting and running off into downstream reservoirs earlier in the season than planned for in most reservoir operation manuals, causing issues for water supply and for cold water flows for fish. Reduced fresh water flows also pose challenges for salinity levels in the Delta, which threaten the water supply and native species. There is an urgent need for the risk and uncertainty of climate change to be incorporated into and accounted for in water resources planning efforts in the Central Valley.

SPONSOR VIEWPOINTS REGARDING USACE POLICY

During the course of this study, the non-Federal sponsor has provided specific concerns with the future of water management in the watershed in light of certain USACE policies and practices. Specifically, the following issues were highlighted:

- Need for streamlined permitting process
- Flexible crediting for work done within the watershed
- Need for recognizing system benefits
- Need for centralized governance
- Need for flexibility in meeting legacy operation and maintenance requirements under current fiscal and environmental constraints

The permitting process throughout construction, operation, and maintenance of projects can be a long, expensive and frustrating experience. Too often, conflicting requirements by various agencies prove impossible to surmount leading to inaction. In the area of operation and maintenance of existing works, this can create additional issues in the future.

The statewide investment in the flood management system in the watershed is substantial and implementation of the preferred alternative of the CVFPP will increase that investment over the next two decades. In an effort to leverage those investments, the non-Federal sponsor is seeking a more flexible system for crediting from the Corps. One example might be where excess funding on one project could be used to credit another project within the watershed. Under current Corps policies, this cannot be accomplished. WRDA 2014, Section 1020 allows the transfer of excess credit to a different study or project, but implementation guidance has not yet been issued by

USACE. The non-Federal sponsor is also investigating advanced mitigation for work done in the watershed for which they would like advanced credit made available for future actions.

Perhaps the largest issue in implementing the strategy of integrated water management within the watershed in partnership with the USACE is the lack of recognition for system benefits outside of NED. Current FRM policies limit USACE financial participation to the level of the NED plan. However, the synergistic benefits of the flood management system are not considered when selecting a plan or identifying Federal participation. The non-Federal sponsor feels that increased value in these system benefits is warranted in the watershed.

Throughout the course of the watershed study, various other agencies have been undertaking studies and implementing projects within the watershed underscoring the need for some form of oversight for water related actions. Although the Flood Board serves as the State of California's oversight for flood related actions in the Central Valley, its mandate does not cover all water activity. The primary purpose for a governance structure would be to efficiently implement projects in a timely and logical manner in the watershed.

This watershed plan does not recommend any solutions for the State's stated issues with policy. Several of the issues are multi-agency in nature and not within the USACE authority to change. The other issues specific to USACE policy are beyond this study to address.

Most of the Sacramento River Flood Control Project was constructed within a rural landscape long before protection of the environment was a fundamental requirement. As the watershed has developed and concern for environmental sustainability has grown, there has been increasing public demand for the Project to meet additional needs beyond flood protection. Most of the operation and maintenance requirements for the Project were established over 50 years ago. Some standard O&M requirements applied uniformly can degrade the ecosystem, conflict with current environmental requirements, or divert the financial resources of small levee maintenance districts from other needs. Recognizing that O&M requirements are intended to safeguard the performance of levees and other features of the flood risk management system, the non-Federal sponsor and local stakeholders seek flexibility in meeting functional criteria for the Project while modifying O&M procedures on a case-by-case basis to reduce adverse environmental effects and financial costs. In some cases, modification of project features may be necessary to allow changes in O&M requirements without diminishing the performance of the flood risk management system.

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Attachment C. CVIFMS Map Book

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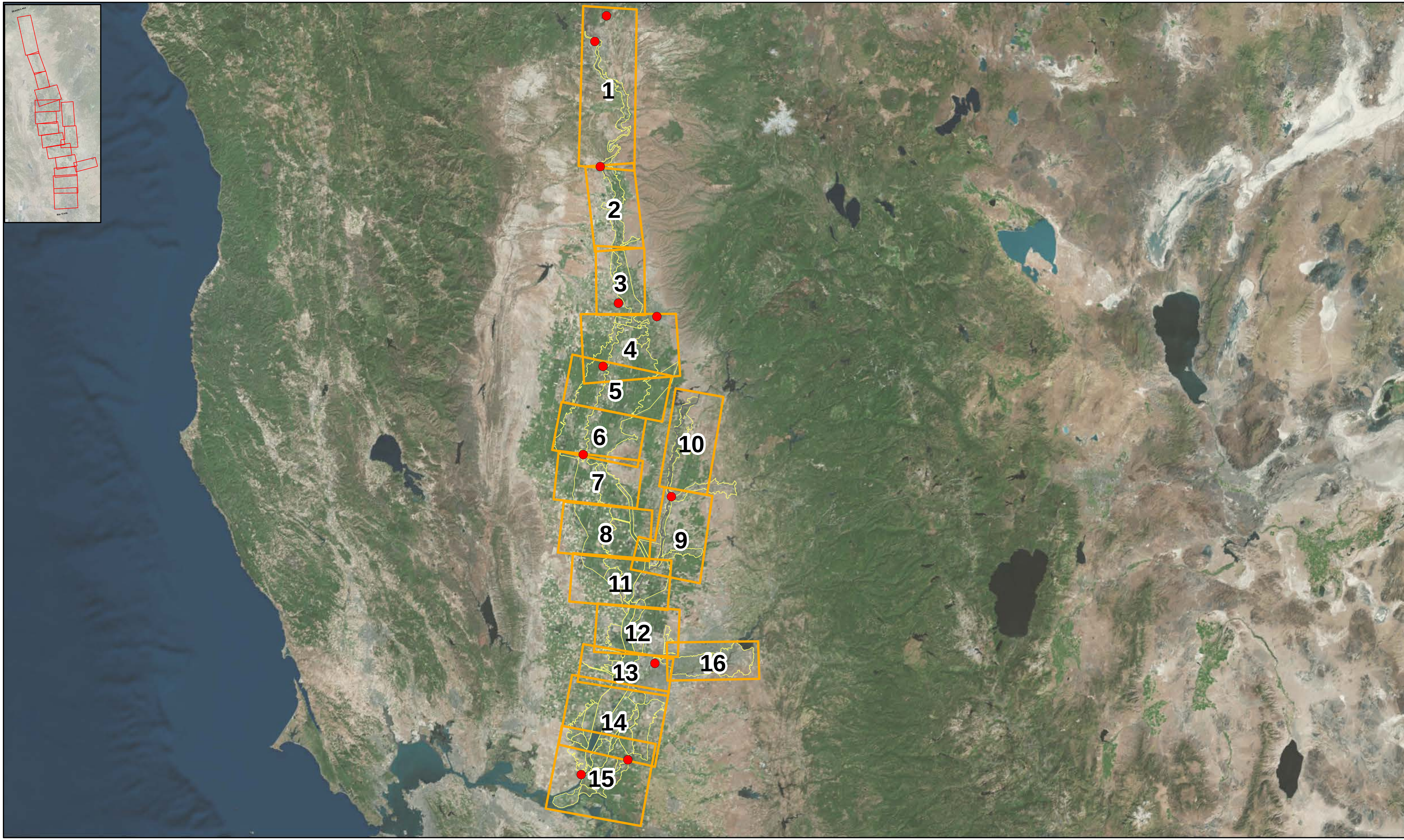

CVIFMS Opportunity Area Map Book

US Army Corps of Engineers®
Sacramento District

N

CA Cities
River Mile
Tribal Lands
Weirs
Sac River System
Federal Levees
Non Federal Levees
CA Counties
Cities

DRAFT

CVIFMS Opportunity Area Map Book

US Army Corps of Engineers
Sacramento District

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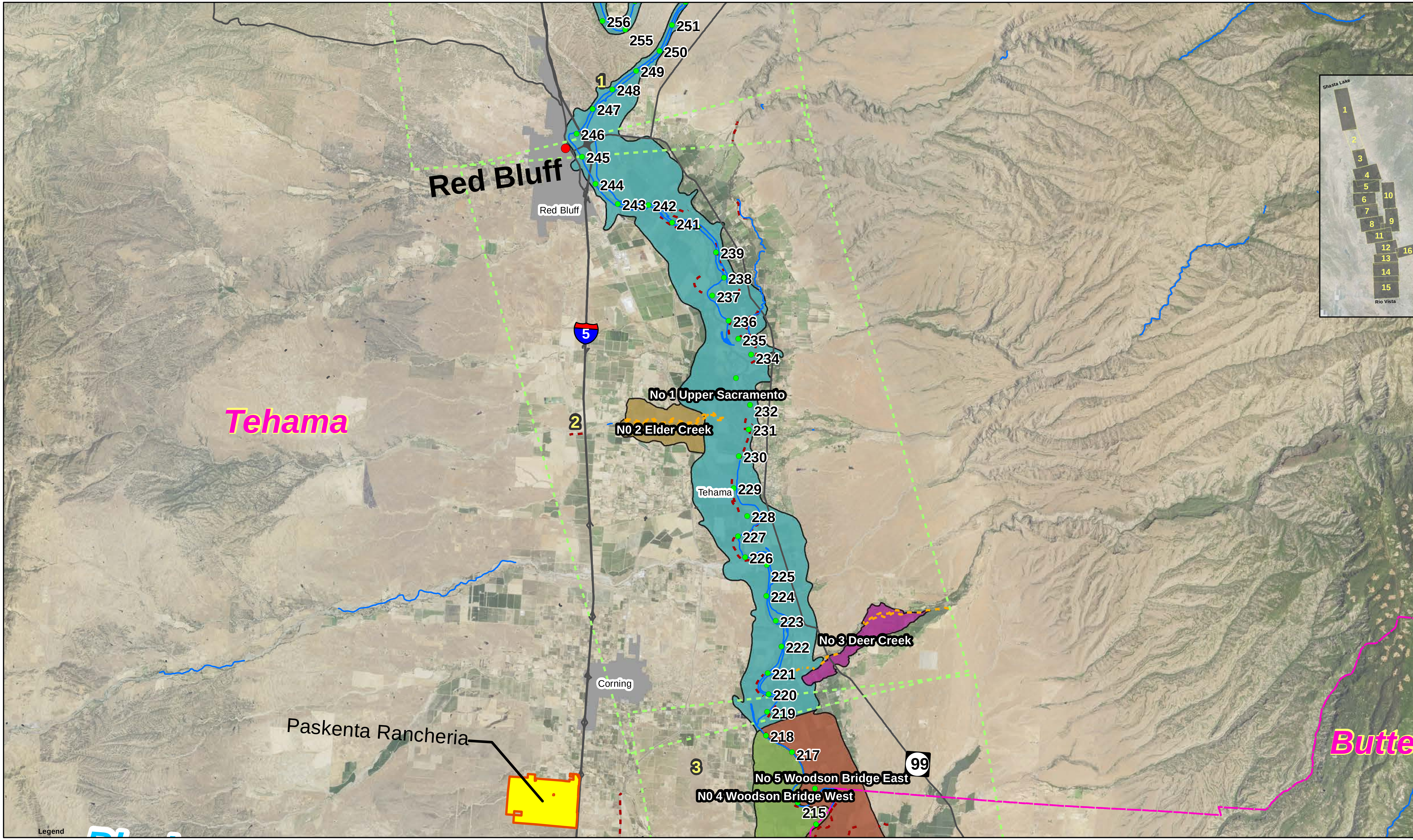

CA Cities
River Mile
Tribal Lands
Weirs
Sac River System
Federal Levees
Non Federal Levees
CA Counties
Cities

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CVIFMS Opportunity Area Map Book

US Army Corps of Engineers®
Sacramento District

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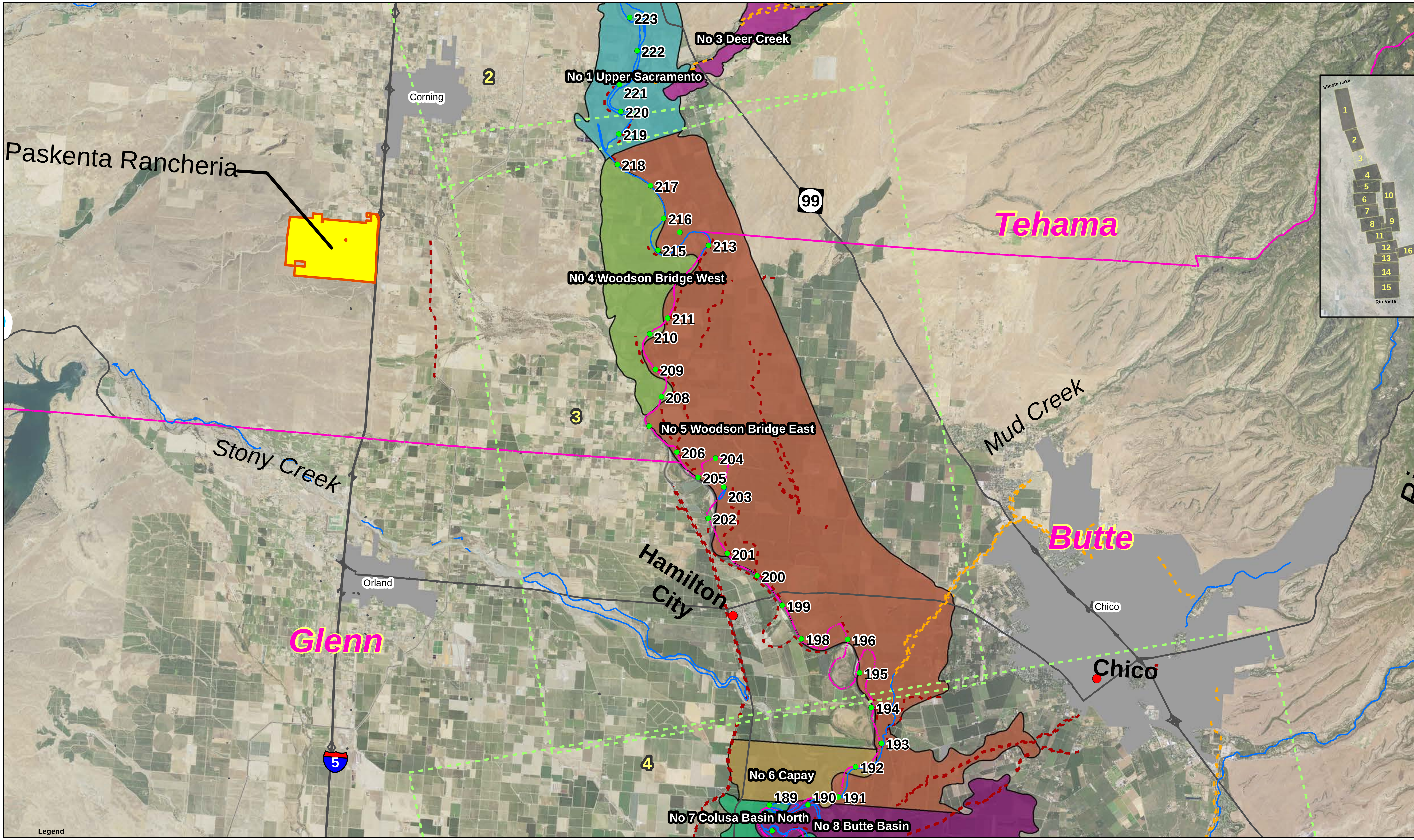

Legend

- CA Cities
- River Mile
- Tribal Lands
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- Sac River System
- Federal Levees
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- CA Counties
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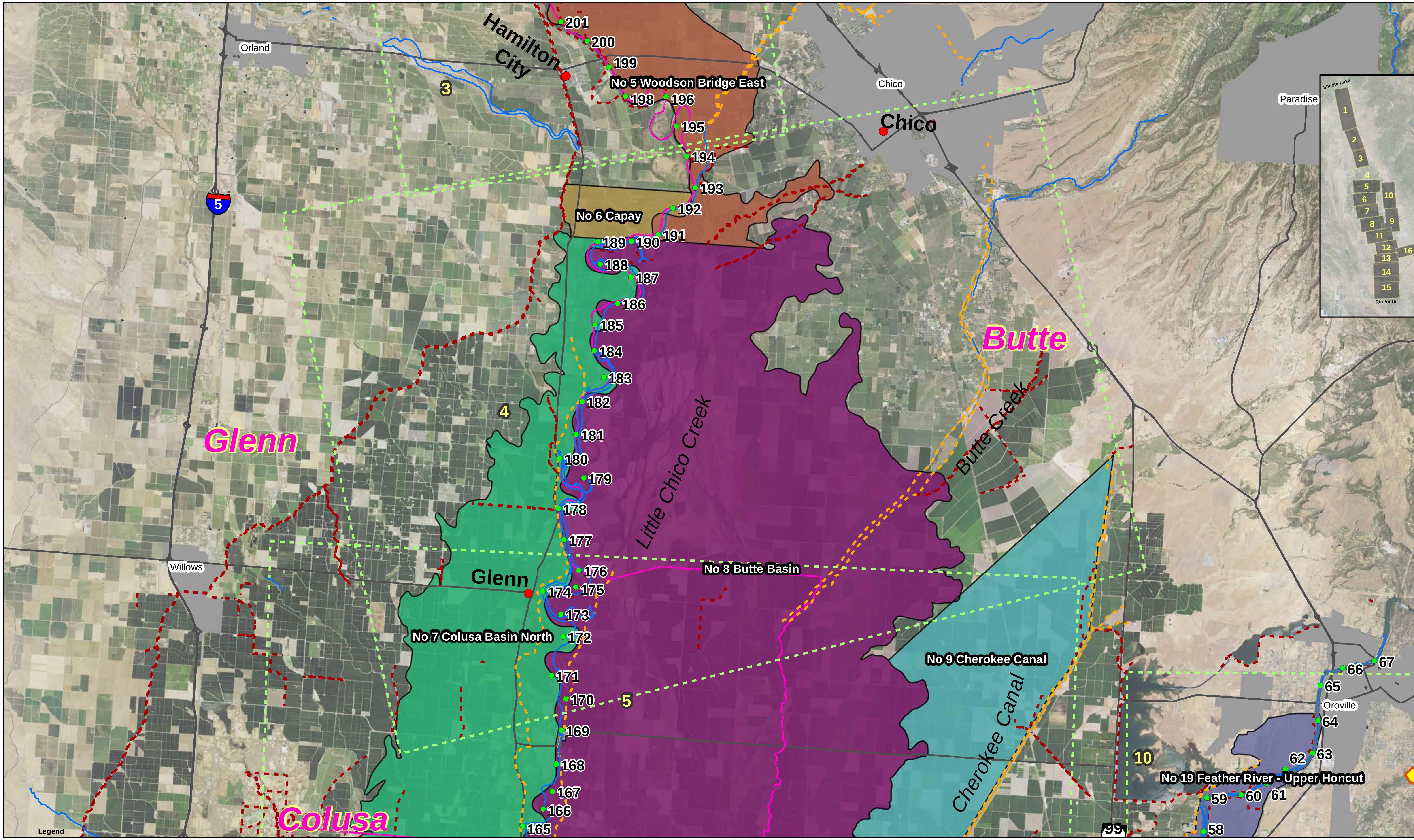

CA Cities
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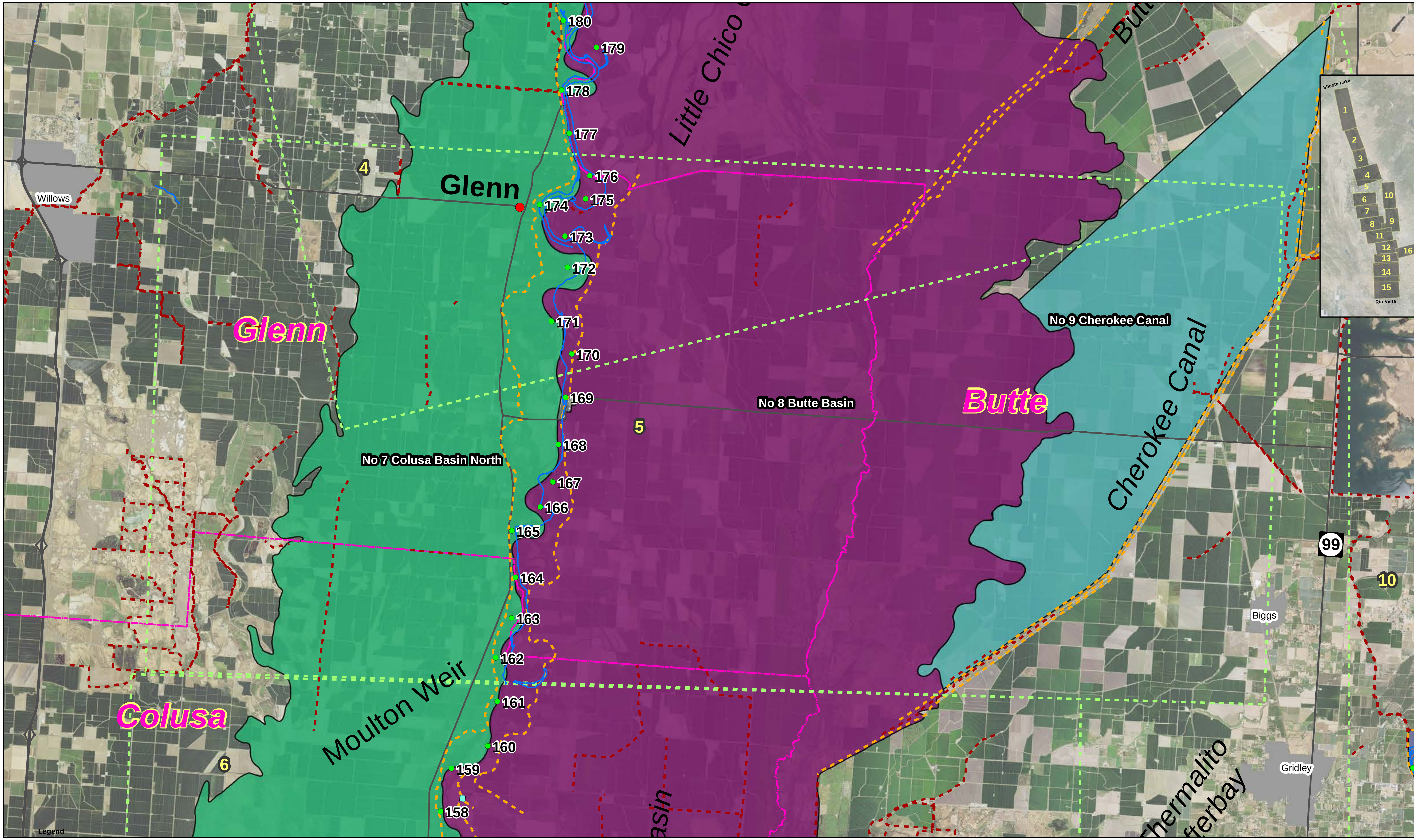

CA Cities
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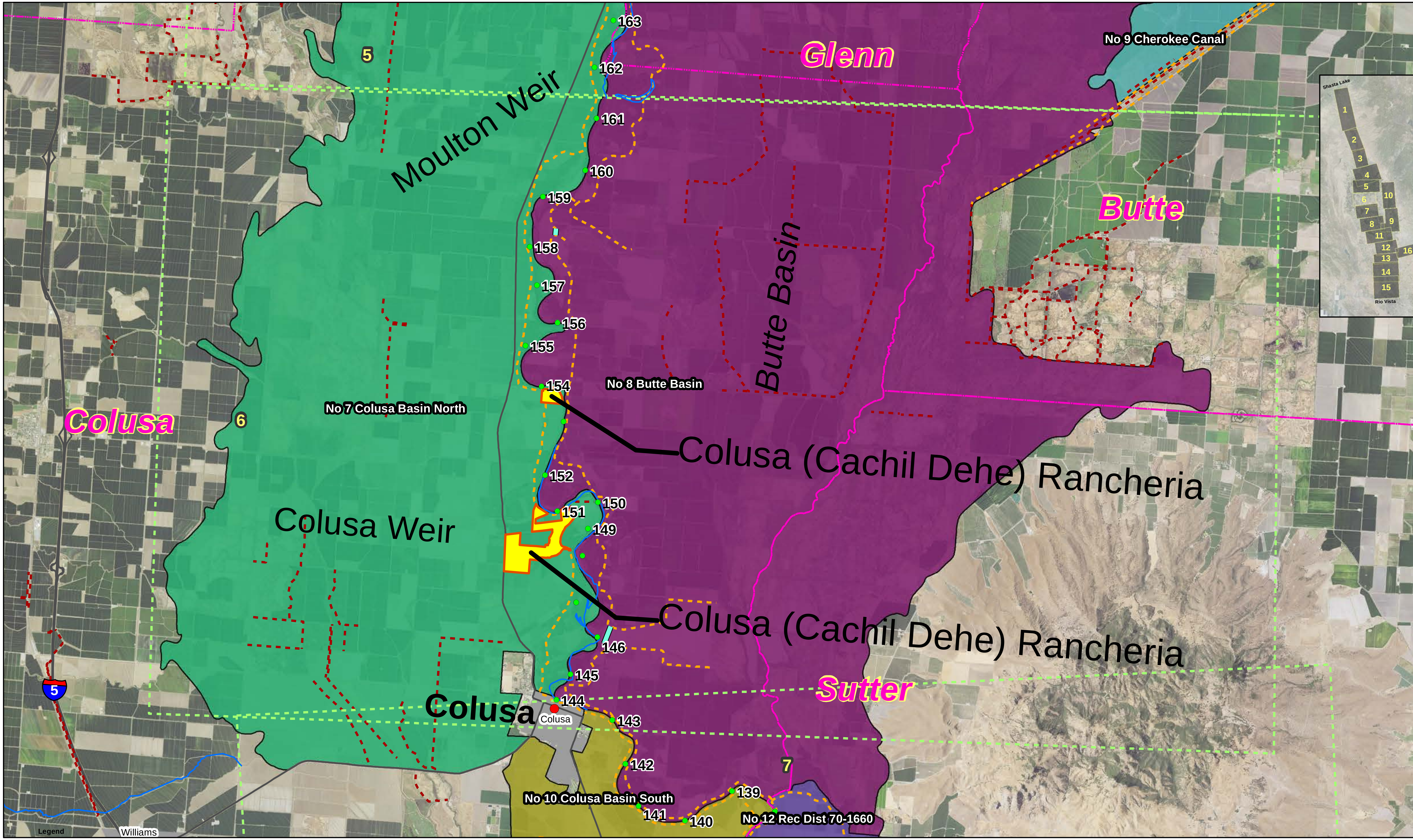

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CA Cities
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CVIFMS Opportunity Area Map Book

US Army Corps of Engineers® Sacramento District

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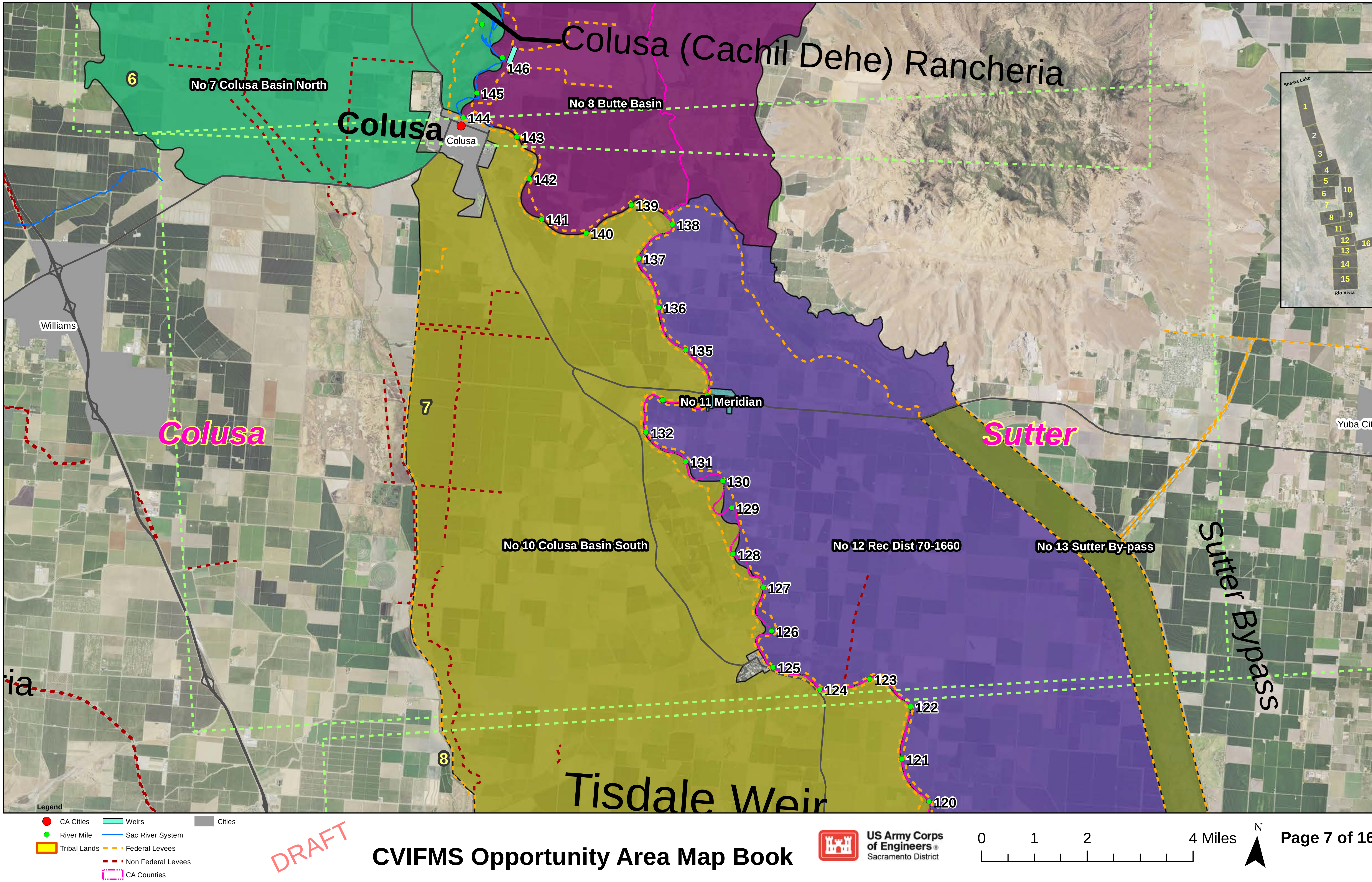

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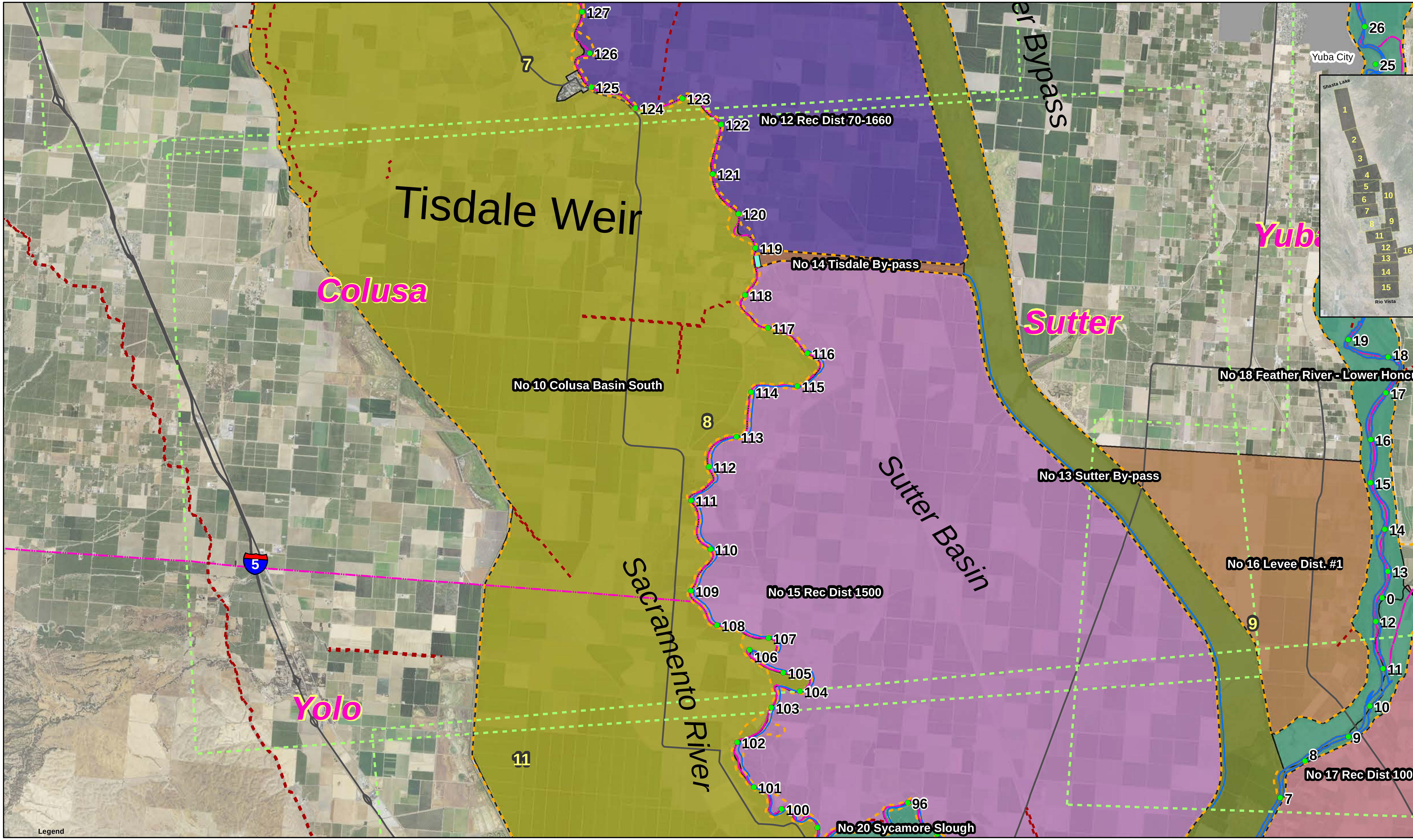

- CA Cities
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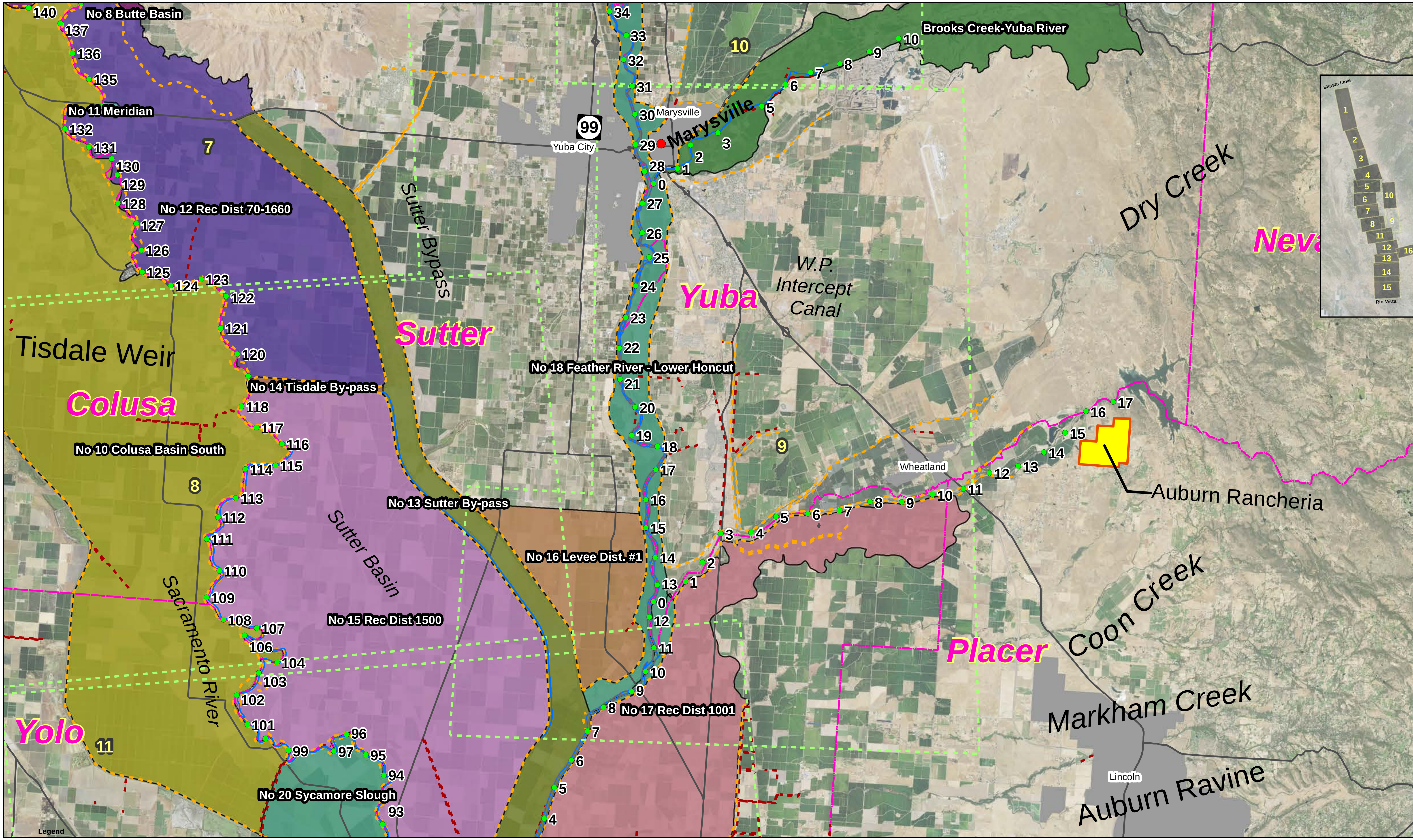

CA Cities | River Mile | Tribal Lands | Weirs | Sac River System | Federal Levees | Non Federal Levees | CA Counties | Cities

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CVIFMS Opportunity Area Map Book

US Army Corps of Engineers® Sacramento District

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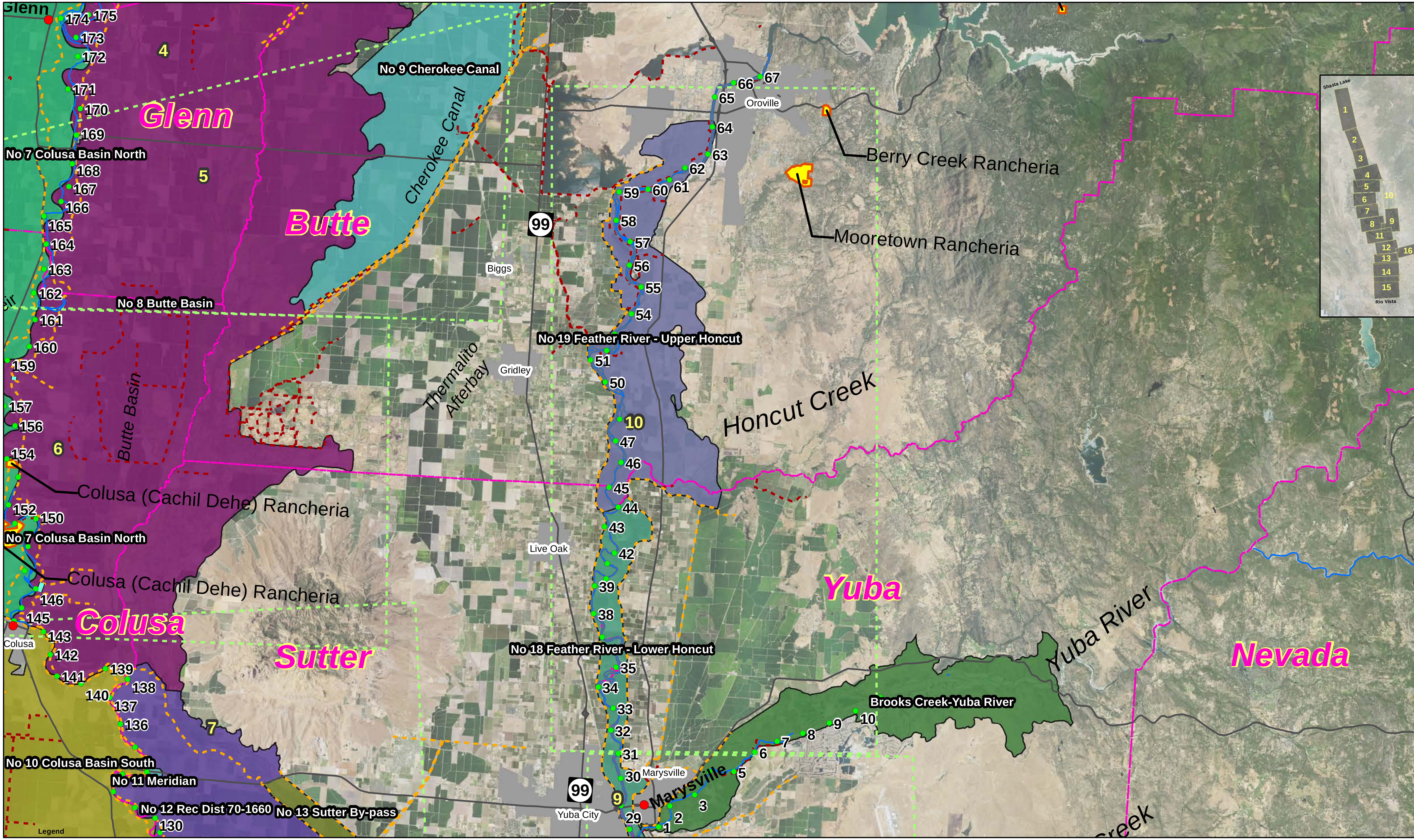

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CVIFMS Opportunity Area Map Book

US Army Corps of Engineers® Sacramento District

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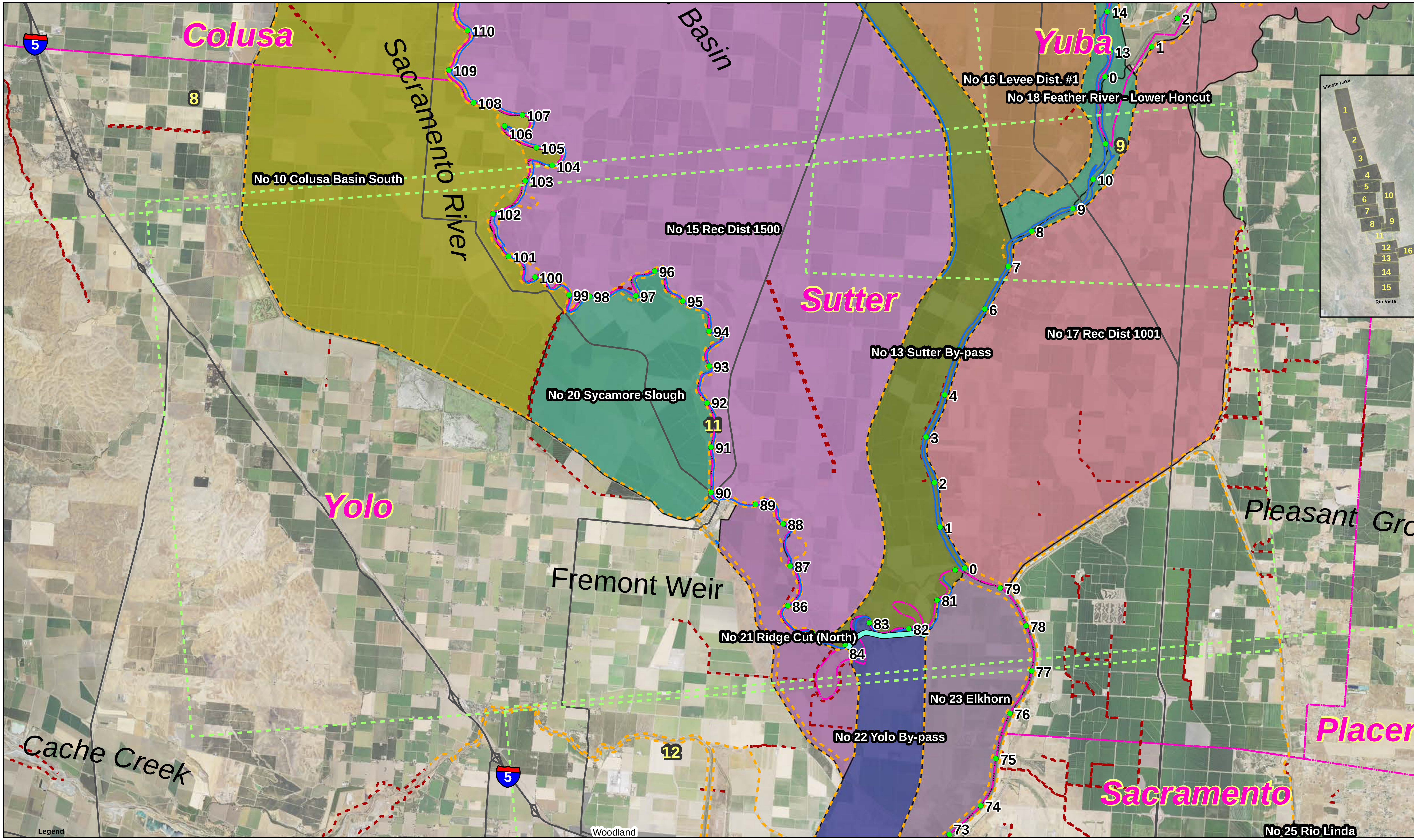

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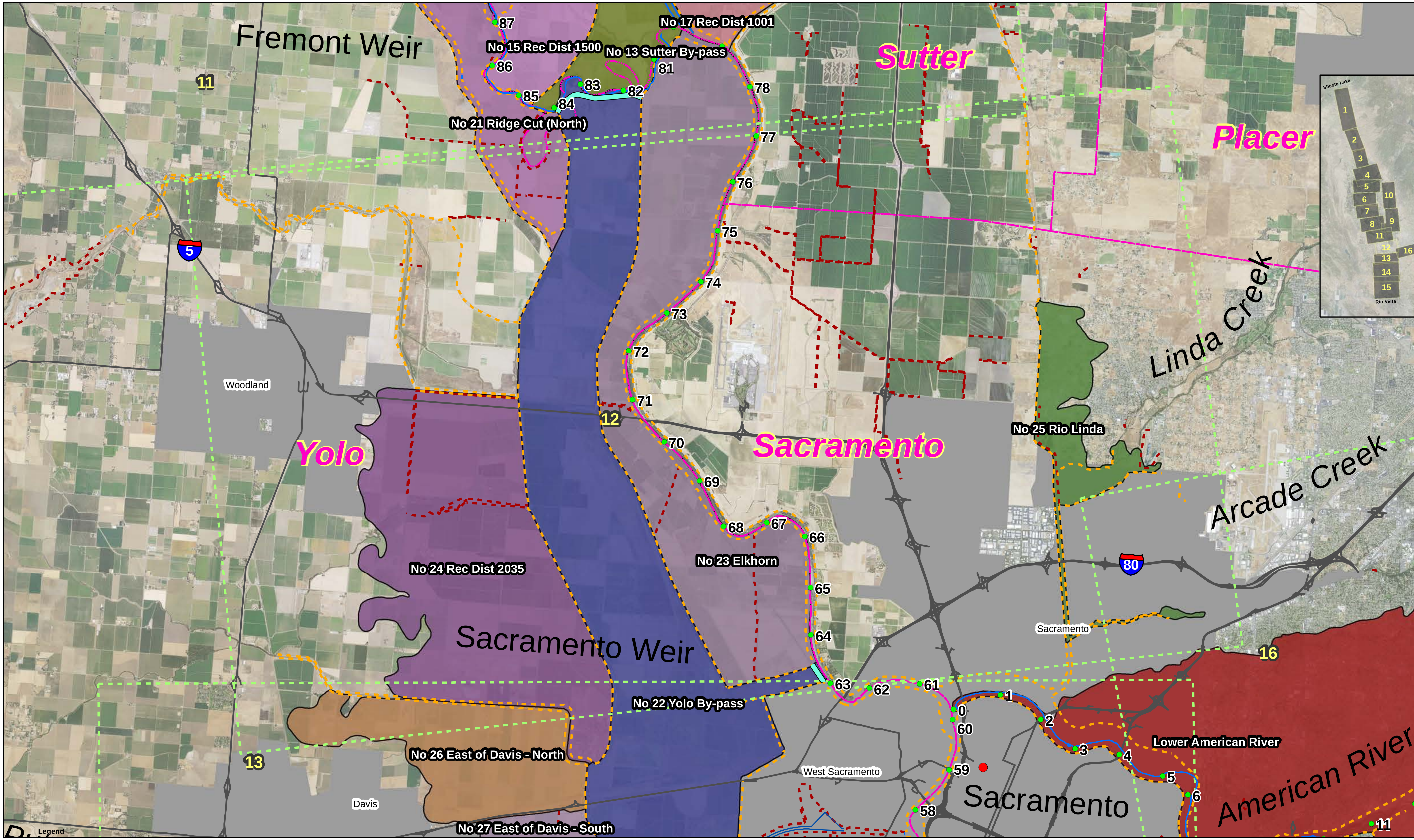
Sacramento District



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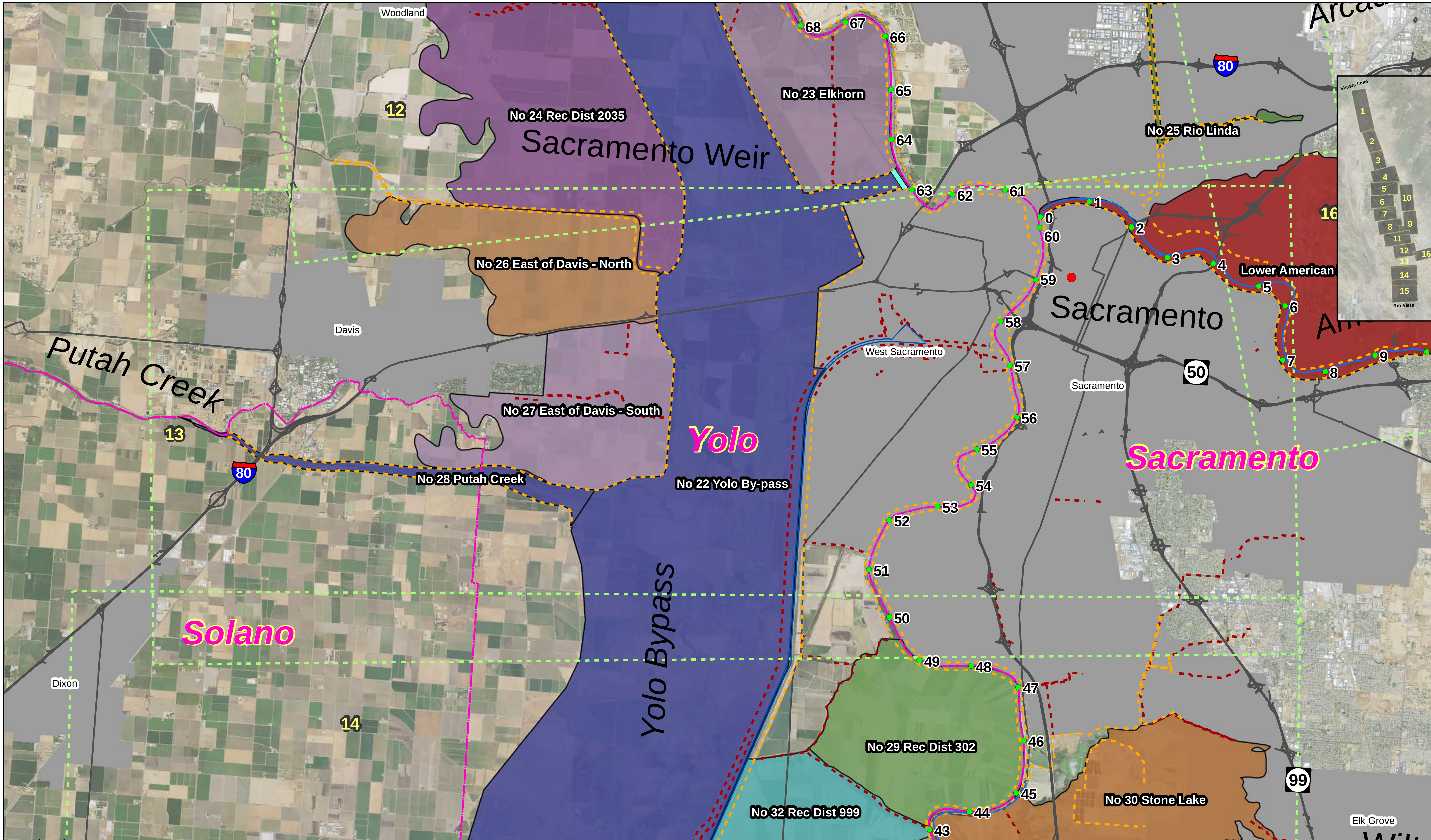

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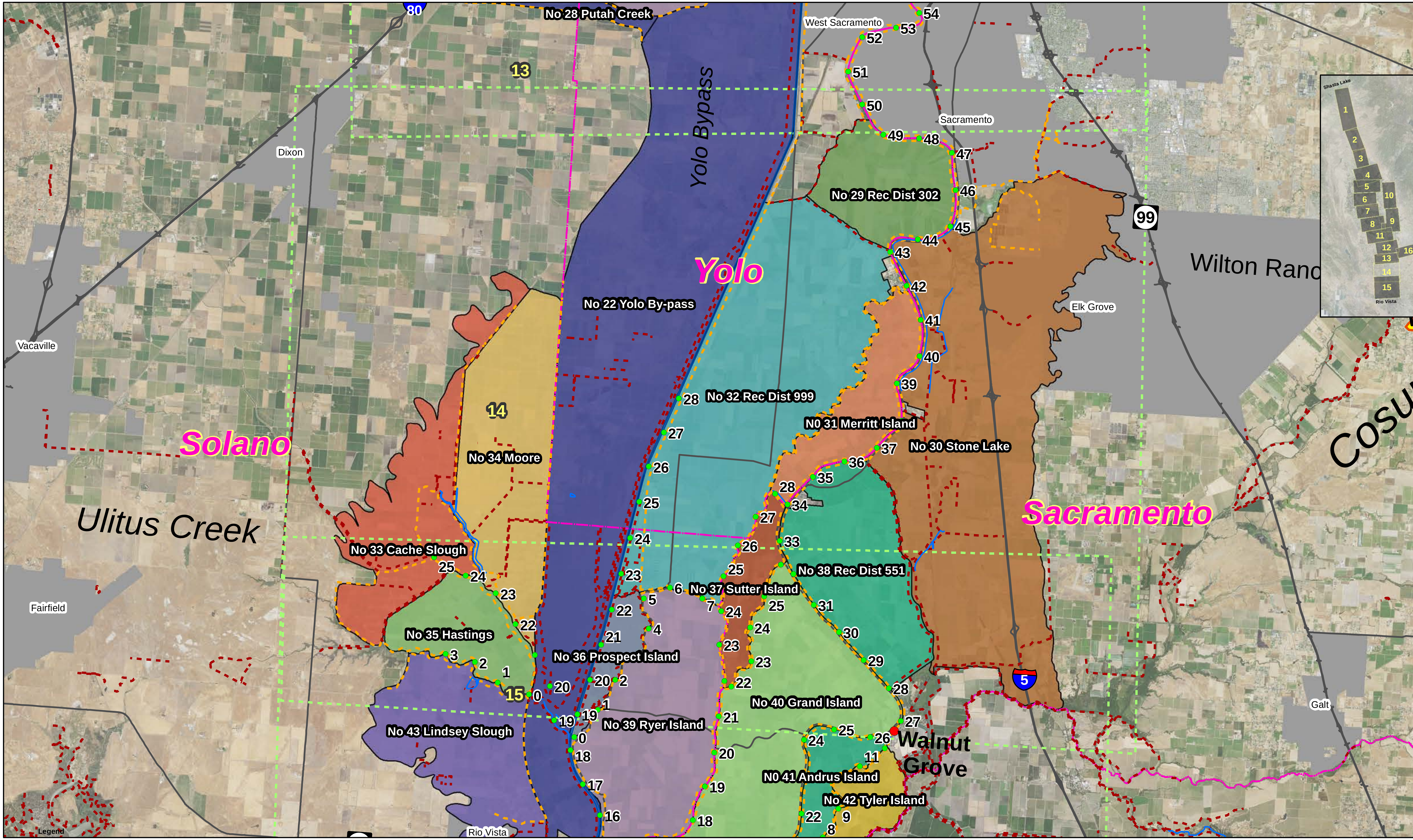

Legend

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CVIFMS Opportunity Area Map Book

US Army Corps of Engineers®
Sacramento District

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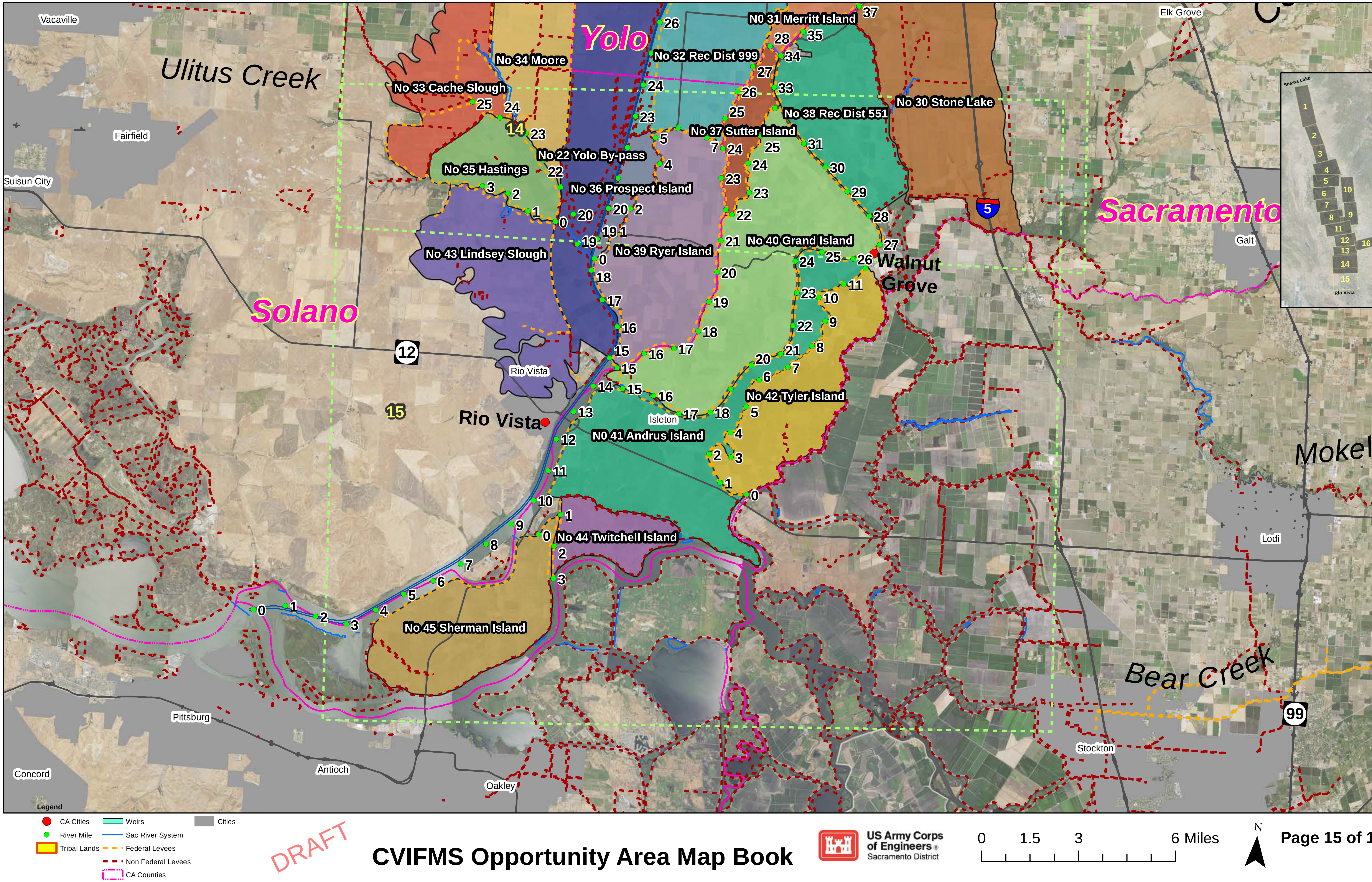

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CVIFMS Opportunity Area Map Book

US Army Corps of Engineers® Sacramento District

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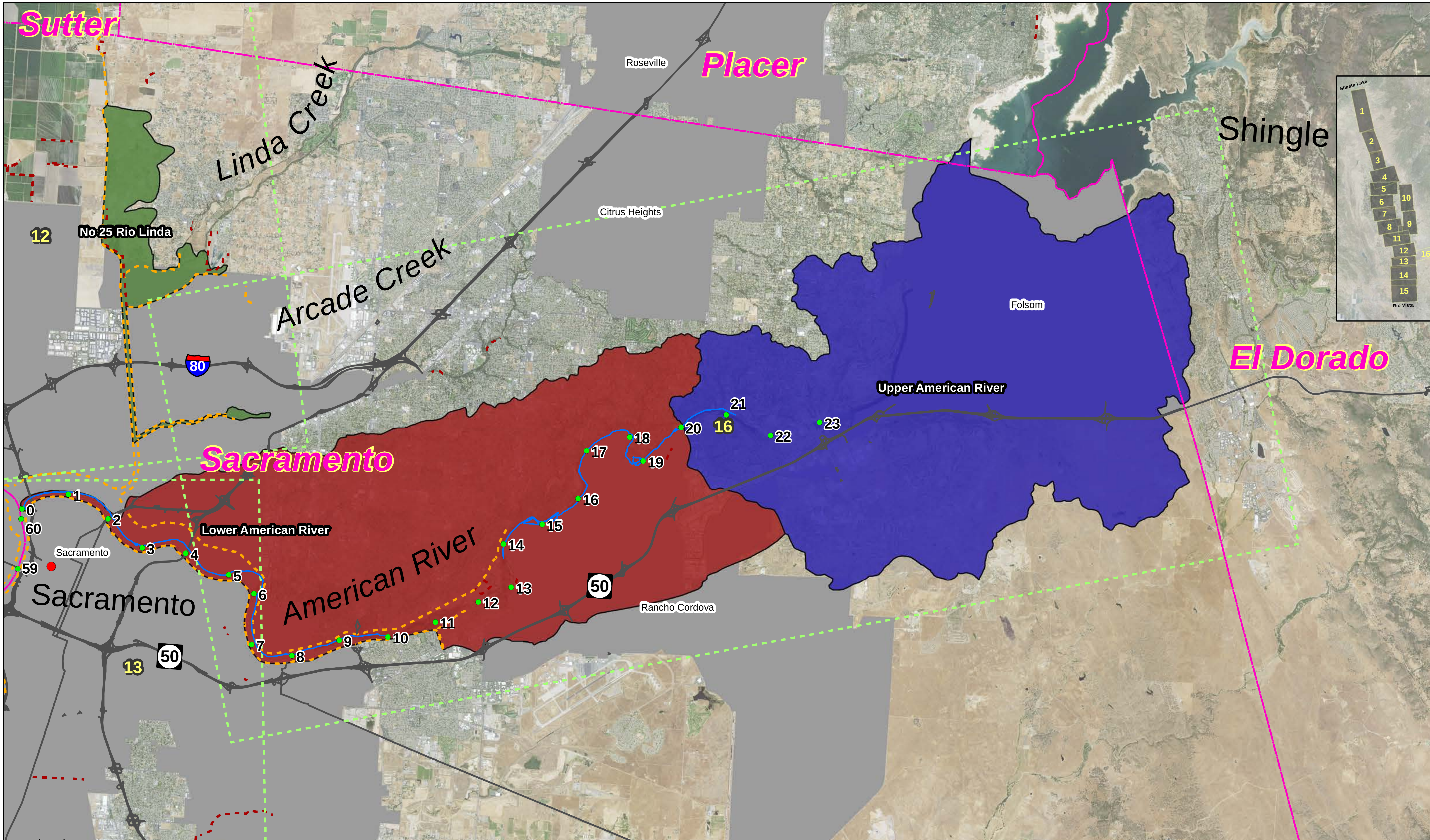

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CVIFMS Opportunity Area Map Book

US Army Corps of Engineers®
Sacramento District

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Attachment D. Conceptual Plan Formulation

As discussed in Section 3 of the watershed plan, an array of measures was identified to address the flood risk management (FRM), ecosystem restoration (ER) and water supply (WS) problems and opportunities in the Sacramento River Watershed. The arrays for each purpose are shown in Tables D-1, D-2 and D-3 below.

Table D-1. Flood Risk Management Measures

FRM Measures (increase conveyance, increase storage, optimize operations of existing system)	
1	Widen bypass
2	Create new bypass
3	Modify weirs
4	Optimize operation of weirs
5	Automate weir operation
6	Remove/modify obstructions
8	New levees
9	Setback levees
10	Coordinated emergency response plans
11	Flood recovery plan
12	Floodplain management plan
13	Create/enlarge floodplain (including transitory) storage
14	Purchase flowage easements
15	Re-operate/optimize reservoirs
16	Raise/upgrade existing dams
17	Forecast-informed reservoir operations
17	Raise/strengthen existing levees
18	Re-allocate storage in reservoirs
19	Construct new dams

Table D-2. Ecosystem Restoration Measures

ER Measures (increase abundance, distribution & diversity of native species)	
1	Increase shaded riverine aquatic habitat
2	Increase riverine aquatic habitat (instream)
3	Increase riparian habitat
4	Increase perennial marsh habitat
5	Impoundments for wetlands
6	Restore natural bank habitat
7	Re-create channel meanders
8	Remove barriers to channel migration
9	Reduce slope of banks to connect with floodplain
10	Terrace floodplains
11	Remove non-native species
11	Recontour floodway
12	Remove barriers to fish passage
13	Screen pump diversions
14	Extend floodplains/expand floodway (ex. Reduce/remove levees)
15	Set back levees
16	Notch weirs

Table D-3. Water Supply Measures

WS Measures (increase availability /reliability of water supply)	
1	New dams that include water supply purpose
2	Re-operation of existing dams to conserve more water
3	Enhancement of groundwater percolation (ex. Slowing flows over infiltration areas or so water districts can divert more water to spreading basins)
4	Re-allocate storage in reservoirs
5	Improve existing water conveyance system

The large watershed planning area was divided into opportunity areas within which measures could be applied and would have independent benefits and costs (See Figure 3-1, and Attachment C. CVIFMS Map Book). These opportunity areas are consistent with the State's planning areas. Measures applicable to each of the opportunity areas were subsequently identified based on previous studies and expert knowledge. See Table D-4 for a listing of the initial array of features (i.e. measures applied to specific opportunity areas).

Table D-4. Initial Array of Features

Feather River Upper Honcut Opportunity Area
Create transitory storage with native habitat restoration
Non-native removal/management
Set back levees - multipurpose
Expand/improve connection to Oroville Wildlife refuge
Floodplain Management Plan
Flood Recovery Plan
Restore habitat within Feather River floodway
Restore Natural Bank Habitat
Remove barriers to channel migration
Screen pump diversions
Raise/strengthen existing levees
Extend the Wadsworth Canal Bypass to the Feather River
Channel improvements - Sediment Removal, Add Gravel and Bed Load
Feather River Lower Honcut Opportunity Area
Set back/reduce/remove levees - multi-purpose
Adjust Englebright Dam for Fish Passage Improvement
Non-native removal/management
Build secondary dam with fish ladder to work in tandem above Englebright
Lengthen the setback levee in the upstream direction just south of the goldfields and west of Beale AFB and restore riverine habitat
Enhance/restore connection to floodplain
Dam removal
Purchase flowage easements and restore native habitat
Set back levees on eastern side of the Sutter Bypass levee and western levee of the Feather River (create transitory storage)
Remove barriers to channel migration
Build a multi-purpose dam (upstream of HWY 20) downstream of Engelbright (AKA Marysville Reservoir)
Floodplain Management Plan
Flood Recovery Plan
Restore habitat within Feather River floodway
Weir removal
Restore natural bank habitat
Riparian habitat restoration - Feather & Yuba Rivers
Enhance connection to/size of Lake of the Woods State Wildlife Area
Improve fish passage/create fish ladder
Improve fish passage by creating a fish ladder
Improve fish screens (RM 8 to 28) to improve fish passage
Upsize/upgrade Engelbright basin/reservoir
Raise/strengthen existing levees (sSeepage, stability, erosion control, encroachment) along East levees Feather River

Upper Sacramento Opportunity Area
Re-operate Shasta
Non-native species removal/management
Upgrade (raise of mod outlets, etc.) Shasta
Floodplain Management Plan
Flood Recovery Plan
Channel improvements - widening
Revetment removal (overall) to reconnect to floodplain
Reduce conservation space at Shasta and create Sites Reservoir where water can be stored that was previously stored at Shasta
Re-allocate WS storage to FRM at Shasta
Updates to O&M manuals for FRM and ER
Off-stream surface storage reservoir - Veterans Lake
Off-stream surface storage reservoir - Cottonwood Lake
Raise/strengthen existing levees
Elder Creek Opportunity Area
Non-native removal/management
Floodplain Management Plan
Flood Recovery Plan
Restore habitat within the Sacramento River floodway
Reduce/remove piece of levee to restore habitat in Sac River Refuge area
Deer Creek Opportunity Area
Non-native removal/management
Floodplain Management Plan
Flood Recovery Plan
Restore habitat within the Sacramento River floodway
Improve Fish Passage (Lower Deer Creek)
Levee Setback (Lower Deer Creek)
O&M Manual change (ER)
Raise/strengthen existing levees
Woodson Bridge West Opportunity Area
Non-native removal/management
Remove barriers to channel migration
Restore natural bank habitat
Floodplain Management Plan
Flood Recovery Plan
Restore habitat within the Sacramento River floodway
Woodson Bridge East Opportunity Area
Non-native removal/management
Set back levees - multipurpose
Reduce/remove levees East

Reduce/remove levees on eastern side of the river adjacent to Hamilton City
Restore habitat within the Sacramento River floodway
Extend or improve spawning habitat
Floodplain Management Plan
Flood Recovery Plan
Restore riparian habitat
Sediment removal at Lindo Creek
Capay Opportunity Area
Non-native removal/management
Create connectivity between Hamilton City project, federal protected lands and The Nature Conservancy lands
Restore riparian habitat
Restore habitat within the Sacramento River floodway
Chico Area (Lindo Channel/Sandy Gulch) Opportunity Area
Non-native removal/management
Improve connectivity to Stone Ridge Ecological Reserve and/or Bidwell Park
Floodplain Management Plan
Flood Recovery Plan
Restore habitat within the Sacramento River floodway
Restore riparian habitat
Improve fish passage/create fish ladder
Raise/strengthen existing levees
Colusa Basin North Opportunity Area
Set back levees - multi-purpose
Remove barriers to channel migration
Non-native removal/management
Enlarge or connect to Delevan National Wildlife Refuge
Restore riparian habitat (outside floodway)
Floodplain Management Plan
Flood Recovery Plan
Restore habitat within the Sacramento River floodway
Restore natural bank habitat
Screen pump diversions (reduce impacts to fish)
Raise/strengthen existing levees
Butte Basin Opportunity Area
Remove/reduce interior levee and restore habitat
Create/increase transitory storage in Butte Basin and restore habitat
Set back levees - multi-purpose
Remove barriers to channel migration
Non-native removal/management
Restore riparian habitat
Floodplain Management Plan

Flood Recovery Plan
Modify Moulton Weir to reduce fish stranding
Modify Colusa Weir to reduce fish stranding
Restore natural bank habitat
Eliminate (agricultural) control dikes and check dams
Improve fish screens
Detention basin(s)
Screen pump diversions (reduce impacts to fish)
Reduce fish stranding
Channel improvements (sediment removal, others)
Raise/strengthen existing levees
Weir improvements - FRM
Improve Butte Slough Outfall gates
Cherokee Canal
Non-native removal/management
Remove/reduce northern side of the levee to let water and sediment overflow on the northern side and restore habitat
Floodplain Management Plan
Flood Recovery Plan
Restore damaged watershed which is sediment rich to prevent losing soils at current rate
Build detention basins upstream of Cherokee Canal to capture mining sediment
O&M Manual change
Restore habitat within the Cherokee Canal
Channel Improvements - reduce road crossing capacity constraints
Elongate canal to direct water from Feather River to the Butte Basin
Channel improvements - sediment removal/management
Raise/strengthen existing levees
Divert flows from Oroville by modifying left bank of Cherokee Canal
Colusa Basin South Opportunity Area
Remove/reduce Colusa Basin Drain levee and reconnect to west side of the Sacramento River by removal or reduction of existing levee
Remove/reduce Colusa Basin Drain levee to allow water to flow across to the Sacramento River and drain south or setback a portion of Colusa Basin Drain levee
Set back some or a portion of Colusa Basin Drain levee
Non-native species removal/management
Set back some or a portion of Sacramento River west levee
Enhance connectivity to/size of Colusa National Wildlife Refuge
Riparian habitat restoration (RD 108)
Floodplain Management Plan
Flood Recovery Plan
Eliminate (agricultural) control dikes and check dams
Fish screen improvements

Reduce fish stranding
Raise/strengthen existing levees
Rec District 70-1660 Opportunity Area
Set back levees - multi-purpose
Remove/reduce eastern levee of the Sacramento River and/or western levee of the Sutter Bypass
Non-native species removal/management
Enhance connectivity to/size of Colusa & Sutter National Wildlife Area
Floodplain Management Plan
Flood Recovery Plan
Fish screen improvements
Eliminate (agricultural) control dikes and check dams
Raise/strengthen existing levees
Reduce fish stranding
Increase groundwater infiltration
Raise/strengthen existing levees
Sutter Bypass Opportunity Area
Widen bypass and restore riparian habitat
Set back levees - multi-purpose
Non-native species removal/management
Remove/reduce levees
Enhance connection to/size of Sutter National Wildlife Refuge (Sutter Bypass)
Floodplain Management Plan
Flood Recovery Plan
Improve existing fish passage
Restore perennial marsh habitat
Plant new riparian habitat
Remove barriers to fish passage
Increase enforcement of O&M requirements to maintain flood risk capacity within refuge
Channel improvements - sediment removal
Tisdale Bypass Opportunity Area
Non-native species removal/management
Widen bypass and restore riparian habitat
Create new perennial marsh habitat
Remove barriers to fish passage
Plant new riparian habitat
Rec District 1500 Opportunity Area
Remove or reduce eastern levee of the Sacramento River and/or western levee of the Sutter Bypass
Set back levees - multi-purpose
Remove barriers to channel migration
Non-native species removal/management
Restore riparian habitat

Floodplain Management Plan
Flood Recovery Plan
Restore natural bank habitat
Raise/strengthen existing levees
Levee District 1 Opportunity Area
Transitory storage at southern tip
Reconnect flood plain by removing barriers to channel migration (e.g., levees, etc.)
Non-native species removal/management
Restore riverine habitat
Enhance/restore connection to preserved areas within the Feather River levees
Raise/strengthen existing levees
Sycamore Slough
Non-native species removal/management
Rec District 1001 Opportunity Area
Non-native species removal/management
Set back levees - multi-purpose (Bear Creek South levee)
Restore riparian habitat
Floodplain Management Plan
Flood Recovery Plan
Restore shaded riverine aquatic habitat
Restore natural bank habitat
Ground water infiltration
Channel improvements - weir removal
Revetment removal
Upgrade/repair flood facilities - main drain at pumping plant
Raise/strengthen existing levees
Reduce/remove levees
Ridge Cut (North) Opportunity Area
Remove barriers to channel migration
Non-native species removal/management
Increase/enhance connection to Fremont Weir State Wildlife Area
Reduce/remove interior levees on the west side of Sac River/east side of Ridge Cut
Restore riparian habitat
Restore shaded riverine aquatic habitat
Restore natural bank habitat
Modify structure to reduce/eliminate fish stranding at Ridge Cut
Elkhorn Opportunity Area
Set back East Yolo Bypass levee - multi-purpose to match length of new Front Weir.
Remove/reduce East Yolo Bypass levee and allow all of Elkhorn to flood - multi-purpose
Remove/reduce West Sacramento River levee - multi-purpose
Set back Yolo Bypass levee to improve fish passage

Non-native species removal/management
Remove barriers to channel migration
Restore riparian habitat
Restore shaded riverine aquatic habitat
Restore natural bank habitat
Fish passage at Fremont Weir
Change floodplain to improve fish passage
Improve O&M Management Coordination
Raise/strengthen existing levees
Rio Linda Opportunity Area
Setback levee - multi-purpose
Non-native species removal/management
Improve spawning habitat for native fish
Restore riparian habitat
Improve fish passage
Rec District 2035 Opportunity Area
Widen bypass by setting back West Yolo Bypass levee across from Elkhorn Basin North of Willow Slough Bypass and restore native habitat
Widen by setting back West Yolo Bypass levee east of Davis and restore native habitat
Remove/reduce West Yolo Bypass levee to widen and restore native habitat
Non-native species removal/management
Improve fish passage in Yolo Bypass in either or both directions (N/S of Willow Slough)
Update O&M Manuals
Increase groundwater infiltration
Remove/reduce barriers to fish passage
Raise/strengthen existing levees
East of Davis - North Opportunity Area
Set back levee - multi-purpose
Non-native species removal/management
Restore riparian habitat
East of Davis - South Opportunity Area
Non-native species removal/management
Potential to expand bypass and/or connect with Putah Creek and restore native habitat
Enhance connection to and/or enlarge the Putah Creek Preserve
Putah Creek Opportunity Area
Non-native species removal/management
Restore riparian habitat
Restore native fish habitat
O&M Manual Update
Improve/restore channel capacity

Yolo Bypass Opportunity Area
Set back West Yolo Bypass levees - multi-purpose
Reduce/remove West Yolo levee northwest of Walnut Grove - multi-purpose
Non-native removal/management
Restore marsh habitat
Reduce/remove non-federal levee embankment at Egbert Tract to restore that area
Restore riparian habitat
Increase native fish habitat
Low flow channel creation for fish habitat and passage (along east side of bypass)
Manage the locks for fish passage/habitat improvements
Encroachment modifications
Remove/reduce barriers to improve fish passage
Reduce/remove chevron (staircase) levees
O&M Manual/management change
Rio Vista Floodwall Pump Station
Improve Rio Vista drainage
Raise/strengthen existing levees
Ship channel closure structure and diversion/weir to pass flood flows through the ship channel when needed
Bank protection
Stone Lake Opportunity Area
Non-native species removal/management
Improve/increase size of/increase connection to Stone Lake Preserve
Restore habitat to potentially increase size of Stone Lake Preserve
Raise/strengthen existing levees
Rec Dist 302 Opportunity Area
Non-native species removal/management
Rec Dist 999 Opportunity Area
Riparian habitat restoration
Install a weir in west side levee that would dump water east of levee (to provide water for habitat restoration) and restore habitat
Non-native species removal/management
Floodplain Management Plan
Flood Recovery Plan
Bank protection
Manage the locks for fish passage/habitat improvements
Groundwater recharge
Ship channel closure structure and diversion/weir to pass flood flows through the ship channel when needed
Bypass to take water off of Sacramento River and put it in the ship channel
Raise/strengthen existing levees

Merritt Island Opportunity Area
Non-native species removal/management
Open up and restore Merritt Island by removal/reduction of levees
Increase fish habitat
Bank protection
Raise/strengthen existing levees
Cache Slough Opportunity Area
Non-native species removal/management
Raise/strengthen existing levees
Hastings Opportunity Area
Non-native species removal/management
Bank protection
Lindsey Slough Opportunity Area
Non-native species removal/management
Floodplain Management Plan
Flood Recovery Plan
Bank protection
Rio Vista waterfront floodwall and pump station
Highway 84 closure structure
Raise/strengthen existing levees
Moore Opportunity Area
Non-native species removal/management
Rec Dist 551 Opportunity Area
Non-native speciesremoval/management
Floodplain Management Plan
Flood Recovery Plan
Raise/strengthen existing levees
Sutter Island Opportunity Area
Non-native species removal/management
Open up and restore Sutter Island by removal/reduction of levees
Increase fish habitat and improve fish passage
Raise/strengthen existing levees
Prospect Island Opportunity Area
Non-native species removal/management
Manage the locks for fish passage/habitat improvements
Ship channel closure structure and diversion/weir to pass flows through the ship channel when needed
Ryer Island Opportunity Area
Non-native species removal/management
Manage the locks for fish passage/habitat improvements
Ship channel closure structure and diversion/weir to pass flood flows through the ship channel when needed
Raise/strengthen existing levees

Grand Island Opportunity Area
Floodplain Management Plan
Flood Recovery Plan
Non-native species removal/management
Encroachment modifications
Raise/strengthen existing levees
Andrus Island Opportunity Area
Floodplain Management Plan
Flood Recovery Plan
Restore channel margin habitat
Non-native species removal/management
Remove/modify obstructions - drainage improvement
Raise/strengthen existing levees
Tyler Island Opportunity Area
Non-native species removal/management
Riparian habitat restoration
Bank protection
Raise/strengthen existing levees
Twitchell Island Opportunity Area
Non-native species removal/management
Set back levees and establish channel margin habitat (multi-purpose)
Restore freshwater perennial marsh habitat
Restore riparian forest/scrub shrub habitat
Raise/strengthen existing levees
Sherman Island Opportunity Area
Non-native species removal/management
Restore freshwater perennial marsh habitat
Restore riparian forest/scrub shrub habitat
Screen pump diversions (to reduce fish impacts)
Raise/strengthen existing levees
Area between pocket and deep water ship channel (Rec District 302)
Reduce or remove portion of western Sacramento River levee north of the Pocket and/or adjacent to the Pocket to take pressure off the eastern Sacramento River levee that protects the pocket in addition to restoring habitat
Put a weir in the west side levee that would dump water east of the levee and restore habitat
Bypass to take water off of Sacramento River and put it in the ship channel
American River (North Fork)
Build a multi-purpose earthen dam/reservoir along North Fork of the American River (American Reservoir)
Build a dry earthen dam along North Fork of the American River
Raise/strengthen existing levees

American River (South Fork)
Improve diversion from American River south-west of Folsom Dam using agricultural water supply canal and re-purposing/re-sizing it
Reservoir or a dry dam on the South Fork of the American River (multi-purpose)
Riparian habitat restoration
Raise/strengthen existing levees
Increase groundwater infiltration (near Elk Grove)
Lake Oroville
Re-operate (multi-purpose) at Oroville
Upgrade (multi-purpose) Oroville
Re-allocate storage (WS -> FRM) at Oroville
Systemwide Surface Storage
Create Off-Stream Storage at Tuscan Buttes Reservoir
FRM: Create Off-Stream Storage at Tuscan Buttes Reservoir
Create Off-Stream Storage at Glenn Reservoir
FRM: Create Off-Stream Storage at Glenn Reservoir
Create Off-Stream Storage at Colusa Reservoir Complex
FRM: Create Off-Stream Storage at Colusa Reservoir Complex
Upgrade On-Stream Storage at Lake Berryessa
FRM: Upgrade On-Stream Storage at Lake Berryessa
Create Combined On- and Off-Stream Storage at Cottonwood Creek Reservoir
FRM: Create Combined On- and Off-Stream Storage at Cottonwood Creek Reservoir
Upgrade On-Stream Storage at Lake Almanor
FRM: Upgrade On-Stream Storage at Lake Almanor
Upgrade On-Stream Storage at Englebright Lake
FRM: Upgrade On-Stream Storage at Englebright Lake
Upgrade On-Stream Storage at Pardee Reservoir
FRM: Upgrade On-Stream Storage at Pardee Reservoir
Create Off-Stream Storage at Sites Reservoir
FRM: Create Off-Stream Storage at Sites Reservoir
Create Off-Stream Storage at Thomes-Newville Reservoir
FRM: Create Off-Stream Storage at Thomes-Newville Reservoir
Create On- and Off-Stream Storage at Nashville Reservoir
FRM: Create On- and Off-Stream Storage at Nashville Reservoir
Create On-Steam Storage at Millville Reservoir
FRM: Create On-Steam Storage at Millville Reservoir
Create On-Stream Storage at Belevista Reservoir
FRM: Create On-Stream Storage at Belevista Reservoir
Create On-Stream Storage at Wing Reservoir
FRM: Create On-Stream Storage at Wing Reservoir
Create On-Stream Storage at Rosewood Reservoir

FRM: Create On-Stream Storage at Rosewood Reservoir
Create On-Stream Storage at Deer Creek Meadows Reservoir
FRM: Create On-Stream Storage at Deer Creek Meadows Reservoir
Create On-Stream Storage with Red Bank Project
FRM: Create On-Stream Storage with Red Bank Project
Create On-Stream Storage at Gallatin Reservoir
FRM: Create On-Stream Storage at Gallatin Reservoir
Create On-Stream Storage at Freemans Crossing Reservoir
FRM: Create On-Stream Storage at Freemans Crossing Reservoir
Create On-Stream Storage at Marysville Reservoir
FRM: Create On-Stream Storage at Marysville Reservoir
Create Off-Stream Storage at Waldo Reservoir
FRM: Create Off-Stream Storage at Waldo Reservoir
Create On-Stream Storage at Garden Bar Reservoir
FRM: Create On-Stream Storage at Garden Bar Reservoir
Create Off-Stream Storage at Deer Creek Reservoir
FRM: Create Off-Stream Storage at Deer Creek Reservoir
Create Off-Stream Storage at Clay Station
FRM: Create Off-Stream Storage at Clay Station
Sacramento River Basin Systemwide Reoperation
Systemwide reoperation

Figure D-1 and the associated Table D-5 below show the surface storage features proposed in the initial array of features.

Table D-5. Surface Storage Features

No.	Surface Storage Feature	Location Description	Storage Type	Feature Description	Storage Capacity (TAF)
1	Cottonwood Creek Reservoir	Shasta County and Tehama Counties, Cottonwood Creek	Combined On- and Off-Stream	Increase regulating capabilities and yield opportunities	1600
2	Tuscan Buttes Reservoir	Tehama County, Paynes and Inks Creeks	Off-Stream	Increase regulating capabilities and yield opportunities	3675-5500
3	Lake Almanor	Plumas County, Feather River	On-Stream	Increase regulating capabilities and yield opportunities	TBD
4	Glenn Reservoir	Glenn and Tehama Counties, Stony Creek	Off-Stream	Storage for Tehama-Colusa Canal or new Westside Canal	8206
5	Thomes-Newville Reservoir	Glenn County, Thomes and Stony Creeks	Off-Stream	Storage for Tehama-Colusa Canal or new Westside Canal	1840-1080
6	Colusa Reservoir Complex	Glenn and Colusa Counties, Funks Creek	Off-Stream	Storage for new Westside and Sacramento River flows	3300
7	Sites Reservoir	Glenn and Colusa Counties, Funks and Stone Corral Creeks	Off-Stream	Storage for Tehama-Colusa Canal or new Westside Canal	1200-1900
8	Englebright Lake	Yuba and Nevada Counties, Yuba River	On-Stream	Increase regulating capabilities and yield opportunities	TBD
9	Lake Berryessa Enlargement	Napa County, Putah Creek	Off-Stream	Storage for North Bay Aqueduct and/or new Westside Canal	4.4-11.7
10	Nashville Reservoir	El Dorado County and Sacramento County, Cosumnes River	Combined On- and Off-Stream	Storage for Consumnes River flows	1155
11	Pardee Reservoir Enlargement	Calaveras and Amador Counties, Mokelumne River	On-Stream	Increase regulating capabilities and yield opportunities	150

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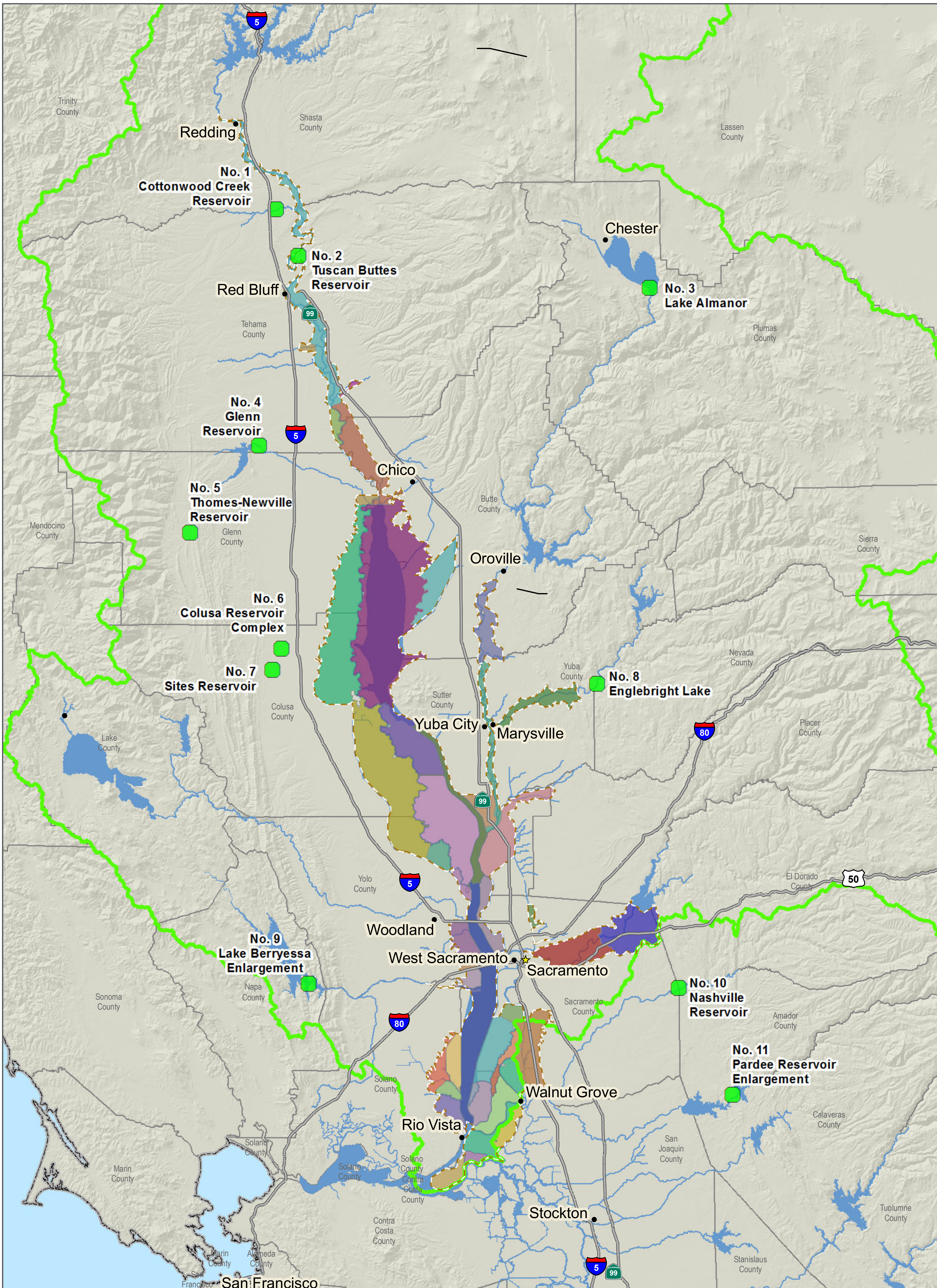

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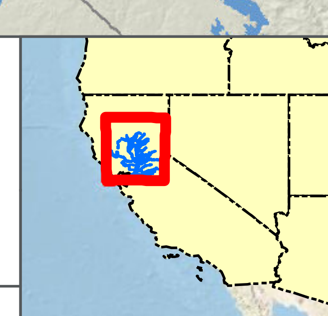
CVIFMS Project Surface Water Storage

Surface Storage | CVIFMS Opportunity Areas | HUC4 Sac Basin Watershed

Figure D-1



The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983 CA State Plane II Feet

PATH: F:\PROJECTS\028_233549_CH2MHILLDWR_CVFPP_TO_14_09\MAP_DOCS\MXD\REPORT\FIGURE_XX_SURFACEWATERSTORAGEREV1_WOCHART_11X17.MXD - USER: AARNOLD - DATE: 11/16/2015

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Every feature was evaluated to assess which purpose or purposes it meets and how well it meets the ranking criteria based on existing information, expert judgment and ? . Each feature was scored for effectiveness with a qualitative ranking of high, medium, low or zero based on expert knowledge and judgment. The effectiveness criteria included:

Flood Risk Management

- How well the feature could reduce risks to life safety from flooding
- How well the feature could reduce the consequences associated with flood risk (with an emphasis on improving system resiliency and increasing the integrity of the flood system)
- How well the feature could reduce risks to critical infrastructure from flooding
- How well the feature could encourage wise use of the floodplain

Water Supply

- How well the feature could increase the availability and reliability of water supply (groundwater and surface water)

Ecosystem Restoration

- How well the feature could increase the area, quality, connectivity and diversity of significant native aquatic and related habitats
- How well the feature could reduce barriers to fish passage
- How well the feature could increase natural dynamic hydrologic and geomorphic processes
- Which types of species the feature could benefit: 1) aquatic, 2) avian, 3) terrestrial or 4) all types (zero = no benefit; low = one type could benefit; medium = two types could benefit; high = all types could benefit)

Each potential feature was also scored for cost magnitude with a qualitative ranking of high, medium, low or zero based on expert knowledge and judgment. The cost criteria included:

- The order of magnitude of costs for the feature
- The order of magnitude of mitigation that could be required for the feature

Each potential feature was evaluated against the effectiveness (benefits) and cost criteria discussed above. For each criterion, the feature was given a score of high, medium, low or zero. After this was completed, the qualitative scores were assigned numerical values as shown in the table below (Table D-6). A net score was calculated for each feature by subtracting the cost magnitude score from the effectiveness score to provide a relative indicator of efficiency. Once this was complete, each feature had a numerical score by which it could be evaluated and compared to other features. Any features that were found to be technically infeasible or that had costs that were very likely to outweigh the benefits were screened out from consideration in the formulation of conceptual alternatives.

Table D-6 Criteria Scoring

Effectiveness Criteria	
High	3
Medium	2
Low	1
Zero	0
Cost Magnitude Criteria	
High	-3
Medium	-2
Low	-1
Zero	0

This process was initially completed by the Project Delivery Team (PDT) and was then validated through quality review and at the public workshop with key stakeholders, including participants from the resource agencies.

Once the raw scores for every feature were input into the spreadsheet, normalization was done to ensure equal weighting among the three purposes and between the criteria (i.e. to allow comparison based upon relative change within each category). The normalized scores, or indices, were used to rank, screen and compare features. Within each opportunity area, the features are ranked from highest to lowest net score. Any features with a net score of zero or less were screened out, as were any features that were found to be infeasible or non-policy compliant. Features that were screened out are noted with “strikethrough” text in the below table.

Table D-7

Features	Purposes: Flood Risk Management	Purposes: Ecosystem Restoration	Purposes: Water Supply/ Conservation	Effectiveness Criteria – Flood Risk Management: Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	WS: Increase reliability & availability of water supply	**WS Normalized**	Ecosystem Restoration: Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	Criteria Ranking Score	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	Criteria and Efficiency Ranking Score	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Feather River Upper Honcut Opportunity Area																											
Create transitory storage with native habitat restoration	X	X	X	2	2	2	3	2.25	1	1	3	0	1	0	3	1.4	17	4.65	-2.5	0	-2.5	-1.3	14.5	3.4	X	X	May have low stage reduction in the direct vicinity. However, this might also reduce stages downstream.
Non-native removal/management	X	X	X	1	1	1	1	1	1	1	3	0	1	0	3	1.4	12	3.4	-1	0	-1	-0.5	11	2.9	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Set back levees - multipurpose	X	X	X	1	1	1	3	1.5	1	1	3	0	3	0	3	1.8	16	4.3	-3	0	-3	-1.5	13	2.8	X		Low population, low critical infrastructuree, setback area would be a wise use of the floodplain; Included in Conservation Strategy, near Oroville WA
Expand/improve connection to Oroville Wildlife refuge	i	X	0	1	1	1	2	1.25	0	0	3	2	1	2	3	2.2	16	3.45	-2	0	-2	-1.0	14	2.45	X	X	Reduce stages in the direct vicinity and result in minor stage reduction due to transitory storage.Eliminate some fish stranding.
Floodplain Management Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.5		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.45			Benefits public safety due to containmenated drinking water or water safety etc.
Restore habitat within Feather River floodway	0	X	0	0	0	0	0	0	0	0	3	0	3	0	3	1.8	9	1.8	-1	0	-1	-0.5	8	1.3	X	X	Likely to increase rougness and increase stages.
Restore Natural Bank Habitat	i	X	0	1	1	0	0	0.5	0	0	3	0	0	0	3	1.2	8	1.7	-1	0	-1	-0.5	7	1.2	X		Assume this will not improve fish passage, only be alongside the stream
Remove barriers to channel migration	0	X	0	0	0	0	0	0	0	0	3	0	3	0	3	1.8	9	1.8	-2	0	-2	-1.0	7	0.8	X	X	Assume this is removal of riprap
~~Screen pump diversions~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0~~	~~0~~	~~1~~	~~0.8~~	4	~~0.8~~	~~-2~~	~~0~~	~~-2~~	~~-1.0~~	~~2~~	~~-0.2~~	X	X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	4	~~1~~	~~-3~~	~~-2~~	~~-5~~	~~-2.5~~	~~-1~~	~~-1.5~~		X	Assuming this is Feather River levee along Gridley. This is part of the Feather river west levee project which will have 0.5% with 90% assurance. Therefore, very low opertunity for risk reduction. Could have a negative effect.
~~Extend the Wadsworth Canal Bypass to the Feather River~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	4	~~3~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-2~~	~~0~~		X	May decrease stages along Feather River but these reaches would already performe to a 0.5% flood with 90% assurance after completion of the Feather River West Levee Project. Flows would be rerouted into into the Sutter Bypass and therefore have no stage reduction downstream of the sutter/feather river confluence. Saw severe consequences from this work. May be infeasible due to environmental impacts.
~~Channel improvements - Sediment Removal, Add Gravel and Bed Load~~	~~X~~	~~Neg~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0.6~~	~~3~~	~~0.6~~	~~-2~~	~~-2~~	~~-4~~	~~-2.0~~	~~-1~~	~~-1.4~~		X	Need location. Typically lost features needed for fish.
Feather River Lower Honcut Opportunity Area																											
Set back/reduce/remove levees - multi-purpose	X	X	0	2.5	2.5	2	3	2.5	1	1	3	0	3	1	3	2	21	5.5	-3	0	-3	-1.5	18	4	X	X	Almost neglibile stage reduction. There may be some reduction in stage downstream due to transitory storage stage reduction but likely to be minor.
Adjust Englebright Dam for Fish Passage Improvement	X	X	X	1	1	1	1	1	1	1	2.5	3	2.5	3	1	2.4	17	4.4	-3	0	-3	-1.5	14	2.9	X		New project from workshop
Non-native removal/management	X	X	X	1	1	1	1	1	1	1	3	0	1	0	3	1.4	12	3.4	-1	0	-1	-0.5	11	2.9	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Build secondary dam with fish ladder to work in tandem above Englebright	X	X	X	1	1	1	0	0.75	1	1	3	3	3	3	1	2.6	17	4.35	-3	0	-3	-1.5	14	2.85	X		Storage vs: Waterhshed area may limit peak flow reducttion on north fork yuba river.

Features	Purposes: Flood Risk Management	Purposes: Ecosystem Restoration	Purposes: Water Supply/ Conservation	Effectiveness – Criteria – Flood Risk Management: Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	FRM Normalized	WS: Increase reliability & availability of water supply	WS Normalized	Ecosystem Restoration: Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	ER Normalized	Criteria Ranking Score	Value Index Normalized	Magnitude of Costs	Level of mitigation	Total	Cost Normalized	Criteria and Efficiency Ranking Score	Overall Normalized	Conservation Strategy Features	Part of CVFPP	Notes
Lengthen the setback levee in the upstream direction just south of the goldfields and west of Beale AFB and restore riverine habitat	X	X	0	3	3	3	1	**2.5**	0	**0**	3	0	3	0	3	**1.8**	19	**4.3**	-2	-2	-4	**-2.0**	15	**2.3**	X		Would reduce potential for flows outflanking the gold fields during more rare events but may allow devopment to occur in some deep floodplain because it would then achieve FEMA NFIP requiements.
Enhance/restore connection to floodplain	X	X	0	1	1	1	3	**1.5**	0	**0**	3	0	3	0	3	**1.8**	15	**3.3**	-2	0	-2	**-1.0**	13	**2.3**	X	X	This was included in Conservation Strategy
Dam removal	0	X	0	0	0	0	2	**0.5**	0	**0**	3	3	3	3	3	**3**	17	**3.5**	-3	0	-3	**-1.5**	14	**2**			Potential Mercury in Sediment
Purchase flowage easments and restore native habitat	X	X	0	2	2	1	3	**2**	0	**0**	3	0	2	0	2	**1.4**	15	**3.4**	-3	0	-3	**-1.5**	12	**1.9**	X	X	Area is rural therefore low opportunities for significant risk reduction. Flowage easements are also costly. Assume this is for lands with good habitat, not just ag lands.
Set back levees on eastern side of the Sutter Bypass levee and western levee of the Feather River (create transitory storage)	X	X	X	1	1	1	3	**1.5**	0	**0**	3	0	3	0	3	**1.8**	15	**3.3**	-3	0	-3	**-1.5**	12	**1.8**	X	X	May decrease stages along Feather River but these reaches would already performe to a 0.5% flood with 90% assurance after completion of the Feather River West Levee Project. There may be some reduction in stage downstream due to transitory storage stage reduction but likely to be minor. 2D modeling on Sutter Bypass performed for the CVFPB (Oct 2013) indicates that setbacks in this location could add to back-up of water in the Sutter Bypass above the point where the Feather River enters the bypass. This is due to the 'bubble' of water created.
Remove barriers to channel migration	X	X	0	1	1	0	1.5	**0.875**	0	**0**	3	0	3	0	3	**1.8**	12.5	**2.675**	-2	0	-2	**-1.0**	10.5	**1.675**	X	X	Assume this is removal of riprap
Build a multi-purpose dam (upstream of HWY 20) downstream of Engelbright (AKA Marysville Reservoir)	X	0	X	3	3	3	0	**2.25**	1	**1**	1	2	1	2	1	**1.4**	17	**4.65**	-3	-3	-6	**-3.0**	11	**1.65**		X	This would improve the ability to manage the coordinated operation of Oroville and New Bullards Bar and meet objective flows downstream of Yuba River and Feather River confluence. Requires other fish passage. Connected to DeGuerrer Dam.
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Benefits public safety due to containmenated drinking water or water safety etc.
Restore habitat within Feather River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	-1	0	-1	**-0.5**	8	**1.3**	X		
Weir removal	X	X	0	0	0	0	0	**0**	0	**0**	2	3	3	3	3	**2.8**	14	**2.8**	-3	0	-3	**-1.5**	11	**1.3**	X		
Restore Natural Bank Habitat	i	X	0	1	1	0	0	**0.5**	0	**0**	3	0	0	0	3	**1.2**	8	**1.7**	-1	0	-1	**-0.5**	7	**1.2**	X	X	Assume this will not improve fish passage, only be alongside the stream
Riparian habitat Restoration - Feather & Yuba rivers	i	X	0	1	1	0	0	**0.5**	0	**0**	3	0	0	0	2	**1**	7	**1.5**	-1	0	-1	**-0.5**	6	**1**	X	X	
Enhance connection to/size of Lake of the Woods State Wildlife Area	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X		
Improve fish passage/create fish ladder	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	1	**1.4**	7	**1.4**	-2	0	-2	**-1.0**	5	**0.4**	X		
Improve fish passage by creating a fish ladder	0	X	0	0	0	0	0	**0**	0	**0**	0	3	0	3	1	**1.4**	7	**1.4**	-2	0	-2	**-1.0**	5	**0.4**	X	X	
~~Improve fish screens (RM 8 to 28) to improve fish passage~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~1~~	~~0~~	~~3~~	~~1~~	~~**1**~~	5	~~**1**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	2	~~**-0.5**~~	X		(Previously in Upper Honcut, moved to Lower Honcut)
~~Upsize/upgrade Engelbright basin/reservoir~~	~~X~~	~~0~~	~~X~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~1~~	~~**1**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	4	~~**1.75**~~	~~-3~~	~~-2~~	~~-5~~	~~**-2.5**~~	~~-1~~	~~**-0.75**~~			~~Canyon would limit potential storage capacity.~~
~~Raise/strengthen existing levees (Seepage, Stability, Erosion Control, Encroachment) East levees Feather River~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~1~~	~~**1**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	4	~~**1**~~	~~-3~~	~~-2~~	~~-5~~	~~**-2.5**~~	~~-1~~	~~**-1.5**~~			~~Levee improvements would be very costly but area is extremely rural and unlikely to have high damages.~~

	Purposes			Effectiveness – Criteria – Flood Risk Management					WS		Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	**Criteria Ranking Score**	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	**Criteria and Efficiency Ranking Score**	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Upper Sacramento Opportunity Area																											
Re-operate Shasta	X	0	X	2	2	2	0	**1.5**	3	**3**	0	0	0	0	0	**0**	9	**4.5**	-1	-1	-2	**-1.0**	7	**3.5**			May be able to increase FRM performance at minor cost.
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	1	3	**1.6**	13	**3.6**	-1	0	-1	**-0.5**	12	**3.1**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Upgrade (Raise of Mod Outlets etc) Shasta	X	0	X	2	2	2	0	**1.5**	3	**3**	0	0	0	0	0	**0**	9	**4.5**	-3	-3	-6	**-3.0**	3	**1.5**		?	
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Benefits public safety due to containmenated drinking water or water safety etc.
Channel improvements - widening	X	X	X	1	0	0	0	**0.25**	1	**1**	0	0	0	1	3	**0.8**	6	**2.05**	-2	0	-2	**-1.0**	4	**1.05**	X	?	Need more information
Revetment removal (overall) to reconnect to floodplain	0	X	0	0	0	0	2	**0.5**	0	**0**	2	0	2	0	3	**1.4**	9	**1.9**	-2	0	-2	**-1.0**	7	**0.9**	X		Most of reach has no significant infrastructure at risk. Primariliy non urban. Must be linked to restoration downstream as well. Could develop early successional habitat types.
Reduce conservation space at Shasta and create Sites reservoir where water can be stored that used to be stored at Shasta	X	0	X	2.5	2.5	2.5	0	**1.875**	2	**2**	0	0	0	0	0	**0**	9.5	**3.875**	-3	-3	-6	**-3.0**	3.5	**0.875**		?	Not a direct tradeoff due to the capacity of being able to transfer flows.
Re-allocate WS storage to FRM at Shasta	X	0	X	3	3	3	0	**2.25**	0	**0**	0	0	0	0	0	**0**	9	**2.25**	-2	-2	-4	**-2.0**	5	**0.25**			Purchase Water Supply Storage to increase FRM pool. Assumes no taking of water from Environmental Needs.
~~Updates to O&M manuals for FRM and ER~~	~~X~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	**~~0~~**	~~0~~	**~~0~~**	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	**~~0.2~~**	~~1~~	**~~0.2~~**	~~-1~~	~~0~~	~~-1~~	**~~-0.5~~**	~~0~~	**~~-0.3~~**			~~Need more information; Changes to allow for more vegetation could be helpful.~~
~~Off-stream surface storage reservoir - Veterans Lake~~	~~0~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	**~~0~~**	~~2~~	**~~2~~**	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	**~~0~~**	~~2~~	**~~2~~**	~~-3~~	~~-3~~	~~-6~~	**~~-3.0~~**	~~-4~~	**~~-1~~**		X	~~Because it is off-stream (100% Water Supply) No USACE interest must have FRM purpose~~
~~Off-stream surface storage reservoir - Cottonwood Lake~~	~~0~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	**~~0~~**	~~2~~	**~~2~~**	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	**~~0~~**	~~2~~	**~~2~~**	~~-3~~	~~-3~~	~~-6~~	**~~-3.0~~**	~~-4~~	**~~-1~~**		X	~~Because it is off-stream,(100% Water Supply) No USACE interest must have FRM purpose~~
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~1~~	**~~1~~**	~~0~~	**~~0~~**	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	**~~0~~**	4	**~~1~~**	~~-3~~	~~-2~~	~~-5~~	**~~-2.5~~**	~~-1~~	**~~-1.5~~**		X	~~Reach is primarily rural with exception of East side of Redbluff and Tehama. Therefore, very low opertunity for risk reduction.~~
Elder Creek Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Benefits public safety due to containmenated drinking water or water safety etc.
Restore habitat within the Sacramento River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	-1	0	-1	**-0.5**	8	**1.3**	X		
Reduce/remove piece of levee to restore habitat in Sac River Refuge area	X	X	0	1	1	1	1	**1**	0	**0**	3	0	3	0	2	**1.6**	12	**2.6**	-3	0	-3	**-1.5**	9	**1.1**	X	X	FRM benefits limited because area is rural
Deer Creek Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		?	Benefits public safety due to containmenated drinking water or water safety etc.

	Purposes			Effectiveness																							
				Criteria																							
				Flood Risk Management					WS		Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	Criteria Ranking Score	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	Criteria and Efficiency Ranking Score	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Restore habitat within the Sacramento River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	-1	0	-1	**-0.5**	8	**1.3**	X	X	
Improve Fish Passage (Lower Deer Creek)	0	X	0	0	0	0	0	**0**	0	**0**	0	1	0	3	1	**1**	5	**1**	-1.5	0	-1.5	**-0.8**	3.5	**0.25**		X	
Levee Setback (Lower Deer Creek)	X	X	0	1	1	1	2	**1.25**	0	**0**	3	0	3	0	3	**1.8**	14	**3.05**	-3	-3	-6	**-3.0**	8	**0.05**	X	?	Minor stage decreases and potential for transitory storage. However, very rural area.
~~O&M Manual change (ER)~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	**0**	~~0~~	**0**	~~2~~	~~0~~	~~1~~	~~0~~	~~1~~	**0.8**	4	**0.8**	~~0~~	~~0~~	0	**0.0**	4	**0.8**			Refers to Ecoystem Benfits; Changes to allow for more vegetation could be helpful
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	0	~~**0.75**~~	0	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-2~~	~~-2~~	~~-4~~	~~**-2.0**~~	~~-1~~	~~**-1.25**~~		X	Area is rural therefore low opertunities for significant risk reduction. Could have a negative effect on habitat.
Woodson Bridge West Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Remove barriers to channel migration	X	X	0	1	1	1	1	**1**	0	**0**	3	0	3	0	3	**1.8**	13	**2.8**	-2	0	-2	**-1.0**	11	**1.8**	X		May include removing barriers to fish migration that also block channel migration.
Restore Natural Bank Habitat	0	X	X	0	0	0	0	**0**	1	**1**	3	0	0	0	3	**1.2**	7	**2.2**	-1	0	-1	**-0.5**	6	**1.7**	X	X	Assume this will not improve fish passage, only be alongside the stream
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Benefits public safety due to containmenated drinking water or water safety etc.
Restore habitat within the Sacramento River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	-1	0	-1	**-0.5**	8	**1.3**	X	X	
Woodson Bridge East Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Set back levees - multipurpose	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	3	**1.8**	16	**4.3**	-3	0	-3	**-1.5**	13	**2.8**	X	?	Rural Area minor FRM benefits; Included in Conservation Strategy
Reduce/remove levees East	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	2	**1.6**	15	**4.1**	-3	0	-3	**-1.5**	12	**2.6**	X		Rural Area minor FRM benefits
Reduce/remove levees on eastern side of the river adjacent to Hamilton City	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	2	**1.6**	15	**4.1**	-3	0	-3	**-1.5**	12	**2.6**	X	?	Rural Area minor FRM benefits
Restore habitat within the Sacramento River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	0	0	0	**0.0**	9	**1.8**	X		
Extend or improve spawning habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	3	1	3	1	**2.2**	11	**2.2**	-1	0	-1	**-0.5**	10	**1.7**	X		
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Benefits public safety due to containmenated drinking water or water safety etc.
Restore riparian habitat	0	X	X	0	0	0	0	**0**	0	**0**	1	0	0	0	2	**0.6**	3	**0.6**	-1	0	-1	**-0.5**	2	**0.1**	X	X	Assume this is not SRA
~~Sediment removal at Lindo Creek~~	~~X~~	~~X~~	~~X~~	~~1~~	~~1~~	~~1~~	~~0~~	**0.75**	~~1~~	**1**	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	4	~~**1.75**~~	~~-2~~	~~-3~~	~~-5~~	~~**-2.5**~~	~~-1~~	~~**-0.75**~~		X	~~Rural Area minor FRM benefits~~
Capay Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	Removal of Non native species may slightly reduce roughness and lower flood stages

	Purposes			Effectiveness													Criteria Ranking Score	Value Index Normalized				Cost Normalized	Criteria and Efficiency Ranking Score	Overall Normalized	Conservation Strategy Features	Part of CVFPP	Notes
				Criteria																							
				Flood Risk Management					WS		Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**			Magnitude of Costs	Level of mitigation	Total						
Create connectivity between Hamilton City project, federal protected lands and TNC lands	0	X	X	0	0	0	0	**0**	1	**1**	3	0	3	0	3	**1.8**	10	**2.8**	-1	0	-1	**-0.5**	9	**2.3**	X	?	
Restore riparian habitat	0	X	X	0	0	0	0	**0**	1	**1**	3	0	0	0	2	**1**	6	**2**	-1	0	-1	**-0.5**	5	**1.5**	X	X	Assume this is not SRA
Restore habitat within the Sacramento River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	-1	0	-1	**-0.5**	8	**1.3**	X	X	
Chico Area (Lindo Channel/Sandy Gulch) Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Improve connectivity to Stone Ridge Ecological Reserve and/or Bidwell Park	0	X	X	0	0	0	0	**0**	1	**1**	3	0	0	0	2	**1**	6	**2**	-1	0	-1	**-0.5**	5	**1.5**	X	X	
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Benefits public safety due to containmenated drinking water or water safety etc.
Restore habitat within the Sacramento River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	-1	0	-1	**-0.5**	8	**1.3**	X		
Restore riparian habitat	0	X	X	0	0	0	0	**0**	1	**1**	1	0	0	0	2	**0.6**	4	**1.6**	-1	0	-1	**-0.5**	3	**1.1**	X	X	Assume this is not SRA
Improve fish passage/create fish ladder	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	1	**1.4**	7	**1.4**	-2	0	-2	**-1.0**	5	**0.4**	X		
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-2~~	~~-2~~	~~-4~~	~~**-2.0**~~	~~2~~	~~**-0.5**~~		X	Could have a negative effect ON ECOSYSTEM
Colusa Basin North Opportunity Area																											
Set back levees - multi-purpose	X	X	X	2	2	1	3	**2**	1	**1**	3	0	3	0	3	**1.8**	18	**4.8**	-3	0	-3	**-1.5**	15	**3.3**	X	?	Included in Conservation Strategy
Remove barriers to channel migration	0	X	X	1	1	1	2	**1.25**	1	**1**	3	0	3	0	3	**1.8**	15	**4.05**	-2	0	-2	**-1.0**	13	**3.05**	X	X	Assume this is removal of riprap
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		
Enlarge or connect to Delevan National wildlife refuge	0	X	X	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X		
Restore riparian habitat (outside floodway)	0	X	X	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X		Assume this is not SRA
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Benefits public safety due to containmenated drinking water or water safety etc.
Restore habitat within the Sacramento River floodway	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	3	**1.8**	9	**1.8**	-1	0	-1	**-0.5**	8	**1.3**	X		Replace orchards on lands owned by TNC or by CDFW. Part of Colusa Subreach Plan.
Restore natural bank habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X	X	Assume this will not improve fish passage, only be alongside the stream
Screen pump diversions (reduce impacts to fish)	0	X	0	0	0	0	0	**0**	0	**0**	2	0	0	3	1	**1.2**	6	**1.2**	-2	0	-2	**-1.0**	4	**0.2**	X	X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-2~~	~~-5~~	~~**-2.5**~~	~~-2~~	~~**-1.75**~~		X	
Butte Basin Opportunity Area																											
Remove/reduce interior levee and restore habitat	X	X	X	3	3	3	2	**2.75**	2	**2**	3	0	3	0	2	**1.6**	21	**6.35**	-3	0	-3	**-1.5**	18	**4.85**	X	X	

	Purposes			Effectiveness – Criteria – Flood Risk Management					Effectiveness – Criteria – WS		Effectiveness – Criteria – Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	Criteria Ranking Score	Value Index Normalized	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	Criteria and Efficiency Ranking Score	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Create/increase transitory storage in Butte Basin and restore habitat	X	X	X	3	3	3	2	**2.75**	2	**2**	3	0	0	1	1	**1**	18	**5.75**	-3	0	-3	**-1.5**	15	**4.25**	X		Fish passage opportunities on Butte Creek
Set back levees - multi-purpose	X	X	X	2	2	2	2	**2**	1	**1**	3	0	3	0	3	**1.8**	18	**4.8**	-3	0	-3	**-1.5**	15	**3.3**	X		
Remove barriers to channel migration	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	3	**1.8**	16	**4.3**	-2	0	-2	**-1.0**	14	**3.3**	X	X	Assume this is removal of riprap
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Restore riparian habitat	0	X	X	0	0	0	1	**0.25**	1	**1**	3	0	0	0	2	**1**	7	**2.25**	-1	0	-1	**-0.5**	6	**1.75**	X	X	
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Benefits public safety due to containmenated drinking water or water safety etc.
Modify Moulton Weir to reduce fish stranding	0	X	0	0	0	0	0	**0**	0	**0**	0	3	0	3	1	**1.4**	7	**1.4**	-1	0	-1	**-0.5**	6	**0.9**	X		
Modify Colusa Weir to reduce fish stranding	0	X	0	0	0	0	0	**0**	0	**0**	0	3	0	3	1	**1.4**	7	**1.4**	-1	0	-1	**-0.5**	6	**0.9**	X		
Restore Natural Bank Habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X		
Eliminate (agricultural) control dikes and check dams	0	X	0	0	0	0	0	**0**	0	**0**	1	1	2	1	3	**1.6**	8	**1.6**	-2	0	-2	**-1.0**	6	**0.6**	X	X	
Improve fish screens	0	X	0	0	0	0	0	**0**	0	**0**	0	2	0	0	1	**0.6**	3	**0.6**	-1	0	-1	**-0.5**	2	**0.1**	X	X	
~~Detension basin(s)~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~1~~	~~**1**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~4~~	~~**1.75**~~	~~-2~~	~~-1.5~~	~~-3.5~~	~~**-1.8**~~	~~0.5~~	~~**0**~~		~~X~~	
~~Screen pump diversions (reduce impacts to fish)~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~3~~	~~0~~	~~0~~	~~1~~	~~**0.8**~~	~~4~~	~~**0.8**~~	~~-2~~	~~0~~	~~-2~~	~~**-1.0**~~	~~2~~	~~**-0.2**~~	~~X~~	~~X~~	
~~Reduce fish stranding~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~2~~	~~0~~	~~2~~	~~1~~	~~**1**~~	~~5~~	~~**1**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	~~2~~	~~**-0.5**~~	X		Modify low flows to reduce fish stranding.
~~Channel Improvements (Sediment Removal, others)~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-2~~	~~-3~~	~~-5~~	~~**-2.5**~~	~~-2~~	~~**-1.75**~~		~~X~~	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		~~X~~	
~~Weir improvements - FRM~~																											~~3B's Ranch Weir - increase elevation of weir so overflows into Butte Basin from the Sac River do NOT occur below flood stage. Also need to harden weir to prevent future degradation; would only provide localized benefits to one land owner and one road. No Federal Interest. - confirm this assumption~~
~~Improve Butte Slough Outfall gates~~																											~~Remove - already in construction~~
Cherokee Canal																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	**X**	**X**	Removal of Non native species may slightly reduce roughness and lower flood stages
Remove/reduce northern side of the levee to let water and sediment overflow on the northern-side and restore habitat	X	X	X	1	1	1	1	**1**	1	**1**	3	0	3	0	3	**1.8**	14	**3.8**	-3	0	-3	**-1.5**	11	**2.3**	X	X	
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Benefits public safety due to containmenated drinking water or water safety etc.

	Purposes			Effectiveness – Criteria – Flood Risk Management					WS		Ecosystem Restoration															
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	FRM Normalized	Increase reliability & availability of water supply	WS Normalized	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	ER Normalized	Criteria Ranking Score	Value Index Normalized	Magnitude of Costs	Level of mitigation	Total	Cost Normalized	Criteria and Efficiency Ranking Score	Overall Normalized	Conservation Strategy Features	Part of CVFPP	Notes
Restore damaged watershed which is sediment rich to prevent losing soils at current rate	X	i	X	1	0	0	1	0.5	1	1	0	0	0	1	1	0.4	5	1.9	-2	0	-2	-1.0	3	0.9			
Detension basins upstream of Cherokee Canal to capture mining sediment	X	0	X	1	0	0	1	0.5	1	1	0	0	0	1	1	0.4	5	1.9	-2	-1	-3	-1.5	2	0.4			
~~O&M Manual change~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0~~	~~1~~	~~0~~	~~2~~	~~1~~	~~5~~	~~1~~	~~-1~~	~~0~~	~~-1~~	~~-0.5~~	4				~~Changes to allow for more vegetation could be helpful~~
~~Restore habitat within the Cherokee Canal~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0.0~~	~~0~~	~~0~~		X	Infeasible on its own because Cherokee Canal clogs with sediment.
~~Channel Improvements - Reduce Road Crossing Capacity Constraints~~	~~X~~	~~i~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	~~1~~	~~0.4~~	~~5~~	~~1.15~~	~~-2~~	~~-2~~	~~-4~~	~~-2.0~~	~~1~~	~~-0.85~~	X	X	
~~Elongate canal to direct water from Feather River to the Butte Basin~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-2~~	~~-2~~	~~-4~~	~~-2.0~~	~~-1~~	~~-1.25~~		X	
~~Channel Improvements - Sediment Removal/Management~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-2.5~~	~~-2~~	~~-4.5~~	~~-2.3~~	~~-1.5~~	~~-1.5~~		X	re-evaluation of existing project; sediment deposition is in excess of estimated amounts; No fish assumed in Cherokee Canal; On-going O&M could be costly.
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-2~~	~~-3~~	~~-5~~	~~-2.5~~	~~-2~~	~~-1.75~~		X	
~~Divert flows from Oroville by modifying left-bank of Cherokee Canal~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-2~~	~~-5~~	~~-2.5~~	~~-2~~	~~-1.75~~			
Colusa Basin South Opportunity Area																											
Remove/reduce Colusa Basin Drain levee and reconnect to to West-side of the Sacramento River by removal or reduction of that levee	X	X	X	2	2	2	3	2.25	1	1	3	1	0	1	3	1.6	18	4.85	-3	0	-3	-1.5	15	3.35	X	X	Assume this is not SRA
Remove/reduce Colusa Basin Drain levee to allow water to flow across to the Sacramento River and drain south or setback a portion of Colusa Basin Drain Levee	X	X	X	2	2	2	3	2.25	1	1	3	1	0	1	3	1.6	18	4.85	-3	0	-3	-1.5	15	3.35	X		Assume this is not SRA
Set back some or a portion of Colusa Basin Drain levee	X	X	X	1	1	1	2	1.25	1	1	3	0	3	0	3	1.8	15	4.05	-2	0	-2	-1.0	13	3.05	X		Included in Conservation Strategy
Non-native removal/management	X	X	X	1	1	1	1	1	1	1	3	0	1	0	3	1.4	12	3.4	-1	0	-1	-0.5	11	2.9	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Set back some or a portion of Sacramento River west levee	X	X	X	1	1	1	2	1.25	1	1	3	0	3	0	3	1.8	15	4.05	-3	0	-3	-1.5	12	2.55	X		Included in Conservation Strategy
Enhance connectivity to/size of Colusa National Wildlife Refuge	0	X	X	0	0	0	2	0.5	1	1	3	0	0	0	2	1	8	2.5	-1	0	-1	-0.5	7	2	X	X	
Riparian habitat restoration (RD 108)		X	X	0	0	0	1	0.25	1	1	3	0	0	0	2	1	7	2.25	-1	0	-1	-0.5	6	1.75	X		Assume this is not SRA
Floodplain Management Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.45			
Flood Recovery Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.45		X	
Eliminate (agricultural) control dikes and check dams	0	X	0	0	0	0	0	0	0	0	1	1	2	1	3	1.6	8	1.6	-2	0	-2	-1.0	6	0.6	X		
Fish screen improvements	0	X	0	0	0	0	0	0	0	0	0	1	0	3	1	1	5	1	-1	0	-1	-0.5	4	0.5	X	X	
~~Reduce fish stranding~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0~~	~~2~~	~~1~~	~~1~~	~~5~~	~~1~~	~~-3~~	~~0~~	~~-3~~	~~-1.5~~	~~2~~	~~-0.5~~	~~X~~	~~X~~	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~1~~	~~0~~	~~1.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~1.75~~	~~-3~~	~~-2~~	~~-5~~	~~-2.5~~	~~2~~	~~-0.75~~		~~X~~	~~Could have a negative effect~~
Rec District 70-1660 Opportunity Area																											
Set back levees - multi-purpose	X	X	X	2	2	2	3	2.25	1	1	3	0	3	0	3	1.8	19	5.05	-3	0	-3	-1.5	16	3.55	X	X	

	Purposes			Effectiveness																						
				Criteria																						
				Flood Risk Management					WS		Ecosystem Restoration															
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	Criteria Ranking Score	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	Criteria and Efficiency Ranking Score	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Remove/reduce Eastern levee of the Sacramento River and/or Western levee of the Sutter Bypass	X	X	X	2	2	2	3	**2.25**	1	**1**	3	0	3	0	3	**1.8**	19	**5.05**	-3	0	-3	**-1.5**	16	**3.55**	X	X	
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Enhance connectivity to/size of Colusa & Sutter National Wildlife Area	0	X	X	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X		
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Benefits public safety due to containmenated drinking water or water safety etc.
Fish screen improvements	0	X	0	0	0	0	0	**0**	0	**0**	0	1	0	3	1	**1**	5	**1**	-1	0	-1	**-0.5**	4	**0.5**	X		
Eliminate (agricultural) control dikes and check dams	0	X	0	0	0	0	0	**0**	0	**0**	1	1	2	1	3	**1.6**	8	**1.6**	-2.5	0	-2.5	**-1.3**	5.5	**0.35**	X		
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~1~~	~~0~~	~~**1.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~5~~	~~**1.25**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	~~2~~	~~**-0.25**~~		X	Rural area
~~Reduce fish stranding~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~2~~	~~0~~	~~2~~	~~1~~	~~**1**~~	~~5~~	~~**1**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	~~2~~	~~**-0.5**~~	X	X	
~~Increase groundwater infiltration~~																											Can happen as benefit of widening floodplain, allowing water to reach more areas over medium-high groundwater infiltration areas
~~Raise/strengthen existing levees~~	~~X~~																										Erase - repeat
Sutter Bypass Opportunity Area																											
Widen bypass and restore riparian habitat	X	X	X	3	3	3	3	**3**	1	**1**	2	0	2	0	3	**1.4**	20	**5.4**	-3	0	-3	**-1.5**	17	**3.9**	X	X	Highs for system benefits; High for wise use of floodplains due to parcels taken out of development and put within floodway
Set back levees - multi-purpose	X	X	X	2	2	2	2	**2**	1	**1**	2	0	2	0	3	**1.4**	16	**4.4**	-3	0	-3	**-1.5**	13	**2.9**	X	X	Same logic as Butte Basin
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Remove/reduce levees	0	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	2	**1.6**	15	**4.1**	-3	0	-3	**-1.5**	12	**2.6**	X	X	Wise use score of high due to potential to get easement up to all ag land in basin
Enhance connection to/size of Sutter National Wildlife Refuge (Sutter Bypass)	0	X	X	0	0	0	1	**0.25**	1	**1**	3	0	0	0	3	**1.2**	8	**2.45**	-1	0	-1	**-0.5**	7	**1.95**	X	X	
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			
Improve existing fish passage	0	X	0	0	1	0	0	**0.25**	0	**0**	0	2	0	2	1	**1**	6	**1.25**	-1.5	0	-1.5	**-0.8**	4.5	**0.5**	X	X	
Restore perennial marsh habitat	0	X	0	0	0	0	0	**0**	0	**0**	2	0	0	0	3	**1**	5	**1**	-1	0	-1	**-0.5**	4	**0.5**	X	X	
~~Plant new riparian habitat~~	~~0~~	~~X~~	~~X~~														0						~~0~~	~~**0**~~			
~~Remove barriers to fish passage~~		~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~2~~	~~0~~	~~2~~	~~1~~	~~**1**~~	~~5~~	~~**1**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	~~2~~	~~**-0.5**~~	X	X	
~~Increase enforcement of O&M requirements to maintain flood risk capacity within refuge~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~-1~~	~~0~~	~~-1~~	~~**-0.5**~~	~~-1~~	~~**-0.5**~~			
~~Channel Improvements - Sediment Removal~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~-2~~	~~0~~	~~-2~~	~~**-1.0**~~	~~-2~~	~~**-1**~~		X	~~localized benefits, not enough to justify federal interest; however, could be borrow source for other need~~
Tisdale Bypass Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		Removal of Non native species may slightly reduce roughness and lower flood stages

Features	Effectiveness: Purposes: Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Criteria: Flood Risk Management: Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	WS: Increase reliability & availability of water supply	**WS Normalized**	Ecosystem Restoration: Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	Criteria Ranking Score	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	Criteria and Efficiency Ranking Score	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Widen bypass and restore riparian habitat	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	3	**1.8**	16	**4.3**	-3	0	-3	**-1.5**	13	**2.8**	X	X	
Create new perennial marsh habitat	0	X	0	0	0	0	0	**0**	0	**0**	2	0	0	0	3	**1**	5	**1**	-1	0	-1	**-0.5**	4	**0.5**	X		Pacific Flyway
~~Remove barriers to fish passage~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~3~~	~~0~~	~~3~~	~~1~~	~~**1.4**~~	~~7~~	~~**1.4**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	4	~~**-0.1**~~	X		
~~Plant new riparian habitat~~																											
Rec District 1500 Opportunity Area																											
Remove or reduce Eastern levee of the Sacramento River and/or Western levee of the Sutter Bypass	X	X	X	2	2	2	3	**2.25**	2	**2**	3	0	3	0	2	**1.6**	19	**5.85**	-3	0	-3	**-1.5**	16	**4.35**	X	X	
Set back levees - multi-purpose	X	X	X	2	2	2	3	**2.25**	1	**1**	3	0	3	0	3	**1.8**	19	**5.05**	-3	0	-3	**-1.5**	16	**3.55**	X	X	Included in Conservation Strategy
Remove barriers to channel migration	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	3	**1.8**	16	**4.3**	-2	0	-2	**-1.0**	14	**3.3**	X	X	Assume this is removal of riprap
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	
Restore riparian habitat	0	X	0	0	0	0	1	**0.25**	1	**1**	3	0	0	0	2	**1**	7	**2.25**	-1	0	-1	**-0.5**	6	**1.75**	X	X	Assume this is not SRA
Floodplain Management Plan	X	i	X	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	X	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Benefits public safety due to containmenated drinking water or water safety etc.
Restore Natural Bank Habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X	X	Assume this will not improve fish passage, only be alongside the stream
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	**0.75**	~~0~~	**0**	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	**0**	3	**0.75**	~~-3~~	~~-3~~		**-3.0**	3	**-2.25**		X	~~Could have a negative effect~~
Levee District 1 Opportunity Area																											
Transitory storage at Southern tip	X	X	X	2	2	2	3	**2.25**	2	**2**	3	0	1	0	2	**1.2**	17	**5.45**	-2.5	0	-2.5	**-1.3**	14.5	**4.2**	X	X	
Reconnect flood plain by removing barriers to channel migration (i.e. levees, etc.)	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	3	**1.8**	16	**4.3**	-2	0	-2	**-1.0**	14	**3.3**	X	?	
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	
Restore riverine habitat	0	X	0	0	0	0	1	**0.25**	1	**1**	1	1	1	1	3	**1.4**	9	**2.65**	-1	0	-1	**-0.5**	8	**2.15**	X	X	
Enhance/restore connection to preserved areas within the Feather River levees	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	2	**1**	5	**1**	-1	0	-1	**-0.5**	4	**0.5**	X	X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		X	~~Most of the Feather river levees are assumed to be strengthened in recently authorized/contructed projects; remaining FRM risks relatively low~~
Sycamore Slough																											
~~Non-native removal/management~~	~~X~~	~~X~~	~~X~~	~~1~~	~~1~~	~~1~~	~~1~~	~~**1**~~	~~1~~	~~**1**~~	~~3~~	~~0~~	~~1~~	~~0~~	~~3~~	~~**1.4**~~	~~12~~	~~**3.4**~~	~~-1~~	~~0~~	~~-1~~	~~**-0.5**~~	~~11~~	~~**2.9**~~	X		~~Screened out; does not stand alone with only non-native removal. Could include if required for success of restoration in downstream opportunity area~~
Rec District 1001 Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	Removal of Non native species may slightly reduce roughness and lower flood stages
Set back levees - multi-purpose (Bear Creek South levee)	X	X	X	1	1	1	3	**1.5**	1	**1**	3	0	3	0	3	**1.8**	16	**4.3**	-3	0	-3	**-1.5**	13	**2.8**	X	X	
Restore riparian habitat	0	X	X	0	0	0	3	**0.75**	1	**1**	1	0	0	0	2	**0.6**	7	**2.35**	-1	0	-1	**-0.5**	6	**1.85**	X	?	Assume this is not SRA

	Purposes			Effectiveness – Criteria – Flood Risk Management					WS		Ecosystem Restoration						Criteria Ranking Score						Criteria and Efficiency Ranking Score				
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**		**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**		**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**		?	Benefits public safety due to containmenated drinking water or water safety etc.
Restore shaded riverine aquatic habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	1	0	3	**1.4**	7	**1.4**	-1	0	-1	**-0.5**	6	**0.9**	X	?	
Restore Natural Bank Habitat	0	X	0	0	0	0	0	**0**	0	**0**	1	0	0	0	3	**0.8**	4	**0.8**	-1	0	-1	**-0.5**	3	**0.3**	X	X	Assume this will not improve fish passage, only be alongside the stream
~~Ground water infiltration~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~**0.0**~~	~~0~~	~~**0**~~			Can happen as benefit of widening floodplain, allowing water to reach more areas over medium-high groundwater infiltration areas. Not a stand-alone measure; not a planning measure by Corps definitions. Screened out.
~~Channel Improvements - Weir Removal~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~3~~	~~0~~	~~3~~	~~0~~	~~1~~	~~**1.4**~~	~~7~~	~~**1.4**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	4	~~**-0.1**~~	X	?	Assume no replacement
~~Revetment removal~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~1~~	~~0~~	~~1~~	~~0~~	~~1~~	~~**0.6**~~	~~3~~	~~**0.6**~~	~~-1.5~~	~~0~~	~~-1.5~~	~~**-0.8**~~	~~1.5~~	~~**-0.15**~~	X		
~~Upgrade/Repair Flood Facilities - Main Drain Pumping Plant~~	~~X~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	~~**0.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~1~~	~~**0.25**~~	~~-1~~	~~-1~~	~~-2~~	~~**-1.0**~~	~~-1~~	~~**-0.75**~~		X	Screened out; negative overall score
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		X	Rural, agricultural area with little development; could have negative effects on ecosystem; Screened out; negative overall score
~~Reduce/remove levees~~																											Infeasible from FRM perspective because water will end up in Sacramento River that should be directed to the bypass, thereby increasing flood risks. Screened out.
Ridge Cut (North) Opportunity Area																											
Remove barriers to channel migration	X	X	X	1	1	1	2	**1.25**	1	**1**	3	0	3	0	3	**1.8**	15	**4.05**	-2	0	-2	**-1.0**	13	**3.05**	X	X	Assume this is removal of riprap
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Increase/enhance connection to Fremont Weir State Wildlife Area	0	X	X	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X		
Reduce/remove interior levees on the West-side of Sac River/East-side of Ridge Cut	X	X	X	1	1	1	3	**1.5**	1	**1**	1	0	1	0	2	**0.8**	11	**3.3**	-2.5	0	-2.5	**-1.3**	8.5	**2.05**	X		
Restore riparian habitat	0	X	X	0	0	0	3	**0.75**	1	**1**	1	0	0	0	2	**0.6**	7	**2.35**	-1	0	-1	**-0.5**	6	**1.85**	X		
Restore shaded riverine aquatic habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X		
Restore Natural Bank Habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X		Assume this will not improve fish passage, only be alongside the stream
Modify structure to reduce/eliminate fish stranding in Ridge Cut	0	X	0	0	0	0	0	**0**	0	**0**	0	3	0	3	1	**1.4**	7	**1.4**	-2.5	0	-2.5	**-1.3**	4.5	**0.15**	X		
Elkhorn Opportunity Area																											
Set back East Yolo Bypass levee - multi-purpose to match length of new Front Weir.	X	X	X	2	2	2	3	**2.25**	1	**1**	3	0	3	0	3	**1.8**	19	**5.05**	-3	0	-3	**-1.5**	16	**3.55**	X	X	
Remove/reduce East Yolo Bypass levee and allow all of Elkhorn to flood - multi-purpose	X	X	X	2	2	2	3	**2.25**	1	**1**	3	0	3	0	2	**1.6**	18	**4.85**	-3	0	-3	**-1.5**	15	**3.35**	X	X	
Remove/reduce West Sacramento River levee - multi-purpose	X	X	X	2	2	2	3	**2.25**	1	**1**	3	0	3	0	2	**1.6**	18	**4.85**	-3	0	-3	**-1.5**	15	**3.35**	X	X	

Features	Purposes: Flood Risk Management	Purposes: Ecosystem Restoration	Purposes: Water Supply/ Conservation	Effectiveness – Criteria – Flood Risk Management: Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	FRM Normalized	WS: Increase reliability & availability of water supply	WS Normalized	Ecosystem Restoration: Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	ER Normalized	Criteria Ranking Score	Value Index Normalized	Magnitude of Costs	Level of mitigation	Total	Cost Normalized	Criteria and Efficiency Ranking Score	Overall Normalized	Conservation Strategy Features	Part of CVFPP	Notes
Set back Yolo Bypass levee to improve fish passage	X	X	X	2	2	2	3	**2.25**	1	**1**	3	0	3	0	1	**1.4**	17	**4.65**	-3	0	-3	**-1.5**	14	**3.15**	X	X	
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Remove barriers to channel migration	X	X	X	0	0	0	3	**0.75**	1	**1**	3	0	3	0	3	**1.8**	13	**3.55**	-2	0	-2	**-1.0**	11	**2.55**	X	X	
Restore riparian habitat	0	X	0	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X	X	
Restore shaded riverine aquatic habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X	X	In Conservation Strategy and BiOps for State Water Project
Restore Natural Bank Habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	0	0	3	**1.2**	6	**1.2**	-1	0	-1	**-0.5**	5	**0.7**	X	X	
Fish passage at Fremont Weir	0	X	0	0	0	0	0	**0**	0	**0**	0	3	0	3	1	**1.4**	7	**1.4**	-2.5	0	-2.5	**-1.3**	4.5	**0.15**	X	X	
Change floodplain to improve fish passage	0	X	0	0	0	0	0	**0**	0	**0**	2	0	2	3	1	**1.6**	8	**1.6**	-3	0	-3	**-1.5**	5	**0.1**	X	X	
~~Improve O&M Management Coordination~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~-1~~	~~0~~	~~-1~~	~~-0.5~~	~~-1~~	~~-0.5~~			Not planning feature; other consideration for regulatory/ops; Screened out
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-3~~	~~-2.25~~			Screened out; negative overall score
Rio Linda Opportunity Area																											
Setback levee - multi-purpose	X	X	X	2	2	2	3	**2.25**	1	**1**	3	0	0	0	2	**1**	15	**4.25**	-2	0	-2	**-1.0**	13	**3.25**	X		
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		Removal of Non native species may slightly reduce roughness and lower flood stages
Improve spawning habitat for native fish	0	X	0	0	0	0	0	**0**	0	**0**	3	3	1	3	1	**2.2**	11	**2.2**	-1	0	-1	**-0.5**	10	**1.7**	X		
Restore riparian habitat	0	X	X	0	0	0	1	**0.25**	1	**1**	1	0	0	0	2	**0.6**	5	**1.85**	-1	0	-1	**-0.5**	4	**1.35**	X		Assume this is not SRA
~~Improve fish passage~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~3~~	~~1~~	~~1~~	~~5~~	~~1~~	~~-2.5~~	~~0~~	~~-2.5~~	~~-1.3~~	~~2.5~~	~~-0.25~~	X		
Rec District 2035 Opportunity Area																											
Widen bypass by setting back West Yolo Bypass levee across from Elkhorn Basin North of Willow Slough Bypass and restore native habitat	X	X	X	3	3	1	3	**2.5**	1	**1**	3	0	3	0	3	**1.8**	20	**5.3**	-3	0	-3	**-1.5**	17	**3.8**	X	X	Included in Conservation Strategy
Widen by setting back West Yolo Bypass levee East of Davis and restore native habitat	X	X	X	3	3	1	3	**2.5**	1	**1**	3	0	3	0	3	**1.8**	20	**5.3**	-3	0	-3	**-1.5**	17	**3.8**	X	X	
Remove/reduce West Yolo Bypass levee to widen and restore native habitat	X	X	X	3	3	1	3	**2.5**	1	**1**	3	0	3	0	3	**1.8**	20	**5.3**	-3	0	-3	**-1.5**	17	**3.8**	X	X	
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	
Improve fish passage in Yolo Bypass in either or both directions (N/S of Willow Slough)	0	X	0	0	0	0	0	**0**	0	**0**	0	3	0	3	1	**1.4**	7	**1.4**	-2.5	0	-2.5	**-1.3**	4.5	**0.15**	X	X	
~~Update O&M Manuals~~	~~X~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0~~	~~1~~	~~0~~	~~3~~	~~1.2~~	~~6~~	~~1.2~~	~~-1~~	~~0~~	~~-1~~	~~-0.5~~	~~5~~	~~0.7~~			Changes to allow for more vegetation could be helpful
~~Increase groundwater infiltration~~	~~0~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0.0~~	~~0~~	~~0~~			Can happen as benefit of widening floodplain, allowing water to reach more areas over medium-high groundwater infiltration areas. Not a stand-alone measure by Corps definitions. Screened out.
~~Remove/reduce barriers to fish passage~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~1~~	~~1~~	~~0.6~~	~~3~~	~~0.6~~	~~-2.5~~	~~0~~	~~-2.5~~	~~-1.3~~	~~0.5~~	~~-0.65~~	X	X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~1~~	~~0~~	~~1.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~1.75~~	~~-3~~	~~-2~~	~~-5~~	~~-2.5~~	~~2~~	~~-0.75~~		X	Could have a negative effect on ecosystem
East of Davis - North Opportunity Area																											
Set back levee - multi-purpose	X	X	X	2	2	1	3	**2**	1	**1**	2	0	2	0	3	**1.4**	16	**4.4**	-3	0	-3	**-1.5**	13	**2.9**	X	?	
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	
Restore riparian habitat	0	X	X	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X	X	Assume this is not SRA
East of Davis - South Opportunity Area																											

Features	Purposes: Flood Risk Management	Purposes: Ecosystem Restoration	Purposes: Water Supply/ Conservation	Effectiveness – Criteria – Flood Risk Management: Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	WS: Increase reliability & availability of water supply	**WS Normalized**	Ecosystem Restoration: Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	**Criteria Ranking Score**	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	**Criteria and Efficiency Ranking Score**	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	14	**3.4**	-1	0	-1	**-0.5**	13	**2.9**	X	X	Removal of Non native species may slightly reduce roughness and lower flood stages
Potential to expand bypass and/or connect with Putah Creek and restore native habitat	X	X	X	2	2	1	3	**2**	1	**1**	3	0	0	0	2	**1**	17	**4**	-3	0	-3	**-1.5**	14	**2.5**	X	X	
Enahance connection to and/or enlarge the Putah Creek preserve	0	X	X	0	0	0	3	**0.75**	1	**1**	1	0	0	0	2	**0.6**	8.75	**2.35**	-1	0	-1	**-0.5**	7.75	**1.85**	X	?	
Putah Creek Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	
Restore riparian habitat	0	X	X	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X	X	Assume this is not SRA
Restore native fish habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	1	**1.4**	7	**1.4**	-1	0	-1	**-0.5**	6	**0.9**	X		Remove/reduce a barrier at the Yolo Bypass and allow more channel morphology to develop
~~O&M Manual Update~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	**0**	~~0~~	**0**	~~2~~	~~0~~	~~1~~	~~0~~	~~1~~	**0.8**	4	**0.8**	~~-1~~	~~0~~	-1	**-0.5**	3	**0.3**		X	Changes to allow for more vegetation could be helpful; Not a planning measure by Corps definition; Screened out. To be discussed in "Other Considerations" Section
~~Improve/restore channel capacity~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~1~~	~~0~~	~~**1.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~5~~	~~**1.25**~~	~~-2~~	~~-3~~	~~-5~~	~~**-2.5**~~	~~0~~	~~**-1.25**~~	~~X~~		Screened out; net score of 0
Yolo Bypass Opportunity Area																											
Set back West Yolo Bypass levees - multi-purpose	X	X	X	2	2	1	3	**2**	1	**1**	3	0	3	0	3	**1.8**	18	**4.8**	-3	0	-3	**-1.5**	15	**3.3**	X	X	
Reduce/remove West Yolo levee Northwest of Walnut Grove - multi-purpose	X	X	X	2	2	1	3	**2**	1	**1**	3	0	3	0	3	**1.8**	18	**4.8**	-3	0	-3	**-1.5**	15	**3.3**	X	X	
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	X	
Restore marsh habitat	0	X	0	0	0	0	3	**0.75**	1	**1**	3	0	0	0	3	**1.2**	10	**2.95**	-1	0	-1	**-0.5**	9	**2.45**	X	X	
Reduce/remove non-federal levee embankment at Egbert Tract to resore that area	0	X	X	0	0	0	3	**0.75**	1	**1**	3	0	3	0	3	**1.8**	13	**3.55**	-2.5	0	-2.5	**-1.3**	10.5	**2.3**	X	X	
Restore riparian habitat	0	X	0	0	0	0	3	**0.75**	1	**1**	3	0	0	0	2	**1**	9	**2.75**	-1	0	-1	**-0.5**	8	**2.25**	X	X	
Increase native fish habitat	0	X	0	0	0	0	0	**0**	0	**0**	3	1	1	2	1	**1.6**	8	**1.6**	-1	0	-1	**-0.5**	7	**1.1**	X	X	
Low flow channel creation for fish habitat and passage (along East-side of bypass)	0	X	0	0	0	0	0	**0**	0	**0**	0	3	0	3	1	**1.4**	7	**1.4**	-2	0	-2	**-1.0**	5	**0.4**	X		Connect from Fremont weir to ponds about 3000 feet south and on to Tule Canal
Manage the locks for fish passage/habitat improvements	0	X	0	0	0	0	0	**0**	0	**0**	0	0	0	3	1	**0.8**	4	**0.8**	-1	0	-1	**-0.5**	3	**0.3**	X	X	
~~Encroachment modifications~~	~~X~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	~~**0.25**~~	~~0~~	~~**0**~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0.2**~~	~~2~~	~~**0.45**~~	~~-1~~	~~0~~	~~-1~~	~~**-0.5**~~	~~1~~	~~**-0.05**~~		X	
~~Remove/reduce barriers to improve fish passage~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~2~~	~~0~~	~~2~~	~~1~~	~~**1**~~	~~5~~	~~**1**~~	~~-2.5~~	~~0~~	~~-2.5~~	~~**-1.3**~~	~~2.5~~	~~**-0.25**~~	X	X	
~~Reduce/remove chevron (staircase) levees~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~2~~	~~0~~	~~2~~	~~1~~	~~**1**~~	~~5~~	~~**1**~~	~~-2.5~~	~~0~~	~~-2.5~~	~~**-1.3**~~	~~2.5~~	~~**-0.25**~~	X	X	
~~O&M Manual/Management Change~~	~~X~~	~~X~~	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	~~**0.25**~~	~~0~~	~~**0**~~	~~2~~	~~0~~	~~1~~	~~0~~	~~1~~	~~**0.8**~~	~~5~~	~~**1.05**~~	~~-1~~	~~0~~	~~-1~~	~~**-0.5**~~	4	**0.55**			Changes to allow for more vegetation could be helpful
~~Rio Vista Floodwall Pump Station~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~**0.0**~~	~~0~~	~~**0**~~		X	Not stand-alone measure; would build in combination with floodwall. Added to Rio Vista Waterfront floodwall feature; Screened out.
~~Improve Rio Vista Drainage~~	~~X~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	~~**0.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~1~~	~~**0.25**~~	~~-1~~	~~-1~~	~~-2~~	~~**-1.0**~~	~~-1~~	~~**-0.75**~~			Screened out; negative score
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~2~~	~~0~~	~~**2**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~8~~	~~**2**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~2~~	~~**-1**~~		X	

Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	FRM Normalized	Increase reliability & availability of water supply	WS Normalized	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	ER Normalized	Criteria Ranking Score	Value Index Normalized	Magnitude of Costs	Level of mitigation	Total	Cost Normalized	Criteria and Efficiency Ranking Score	Overall Normalized	Conservation Strategy Features	Part of CVFPP	Notes
	Purposes			Effectiveness – Criteria – Flood Risk Management					WS		Ecosystem Restoration																
~~Ship channel closure structure and diversion/weir to pass flood flows through the ship channel when needed~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0.5~~	~~-3~~	~~0~~	~~-3~~	~~-1.5~~	~~-1~~	~~-1~~		X	Per DES fishery experts, no conservation benefits are associated with sending additional flood flows down the DWSC as there are too many assumptions and uncertainties related to that action.
~~Bank protection~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~1~~	~~0~~	~~2~~	~~0.8~~	~~4~~	~~0.8~~	~~-1.5~~	~~-2.5~~	~~-4~~	~~-2.0~~	~~0~~	~~-1.2~~		X	Screened out; negative score
Stone Lake Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	1	1	1	3	0	1	0	3	1.4	12	3.4	-1	0	-1	-0.5	11	2.9	X	?	
Improve/increase size of/increase connection to Stone Lake preserve	0	X	X	0	0	0	3	0.75	1	1	3	0	0	0	2	1	9	2.75	-1	0	-1	-0.5	8	2.25	X		
~~Restore habitat to potentially increase size of Stone Lake preserve~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0.0~~	~~0~~	~~0~~			Combined into one feature to improve/increase size of/increase connection to Stone Lake Preserve b/c not uniquely different; Remove this row b/c duplicate to above feature
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~3~~	~~0~~	~~2.25~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~9~~	~~2.25~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~3~~	~~-0.75~~		X	Could have a negative effect on ecosystem
Rec Dist 302 Opportunity Area																											
~~Non-native removal/management~~	~~X~~	~~X~~	~~X~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~3~~	~~0~~	~~1~~	~~0~~	~~3~~	~~1.4~~	~~12~~	~~3.4~~	~~-1~~	~~0~~	~~-1~~	~~-0.5~~	~~11~~	~~2.9~~	X	?	Would only work in this opportunity area if downstream restoration was dependent upon removal of invasive seed sources from this area; not a stand-alone feature; Screened out
Rec Dist 999 Opportunity Area																											
Riparian habitat Restoration	0	X	X	0	0	0	3	0.75	1	1	3	0	0	0	2	1	9	2.75	-1	0	-1	-0.5	8	2.25	X		
Install a weir in West-side levee that would dump water East of levee (to provide water for habitat restoration) and restore habitat	0	X	X	0	0	0	1.5	0.375	1	1	3	0	3	0	3	1.8	11.5	3.175	-2	0	-2	-1.0	9.5	2.175	X		
Non-native removal/management	X	X	X	1	1	1	1	1	0	0	3	0	1	0	3	1.4	11	2.4	-1	0	-1	-0.5	10	1.9	X	?	
Floodplain Management Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.45		X	
Flood Recovery Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.45			
Bank Protection	X	0	0	1	1	1	0	0.75	0	0	1	0	1	0	2	0.8	7	1.55	-1.5	0	-1.5	-0.8	5.5	0.8			
Manage the locks for fish passage/habitat improvements	0	X	0	0	0	0	0	0	0	0	0	0	0	3	1	0.8	4	0.8	-1	0	-1	-0.5	3	0.3	X	X	
~~Groundwater recharge~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0.0~~	~~0~~	~~0~~			Can happen as benefit of widening floodplain, allowing water to reach more areas over medium-high groundwater infiltration areas. Not a stand-alone measure
~~Ship channel closure structure and diversion/weir to pass flood flows through the ship channel when needed~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0.5~~	~~0~~	~~0~~	~~1~~	~~1~~	~~0~~	~~1~~	~~1~~	~~0.8~~	~~6~~	~~1.3~~	~~-3~~	~~0~~	~~-3~~	~~-1.5~~	~~3~~	~~-0.2~~		X	
~~Bypass to take water off of Sacramento River and put it in the ship channel~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0.5~~	~~-3~~	~~0~~	~~-3~~	~~-1.5~~	~~-1~~	~~-1~~		X	Per DES fishery experts, no conservation benefits are associated with sending additional flood flows down the DWSC as there are too many assumptions and uncertainties related to that action.
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-3~~	~~-2.25~~		X	Screened out; negative score
Merritt Island Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	1	0	0	3	0	1	0	3	1.4	11	2.4	-1	0	-1	-0.5	10	1.9	X	?	
Open up and restore Merritt Island by removal/reduction of levees	0	X	0	0	0	0	3	0.75	0	0	3	0	0	0	3	1.2	9	1.95	-2	0	-2	-1.0	7	0.95	X		
Increase fish habitat ~~and improve fish passage~~	0	X	0	0	0	0	0	0	0	0	3	0	3	0	1	1.4	7	1.4	-1	0	-1	-0.5	6	0.9			
Bank protection	X	0	0	1	1	1	0	0.75	0	0	1	0	1	0	2	0.8	7	1.55	-2	0	-2	-1.0	5	0.55		X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-3~~	~~-2.25~~		X	

	Purposes			Effectiveness: Criteria: Flood Risk Management					WS		Ecosystem Restoration															
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	**Criteria Ranking Score**	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	**Criteria and Efficiency Ranking Score**	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Cache Slough Opportunity Area																											
~~Non-native removal/management~~	~~X~~	~~X~~	~~X~~	~~1~~	~~1~~	~~0~~	~~1~~	**0.75**	~~1~~	**1**	~~3~~	~~0~~	~~1~~	~~0~~	~~3~~	**1.4**	11	**3.15**	-1	0	-1	**-0.5**	10	**2.65**	X	X	Would only work in this opportunity area if downstream restoration was dependent upon removal of invasive seed sources from this area; not a stand-alone feature; Screened out
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		X	Screened out; negtive net score
Hastings Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	
Bank protection	X	0	0	1	1	1	0	**0.75**	0	**0**	1	0	1	0	2	**0.8**	7	**1.55**	-2	0	-2	**-1.0**	5	**0.55**		X	
Lindsey Slough Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.5**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Benefits public safety due to containmenated drinking water or water safety etc.
Bank protection	X	0	0	1	1	1	0	**0.75**	0	**0**	1	0	1	0	2	**0.8**	7	**1.55**	-2	0	-2	**-1.0**	5	**0.55**		X	
~~Rio Vista Waterfront Floodwall and pump station~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~2~~	~~0~~	~~**2**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~8~~	~~**2**~~	~~-2~~	~~-2.5~~	~~-4.5~~	~~**-2.3**~~	~~3.5~~	~~**-0.25**~~		X	
~~Highway 84 Closure Structure~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~3~~	~~0~~	~~**1.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~7~~	~~**1.75**~~	~~-2~~	~~-2~~	~~-4~~	~~**-2.0**~~	~~3~~	~~**-0.25**~~		X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		X	~~Could have a negative effect on ecosystem~~
Moore Opportunity Area																											
~~Non-native removal/management~~	~~X~~	~~X~~	~~X~~	~~1~~	~~1~~	~~1~~	~~1~~	**1**	~~1~~	**1**	~~3~~	~~0~~	~~1~~	~~0~~	~~3~~	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	Would only work in this opportunity area if downstream restoration was dependent upon removal of invasive seed sources from this area; not a stand-alone feature; Screened out
Rec Dist 551 Opportunity Area																											
Non-native removal/management	~~X~~	~~X~~	~~X~~	~~1~~	~~1~~	~~1~~	~~1~~	**1**	~~1~~	**1**	~~3~~	~~0~~	~~1~~	~~0~~	~~3~~	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	Would only work in this opportunity area if downstream restoration was dependent upon removal of invasive seed sources from this area; not a stand-alone feature
Floodplain Management Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.5**		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	**0.75**	0	**0**	1	1	0	1	3	**1.2**	9	**1.95**	-1	0	-1	**-0.5**	8	**1.45**			Benefits public safety due to containmenated drinking water or water safety etc.
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		X	~~Could have a negative effect on ecosystem~~
Sutter Island Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	
Open up and restore Sutter Island by removal/reduction of levees	0	X	0	0	0	0	3	**0.75**	0	**0**	3	0	0	0	3	**1.2**	9	**1.95**	-2	0	-2	**-1.0**	7	**0.95**	X		
Increase fish habitat and improve fish passage	0	X	0	0	0	0	0	**0**	0	**0**	3	0	3	0	1	**1.4**	7	**1.4**	-2	0	-2	**-1.0**	5	**0.4**	X		
~~Raise/strengthen existing levees~~	~~0~~	~~X~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		X	~~Could have a negative effect on ecosystem~~
Prospect Island Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X	?	
Manage the locks for fish passage/habitat improvements	0	X	0	0	0	0	0	**0**	0	**0**	0	0	0	3	1	**0.8**	4	**0.8**	-1	0	-1	**-0.5**	3	**0.3**	X		

	Purposes			Effectiveness																							
				Criteria																							
				Flood Risk Management					WS		Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	**Criteria Ranking Score**	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	**Criteria and Efficiency Ranking Score**	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
~~Ship channel closure structure and diversion/weir to pass flows through the ship channel when needed~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0.5~~	~~-3~~	~~0~~	~~-3~~	~~-1.5~~	~~-1~~	~~-1~~		X	Per DES fishery experts, no conservation benefits are associated with sending additional flood flows down the DWSC as there are too many assumptions and uncertainties related to that action.
Ryer Island Opportunity Area																											
Non-native removal/management	X	X	X	1	1	1	1	1	1	1	3	0	1	0	3	1.4	12	3.4	-1	0	-1	-0.5	11	2.9	X	?	
Manage the locks for fish passage/habitat improvements	0	X	0	0	0	0	0	0	0	0	0	0	0	3	1	0.8	4	0.8	-1	0	-1	-0.5	3	0.3	X		
~~Ship channel closure structure and diversion/weir to pass flood flows through the ship channel when needed~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0.5~~	~~-3~~	~~0~~	~~-3~~	~~-1.5~~	~~-1~~	~~-1~~		X	~~Per DES fishery experts, no conservation benefits are associated with sending additional flood flows down the DWSC as there are too many assumptions and uncertainties related to that action.~~
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~1~~	1	~~0~~	0	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	0	4	1	~~-3~~	~~-3~~	-6	-3.0	-2	-2		X	
Grand Island Opportunity Area																											
Floodplain Management Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.5		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.45			Benefits public safety due to containmenated drinking water or water safety etc.
Non-native removal/management	X	X	X	0	0	0	1	0.25	0	0	3	0	1	0	3	1.4	8	1.65	-1	0	-1	-0.5	7	1.15	X	?	
Encroachment modifications	X	0	0	1	1	1	0	0.75	0	0	1	0	0	0	0	0.2	4	0.95	-1	0	-1	-0.5	3	0.45		X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-3~~	~~-2.25~~		X	~~Could have a negative effect to the ecosystem~~
Andrus Island Opportunity Area																											
Floodplain Management Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.5		X	Potentially high net FRM benefit because of low cost relative to risk reduction.
Flood Recovery Plan	X	i	0	1	1	0	1	0.75	0	0	1	1	0	1	3	1.2	9	1.95	-1	0	-1	-0.5	8	1.45			Benefits public safety due to containmenated drinking water or water safety etc.
Restore channel margin habitat	0	X	0	0	0	0	0	0	0	0	3	0	3	0	3	1.8	9	1.8	-1	0	-1	-0.5	8	1.3	X	?	
Non-native removal/management	X	X	X	0	0	0	1	0.25	0	0	3	0	1	0	3	1.4	8	1.65	-1	0	-1	-0.5	7	1.15	X		
Remove/modify obstructions - drainage improvement	X	0	0	1	1	0	0	0.5	0	0	0	3	0	0	0	0.6	5	1.1	-2	0	-2	-1.0	3	0.1		X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-3~~	~~-2.25~~		X	~~Could have a negative effect on the ecosystem~~
Tyler Island Opportunity Area																											
Non-native removal/management	X	X	X	0	0	0	1	0.25	0	0	3	0	1	0	3	1.4	8	1.65	-1	0	-1	-0.5	7	1.15	X	?	
Riparian habitat restoration	0	X	0	0	0	0	3	0.75	0	0	1	0	0	0	2	0.6	6	1.35	-1	0	-1	-0.5	5	0.85	X	X	Assume this is not SRA
~~Bank protection~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0.6~~	~~6~~	~~1.35~~	~~-2~~	~~-2~~	~~-4~~	~~-2.0~~	~~2~~	~~-0.65~~		X	
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-3~~	~~-2.25~~		X	~~Could have a negative effect on ecosystem~~
Twitchell Island Opportunity Area																											
Non-native removal/management	X	X	X	0	0	0	1	0.25	1	1	3	0	1	0	3	1.4	9	2.65	-1	0	-1	-0.5	8	2.15	X		
Set back levees and establish channel margin habitat (multi-purpose)	X	X	X	1	1	1	3	1.5	0	0	2	0	2	0	3	1.4	13	2.9	-3	0	-3	-1.5	10	1.4	X	?	
Restore freshwater perennial marsh habitat	0	X	0	0	0	0	3	0.75	0	0	3	0	0	0	2	1	8	1.75	-1	0	-1	-0.5	7	1.25	X		
Restore riparian forest/scrub shrub habitat	0	X	0	0	0	0	3	0.75	0	0	2	0	0	0	2	0.8	7	1.55	-1	0	-1	-0.5	6	1.05	X		
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0.75~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0.75~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~-3~~	~~-2.25~~		X	~~Assume on-island~~
Sherman Island Opportunity Area																											

Features	Purposes: Flood Risk Management	Purposes: Ecosystem Restoration	Purposes: Water Supply/ Conservation	Effectiveness – Criteria – Flood Risk Management: Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	WS: Increase reliability & availability of water supply	**WS Normalized**	Ecosystem Restoration: Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	Criteria Ranking Score	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	Criteria and Efficiency Ranking Score	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Non-native removal/management	X	X	X	1	1	1	1	**1**	1	**1**	3	0	1	0	3	**1.4**	12	**3.4**	-1	0	-1	**-0.5**	11	**2.9**	X		
Restore freshwater perennial marsh habitat	0	X	0	0	0	0	3	**0.75**	0	**0**	3	0	0	0	2	**1**	8	**1.75**	-1	0	-1	**-0.5**	7	**1.25**	X		Assume on-island
Restore riparian forest/scrub shrub habitat	0	X	0	0	0	0	3	**0.75**	0	**0**	2	0	0	0	2	**0.8**	7	**1.55**	-1	0	-1	**-0.5**	6	**1.05**	X		
~~Screen pump diversions (to reduce fish impacts)~~	~~0~~	~~X~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~0~~	~~**0**~~	~~0~~	~~1~~	~~0~~	~~0~~	~~1~~	~~**0.4**~~	~~2~~	~~**0.4**~~	~~-1~~	~~0~~	~~-1~~	~~**-0.5**~~	~~1~~	~~**-0.1**~~	X		
~~Raise/strengthen existing levees~~	~~0~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~**0.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~3~~	~~**0.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~-3~~	~~**-2.25**~~		X	Could have a negative effect on ecosystem; Screened out; negative net score
Area between pocket and deep water ship channel (Rec District 302)																											
Reduce or remove portion of western Sacramento River levee north of the Pocket and/or adjacent to the Pocket to take pressure off the eastern Sacramento River levee that protects the pocket in addition to restoring habitat	X	X	X	3	3	3	3	**3**	1	**1**	3	0	3	0	2	**1.6**	21	**5.6**	-3	0	-3	**-1.5**	18	**4.1**	X		FRM benefits to pocket adjacent urban areas and I-5
Put a weir in the west-side levee that would dump water east of the levee and restore habitat	X	X	X	3	3	3	3	**3**	1	**1**	3	0	3	0	2	**1.6**	21	**5.6**	-3	0	-3	**-1.5**	18	**4.1**	X		
~~Bypass to take water off of Sacramento River and put it in the ship channel~~	~~X~~	~~0~~	~~0~~	~~1~~	~~1~~	~~0~~	~~0~~	~~**0.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~2~~	~~**0.5**~~	~~-3~~	~~0~~	~~-3~~	~~**-1.5**~~	~~-1~~	~~**-1**~~			Per DES fishery experts, no conservation benefits are associated with sending additional flood flows down the DWSC as there are too many assumptions and uncertainties related to that action.
American River (North Fork)																											
Build a multi-purpose earthen dam/reservoir along North Fork of the American River (American Reservoir)	X	0	X	3	3	3	0	**2.25**	3	**3**	0	0	0	0	0	**0**	12	**5.25**	-3	-3	-6	**-3.0**	6	**2.25**			
Build a dry earthen dam along North ForK of the American River	X	0	X	3	3	3	0	**2.25**	1	**1**	0	0	0	0	0	**0**	10	**3.25**	~~-3~~	~~-3~~	-6	**-3.0**	4	**0.25**			
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~2~~	~~0~~	~~**2**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~8~~	~~**2**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~2~~	~~**-1**~~		X	
American River (South Fork)																											
Improve diversion from American River south-west of Folsom Dam using agricultural water supply canal and re-purposing/re-sizing it	X	0	X	2	2	2	0	**1.5**	3	**3**	0	0	0	0	0	**0**	9	**4.5**	-2	-2	-4	**-2.0**	5	**2.5**		X	
Reservoir or a dry dam on the South Fork of the American river (multi-purpose)	X	X	X	3	3	3	0	**2.25**	3	**3**	0	0	0	0	0	**0**	12	**5.25**	-3	-3	-6	**-3.0**	6	**2.3**			
Riparian habitat restoration	0	X	X	0	0	0	3	**0.75**	1	**1**	2	0	0	0	2	**0.8**	8	**2.55**	-1	0	-1	**-0.5**	7	**2.05**	X		
~~Raise/strengthen existing levees~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~3~~	~~2~~	~~**2.75**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~11~~	~~**2.75**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~5~~	~~**-0.25**~~		X	
~~Increase groundwater infiltration (near Elk Grove)~~																											Not a stand-alone measure. Would need to be done in conjunction with other measure(s). Screened out.
Lake Oroville																											
Re-operate (multi-purpose) at Oroville	X	0	X	3	3	3	0	**2.25**	3	**3**	0	0	0	0	0	**0**	12	**5.25**	-1	-1	-2	**-1.0**	10	**4.25**		X	Assumes no construction needed
Upgrade (multi-purpose) Oroville	X	0	X	3	3	3	0	**2.25**	3	**3**	0	0	0	0	0	**0**	12	**5.25**	-3	-2	-5	**-2.5**	7	**2.75**			
Re-allocate storage (WS -> FRM) at Oroville	X	0	0	3	3	3	0	**2.25**	0	**0**	0	0	0	0	0	**0**	9	**2.25**	-2	0	-2	**-1.0**	7	**1.25**		?	Purchase Water Supply Storage to increase FRM pool. Assumes no taking of water from Environmental Needs.
Systemwide Surface Storage																											

	Purposes			Effectiveness																							
				Criteria																							
				Flood Risk Management					WS		Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	**Criteria Ranking Score**	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	**Criteria and Efficiency Ranking Score**	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
Systemwide Surface Storage																											
Create Off-Stream Storage at Tuscan Buttes Reservoir	X	0	X	3	3	3	0	**2.25**	3	**3**	0	0	0	0	0	**0**	12	**5.25**	-3	-3	-6	-3.0	6	**2.25**			
~~FRM: Create Off-Stream Storage at Tuscan Buttes Reservoir~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~3~~	~~0~~	~~**2.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~9~~	~~**2.25**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~3~~	~~**-0.75**~~			FRM Only Action
Create Off-Stream Storage at Glenn Reservoir	X	0	X	3	3	3	0	**2.25**	3	**3**	0	0	0	0	0	**0**	12	**5.25**	-3	-3	-6	-3.0	6	**2.25**			
~~FRM: Create Off-Stream Storage at Glenn Reservoir~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~3~~	~~0~~	~~**2.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~9~~	~~**2.25**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~3~~	~~**-0.75**~~			FRM Only Action
Create Off-Stream Storage at Colusa Reservoir Complex	X	0	X	3	3	3	0	**2.25**	3	**3**	0	0	0	0	0	**0**	12	**5.25**	-3	-3	-6	-3.0	6	**2.25**			
~~FRM: Create Off-Stream Storage at Colusa Reservoir Complex~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~3~~	~~0~~	~~**2.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~9~~	~~**2.25**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~3~~	~~**-0.75**~~			FRM Only Action
Upgrade On-Stream Storage at Lake Berryessa	X	0	X	3	3	3	0	**2.25**	1	**1**	0	0	0	0	0	**0**	10	**3.25**	-2	-2	-4	-2.0	6	**1.25**			
FRM: Upgrade On-Stream Storage at Lake Berryessa	X	0	0	3	3	3	0	**2.25**	0	**0**	0	0	0	0	0	**0**	9	**2.25**	-2	-2	-4	-2.0	5	**0.25**			FRM Only Action
Create Combined On- and Off-Stream Storage at Cottonwood Creek Reservoir	X	0	X	3	3	3	0	**2.25**	2	**2**	0	0	0	0	0	**0**	11	**4.25**	-3	-3	-6	-3.0	5	**1.25**			
~~FRM: Create Combined On- and Off-Stream Storage at Cottonwood Creek Reservoir~~	~~X~~	~~0~~	~~0~~	~~3~~	~~3~~	~~3~~	~~0~~	~~**2.25**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~9~~	~~**2.25**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~3~~	~~**-0.75**~~			FRM Only Action
Upgrade On-Stream Storage at Lake Almanor	X	0	X	2	2	2	0	**1.5**	2	**2**	0	0	0	0	0	**0**	8	**3.5**	-2	-2	-4	-2.0	4	**1.5**			
~~FRM: Upgrade On-Stream Storage at Lake Almanor~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-2~~	~~-2~~	~~-4~~	~~-2.0~~	~~2~~	~~**-0.5**~~			FRM Only Action
Upgrade On-Stream Storage at Englebright Lake	X	0	X	2	2	2	0	**1.5**	2	**2**	0	0	0	0	0	**0**	8	**3.5**	-2	-2	-4	-2.0	4	**1.5**			
~~FRM: Upgrade On-Stream Storage at Englebright Lake~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-2~~	~~-2~~	~~-4~~	~~-2.0~~	~~2~~	~~**-0.5**~~			FRM Only Action
Upgrade On-Stream Storage at Pardee Reservoir	X	0	X	2	2	2	0	**1.5**	1	**1**	0	0	0	0	0	**0**	7	**2.5**	-2	-2	-4	-2.0	3	**0.5**			
~~FRM: Upgrade On-Stream Storage at Pardee Reservoir~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-2~~	~~-2~~	~~-4~~	~~-2.0~~	~~2~~	~~**-0.5**~~			FRM Only Action
Create Off-Stream Storage at Sites Reservoir	X	0	X	2	2	2	0	**1.5**	2	**2**	0	0	0	0	0	**0**	8	**3.5**	-3	-3	-6	-3.0	2	**0.5**			
~~FRM: Create Off-Stream Storage at Sites Reservoir~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~**-1.5**~~			FRM Only Action
Create Off-Stream Storage at Thomes-Newville Reservoir	X	0	X	2	2	2	0	**1.5**	2	**2**	0	0	0	0	0	**0**	8	**3.5**	-3	-3	-6	-3.0	2	**0.5**			
~~FRM: Create Off-Stream Storage at Thomes-Newville Reservoir~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~**-1.5**~~			FRM Only Action
Create On- and Off-Stream Storage at Nashville Reservoir	X	0	X	2	2	2	0	**1.5**	2	**2**	0	0	0	0	0	**0**	8	**3.5**	-3	-3	-6	-3.0	2	**0.5**			
~~FRM: Create On- and Off-Stream Storage at Nashville Reservoir~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~**-1.5**~~			FRM Only Action
~~Create On-Steam Storage at Millville Reservoir~~	~~X~~	~~0~~	~~X~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~1~~	~~**1**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~7~~	~~**2.5**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~**-0.5**~~			
~~FRM: Create On-Steam Storage at Millville Reservoir~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~**-1.5**~~			FRM Only Action

	Purposes			Effectiveness / Criteria / Flood Risk Management					WS		Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	**Criteria Ranking Score**	**Value Index Normalized**	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	**Criteria and Efficiency Ranking Score**	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
~~Create On-Stream Storage at Belevista Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Belevista Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage at Wing Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Wing Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage at Rosewood Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Rosewood Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage at Deer Creek Meadows Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Deer Creek Meadows Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage with Red Bank Project~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage with Red Bank Project~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage at Gallatin Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Gallatin Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage at Freemans Crossing Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Freemans Crossing Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage at Marysville Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Marysville Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create Off-Stream Storage at Waldo Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create Off-Stream Storage at Waldo Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create On-Stream Storage at Garden Bar Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create On-Stream Storage at Garden Bar Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create Off-Stream Storage at Deer Creek Reservoir~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			
~~FRM: Create Off-Stream Storage at Deer Creek Reservoir~~	~~x~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~6~~	~~1.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~0~~	~~-1.5~~			FRM Only Action
~~Create Off-Stream Storage at Clay Station~~	~~x~~	~~0~~	~~x~~	~~2~~	~~2~~	~~2~~	~~0~~	~~1.5~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~7~~	~~2.5~~	~~-3~~	~~-3~~	~~-6~~	~~-3.0~~	~~1~~	~~-0.5~~			

	Purposes			Effectiveness																							
				Criteria																							
				Flood Risk Management					WS		Ecosystem Restoration																
Features	Flood Risk Management	Ecosystem Restoration	Water Supply/ Conservation	Reduce risks to life safety in Sac River Basin focusing on improved system flexibility under variety of climate change & development patterns	Reduce the consequences associated with flood risk in study area, with emphasis on improving system resiliency & increasing integrity of flood system	Reduce risks to critical infrastructure due to flooding	Encourage wise use of floodplain	**FRM Normalized**	Increase reliability & availability of water supply	**WS Normalized**	Increase area, quality, connectivity, & diversity of significant native aquatic & related habitats in Sac River ecosystem	Reduce barriers to fish passage	Increase natural dynamic hydrologic & geomorphic processes	Increase fish passage on Sac River & tributaries	Types of species that could benefit: 1) aquatic, 2) avian, 3) terrestrial	**ER Normalized**	Criteria Ranking Score	Value Index Normalized	Magnitude of Costs	Level of mitigation	Total	**Cost Normalized**	Criteria and Efficiency Ranking Score	**Overall Normalized**	Conservation Strategy Features	Part of CVFPP	Notes
~~FRM: Create Off-Stream Storage at Clay Station~~	~~X~~	~~0~~	~~0~~	~~2~~	~~2~~	~~2~~	~~0~~	~~**1.5**~~	~~0~~	~~**0**~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~**0**~~	~~6~~	~~**1.5**~~	~~-3~~	~~-3~~	~~-6~~	~~**-3.0**~~	~~0~~	~~**-1.5**~~			FRM Only Action
Sacramento River Basin Systemwide Reoperation																											
Systewide Reoperation	X	i	X	2	3	2	1	**2**	3	**3**	1	0	0	0	3	**0.8**	15	**5.8**	-3	0	-3	**-1.5**	12	**4.3**			

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After the measures for each opportunity area were screened, the retained measures for all opportunity areas were combined into conceptual alternatives based on several formulation strategies.

Formulation strategies for single purpose conceptual alternatives included:

- Non-structural Flood Risk Management
- Structural Flood Risk Management
- Ecosystem Restoration

Although there are significant water supply problems and opportunities in the watershed, a single purpose water supply alternative was not formulated because water supply is not a main USACE mission. In the Western States, the single purpose water supply mission resides with the USBR. As such, future single purpose water supply projects with a federal nexus should be pursued in partnership with the USBR. USACE could play a supporting role, or could be a joint federal partner in future projects, if requested by the USBR.

After conceptual single-purpose alternatives were formulated multiple purpose alternatives were formulated by combining single purpose alternatives.

Formulation strategies for multiple purpose conceptual alternatives included:

- Flood risk management and ecosystem restoration
- Flood risk management and water supply
- Flood risk management, ecosystem restoration and water supply

In addition, a locally developed plan (LDP) for flood risk management and ecosystem restoration was included in the conceptual alternatives. The resulting seven conceptual alternatives are:

(0) No Action Alternative

(1) Non- Structural Flood Risk Management Alternative – This includes flood risk management plans and flood recovery plans that include economic and environmental recovery after flood events.

(2) Ecosystem Restoration (ER) Alternative – This includes the remaining ecosystem restoration features that were not screened out.

(3) Structural Flood Risk Management (FRM) Alternative – This includes the remaining flood risk management features that were not screened out.

(4) Ecosystem Restoration (ER) and Flood Risk Management (FRM) Alternative – This is a combination of Alternatives (2) and (3).

(4a) Central Valley Flood Protection Plan (CVFPP) and the Draft Conservation Strategy (CS) – This is a locally developed plan (LDP) submitted by the sponsors, the Central Valley Flood Protection Board (CVFPB) and the State of California Department of Water Resources (DWR). It is a combination of the flood risk management and ecosystem restoration features included in the 2012 CVFPP and the Draft Conservation Strategy.

(5) FRM and Water Supply (WS) Alternative – This is a combination of alternative (3) and the remaining water supply features that were not screened out.

(6) FRM, ER and WS Alternative – This is a combination of alternative (4) and the remaining water supply features that were not screened out.

These conceptual alternatives could be pursued at the scale of one opportunity area (smallest scale) or at the scale of the entire watershed (largest scale). For the purposes of this watershed plan, the maximum possible score was used (i.e. the largest scale) for comparison of the conceptual alternatives.

Based on the normalized scores for the features, a benefits value index, costs and mitigation value index and net value index were calculated for each opportunity area under all conceptual alternatives. Table D-8 shows the benefits value index for all alternatives.

Table D-8 Benefits Value Index for All Conceptual Alternatives

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Opportunity Areas:	***Notes: 1) Any of the alternatives can be done on a scale ranging from 1 opportunity area to ALL opportunity areas; 2) All scores below are normalized scores from the features screening scoring table**							
Feather River Upper Honcut	0.0	3.9	21.1	16.3	25.0	23.1	16.3	25.0
Feather River Lower Honcut	0.0	3.9	49.9	46.0	58.5	55.0	46.0	58.5
Upper Sacramento	0.0	3.9	7.6	24.7	26.6	7.6	24.7	26.6
Elder Creek	0.0	3.9	7.8	9.9	11.7	11.7	9.9	11.7
Deer Creek	0.0	3.9	9.3	10.4	13.2	11.2	10.4	13.2
Woodson Bridge West	0.0	3.9	10.2	10.1	14.1	12.2	12.3	14.1
Woodson Bridge East	0.0	3.9	20.5	19.8	24.4	22.5	20.4	24.4
Capay	0.0	0.0	10.0	3.4	10.0	10.0	8.2	10.0
Chico Area	0.0	3.9	10.2	7.3	14.1	14.1	10.9	14.1
Colusa Basin North	0.0	3.9	22.0	12.1	25.9	23.9	21.7	25.9
Butte Basin	0.0	3.9	33.1	28.5	37.0	33.1	30.8	37.0
Cherokee Canal	0.0	3.9	7.2	14.9	14.9	9.2	14.9	14.9
Colusa Basin South	0.0	3.9	28.6	25.1	32.5	30.5	29.9	32.5
Rec District 70-1660	0.0	3.9	18.9	17.4	22.8	20.8	20.2	22.8
Sutter Bypass	0.0	3.9	22.0	17.1	25.9	24.0	23.7	25.9
Tisdale Bypass	0.0	0.0	8.7	7.7	8.7	8.7	7.7	8.7

Rec District 1500	0.0	3.9	22.1	22.5	26.0	24.0	22.5	26.0
Levee District 1	0.0	0.0	16.8	13.2	16.8	16.8	13.2	16.8
Sycamore Slough	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Ditrict 1001	0.0	3.9	12.3	11.6	16.2	12.3	14.0	16.2
Ridge Cut (North)	0.0	0.0	19.7	10.8	19.7	19.7	15.9	19.7
Elkhorn	0.0	0.0	34.5	26.4	34.5	34.5	26.4	34.5
Rio Linda	0.0	0.0	11.7	7.7	11.7	11.7	9.5	11.7
Rec District 2035	0.0	0.0	20.7	19.3	20.7	20.7	19.3	20.7
East of Davis - North	0.0	0.0	10.6	7.8	10.6	10.6	10.6	10.6
East of Davis - South	0.0	0.0	9.8	7.4	9.8	9.8	9.8	9.8
Putah Creek	0.0	0.0	7.6	3.4	7.6	7.6	6.2	7.6
Yolo Bypass	0.0	0.0	28.1	13.5	28.5	28.5	17.0	28.5
Stone Lake	0.0	0.0	6.2	3.4	6.2	6.2	6.2	6.2
Rec Dist 302	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 999	0.0	3.9	9.1	7.9	14.6	11.1	13.8	14.6
Merritt Island	0.0	0.0	5.8	4.0	7.3	5.9	4.0	7.3
Cache Slough	0.0	0.0	3.2	3.2	3.2	3.2	3.2	3.2
Hastings	0.0	0.0	3.4	5.0	5.0	5.0	5.0	5.0
Lindsey Slough	0.0	3.9	3.4	8.9	8.9	6.9	8.9	8.9
Moore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 551	0.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0
Sutter Island	0.0	0.0	6.8	3.4	6.8	6.8	3.4	6.8
Prospect Island	0.0	0.0	4.2	3.4	4.2	4.2	3.4	4.2
Ryer Island	0.0	0.0	4.2	3.4	4.2	4.2	3.4	4.2
Grand Island	0.0	3.9	1.7	6.5	6.5	4.6	6.5	6.5
Andrus Island	0.0	0.0	3.5	2.8	4.6	4.6	2.8	4.6
Tyler Island	0.0	0.0	3.0	1.7	3.0	3.0	1.7	3.0
Twitchell Island	0.0	0.0	8.9	5.6	8.9	8.9	5.6	8.9
Sherman Island	0.0	0.0	6.7	3.4	6.7	6.7	3.4	6.7
Area between pocket and deep water ship channel (Rec District 302)	0.0	0.0	11.2	11.2	11.2	11.2	11.2	11.2
American River (North Fork)	0.0	0.0	0.0	5.3	5.3	0.0	5.3	5.3
American River (South Fork)	0.0	0.0	7.8	9.8	12.3	0.0	12.3	12.3
Lake Oroville	0.0	0.0	0.0	12.8	12.8	5.3	12.8	12.8
Systemwide Surface Storage	0.0	0.0	0.0	75.8	39.8	0.0	75.8	75.8
Sacramento River Basin Systemwide Reoperation	0.0	0.0	0.0	5.8	5.8	0.0	5.8	5.8

Total benefits per alternative at largest scale (all opportunity areas)	0.0	76.1	569.2	598.6	745.5	610.6	667.5	781.5

Table D-9 shows the costs and mitigation value index for all conceptual alternatives.

Table D-9 Costs and Mitigation Value Index for All Conceptual Alternatives

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Opportunity Areas:	***Notes: 1) Any of the alternatives can be done on a scale ranging from 1 opportunity area to ALL opportunity areas; 2) All scores below are raw scores from the features screening scoring table**							
Feather River Upper Honcut	0.0	-1.0	-6.3	-4.3	-7.3	-6.8	-4.3	-7.3
Feather River Lower Honcut	0.0	-1.0	-19.0	-17.5	-23.0	-21.5	-17.5	-23.0
Upper Sacramento	0.0	-1.0	-2.5	-11.5	-12.5	-2.5	-11.5	-12.5
Elder Creek	0.0	-1.0	-2.5	-3.0	-3.5	-3.5	-3.0	-3.5
Deer Creek	0.0	-1.0	-4.8	-4.5	-5.8	-5.3	-4.5	-5.8
Woodson Bridge West	0.0	-1.0	-2.5	-2.5	-3.5	-3.0	-3.0	-3.5
Woodson Bridge East	0.0	-1.0	-6.0	-6.0	-7.0	-6.5	-6.5	-7.0
Capay	0.0	0.0	-2.0	-0.5	-2.0	-2.0	-1.5	-2.0
Chico Area	0.0	-1.0	-3.0	-1.5	-4.0	-4.0	-2.5	-4.0
Colusa Basin North	0.0	-1.0	-6.0	-3.0	-7.0	-6.5	-5.0	-7.0
Butte Basin	0.0	-1.0	-9.5	-7.0	-10.5	-9.5	-7.5	-10.5
Cherokee Canal	0.0	-1.0	-2.0	-5.5	-5.5	-2.5	-5.5	-5.5
Colusa Basin South	0.0	-1.0	-8.5	-7.0	-9.5	-9.0	-8.0	-9.5
Rec District 70-1660	0.0	-1.0	-5.8	-4.5	-6.8	-6.3	-5.0	-6.8
Sutter Bypass	0.0	-1.0	-6.8	-4.5	-7.8	-7.3	-6.5	-7.8
Tisdale Bypass	0.0	0.0	-2.5	-2.0	-2.5	-2.5	-2.0	-2.5
Rec District 1500	0.0	-1.0	-5.5	-5.5	-6.5	-6.0	-5.5	-6.5
Levee District 1	0.0	0.0	-3.8	-2.8	-3.8	-3.8	-2.8	-3.8
Sycamore Slough	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Ditrict 1001	0.0	-1.0	-3.5	-3.0	-4.5	-3.5	-3.5	-4.5
Ridge Cut (North)	0.0	0.0	-6.0	-2.8	-6.0	-6.0	-3.8	-6.0
Elkhorn	0.0	0.0	-11.8	-7.5	-11.8	-11.8	-7.5	-11.8
Rio Linda	0.0	0.0	-2.5	-1.5	-2.5	-2.5	-2.0	-2.5
Rec District 2035	0.0	0.0	-6.3	-5.0	-6.3	-6.3	-5.0	-6.3
East of Davis - North	0.0	0.0	-2.5	-2.0	-2.5	-2.5	-2.5	-2.5

East of Davis - South	0.0	0.0	-2.5	-2.0	-2.5	-2.5	-2.5	-2.5
Putah Creek	0.0	0.0	-1.5	-0.5	-1.5	-1.5	-1.0	-1.5
Yolo Bypass	0.0	0.0	-10.3	-4.0	-10.8	-10.8	-5.3	-10.8
Stone Lake	0.0	0.0	-1.0	-0.5	-1.0	-1.0	-1.0	-1.0
Rec Dist 302	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 999	0.0	-1.0	-2.5	-2.3	-4.3	-3.0	-3.8	-4.3
Merritt Island	0.0	0.0	-2.0	-1.5	-3.0	-2.5	-1.5	-3.0
Cache Slough	0.0	0.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Hastings	0.0	0.0	-0.5	-1.5	-1.5	-1.5	-1.5	-1.5
Lindsey Slough	0.0	-1.0	-0.5	-2.5	-2.5	-2.0	-2.5	-2.5
Moore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 551	0.0	-0.5	0.0	-0.5	-0.5	0.0	-0.5	-0.5
Sutter Island	0.0	0.0	-2.5	-0.5	-2.5	-2.5	-0.5	-2.5
Prospect Island	0.0	0.0	-1.0	-0.5	-1.0	-1.0	-0.5	-1.0
Ryer Island	0.0	0.0	-1.0	-0.5	-1.0	-1.0	-0.5	-1.0
Grand Island	0.0	-1.0	-0.5	-2.0	-2.0	-1.5	-2.0	-2.0
Andrus Island	0.0	0.0	-1.0	-1.5	-2.0	-2.0	-1.5	-2.0
Tyler Island	0.0	0.0	-1.0	-0.5	-1.0	-1.0	-0.5	-1.0
Twitchell Island	0.0	0.0	-3.0	-2.0	-3.0	-3.0	-2.0	-3.0
Sherman Island	0.0	0.0	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5
Area between pocket & deep water ship channel (Rec District 302)	0.0	0.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
American River (North Fork)	0.0	0.0	0.0	-3.0	-3.0	0.0	-3.0	-3.0
American River (South Fork)	0.0	0.0	-3.5	-5.0	-5.5	0.0	-5.5	-5.5
Lake Oroville	0.0	0.0	0.0	-4.5	-4.5	-1.0	-4.5	-4.5
Systemwide Surface Storage	0.0	0.0	0.0	-68.0	-68.0	0.0	-68.0	-68.0
Sacramento River Basin Systemwide Reoperation	0.0	0.0	0.0	-3.0	-3.0	0.0	-3.0	-3.0
Total costs per alternative at largest scale (all opportunity areas)	**0.0**	**-19.5**	**-170.5**	**-225.0**	**-290.8**	**-183.5**	**-241.3**	**-290.8**

Once the relative benefit and cost indices were calculated, a net value index was determined for each conceptual alternative (Table D-8). It should be noted that the net value index provides only an approximate indication of the relative net benefits for the various opportunity areas and conceptual alternatives. Because the various types of benefits and costs used to calculate the net value index were evaluated qualitatively and comparatively, and were not calibrated to the same monetary scale (i.e., a unit of benefit is not necessarily equivalent in magnitude to a unit of cost), a positive net value index does not necessarily indicate that an alternative would have positive net benefits. Table D-10 below shows the net value index for all conceptual alternatives.

Table D-10 Net Value Index

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Opportunity Areas:	***Notes: 1) Any of the alternatives can be done on a scale ranging from 1 opportunity area to ALL opportunity areas; 2) All scores below are raw scores from the features screening, scoring & ranking table**							
Feather River Upper Honcut	0.0	2.9	14.9	12.0	17.8	16.3	12.0	17.8
Feather River Lower Honcut	0.0	2.9	30.9	28.5	35.5	33.5	28.5	35.5
Upper Sacramento	0.0	2.9	5.1	13.2	14.1	5.1	13.2	14.1
Elder Creek Opportunity Area	0.0	2.9	5.3	6.9	8.2	8.2	6.9	8.2
Deer Creek	0.0	2.9	4.5	5.9	7.4	6.0	5.9	7.4
Woodson Bridge West	0.0	2.9	7.7	7.6	10.6	9.2	9.3	10.6
Woodson Bridge East	0.0	2.9	14.5	13.8	17.4	16.0	13.9	17.4
Capay	0.0	0.0	8.0	2.9	8.0	8.0	6.7	8.0
Chico Area	0.0	2.9	7.2	5.8	10.1	10.1	8.4	10.1
Colusa Basin North	0.0	2.9	16.0	9.1	18.9	17.4	16.7	18.9
Butte Basin	0.0	2.9	23.6	21.5	26.5	23.6	23.3	26.5
Cherokee Canal	0.0	2.9	5.2	9.4	9.4	6.7	9.4	9.4
Colusa Basin South	0.0	2.9	20.1	18.1	23.0	21.5	21.9	23.0
Rec District 70-1660	0.0	2.9	13.1	12.9	16.0	14.6	15.2	16.0
Sutter Bypass	0.0	2.9	15.3	12.6	18.2	16.7	17.2	18.2
Tisdale Bypass	0.0	0.0	6.2	5.7	6.2	6.2	5.7	6.2
Rec District 1500	0.0	2.9	16.6	17.0	19.5	18.0	17.0	19.5
Levee District 1	0.0	0.0	13.1	10.4	13.1	13.1	10.4	13.1
Sycamore Slough	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Ditrict 1001	0.0	2.9	8.8	8.6	11.7	8.8	10.5	11.7
Ridge Cut (North)	0.0	0.0	13.7	8.0	13.7	13.7	12.1	13.7
Elkhorn	0.0	0.0	22.8	18.9	22.8	22.8	18.9	22.8
Rio Linda	0.0	0.0	9.2	6.2	9.2	9.2	7.5	9.2
Rec District 2035	0.0	0.0	14.5	14.3	14.5	14.5	14.3	14.5
East of Davis - North	0.0	0.0	8.1	5.8	8.1	8.1	8.1	8.1
East of Davis - South	0.0	0.0	7.3	5.4	7.3	7.3	7.3	7.3
Putah Creek	0.0	0.0	6.1	2.9	6.1	6.1	5.2	6.1

Yolo Bypass	0.0	0.0	17.8	9.5	17.8	17.8	11.8	17.8
Stone Lake	0.0	0.0	5.2	2.9	5.2	5.2	5.2	5.2
Rec Dist 302	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 999	0.0	2.9	6.6	5.6	10.3	8.1	10.0	10.3
Merritt Island	0.0	0.0	3.8	2.5	4.3	3.4	2.5	4.3
Cache Slough	0.0	0.0	2.7	2.7	2.7	2.7	2.7	2.7
Hastings	0.0	0.0	2.9	3.5	3.5	3.5	3.5	3.5
Lindsey Slough	0.0	2.9	2.9	6.4	6.4	4.9	6.4	6.4
Moore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rec Dist 551	0.0	1.5	0.0	1.5	1.5	0.0	1.5	1.5
Sutter Island	0.0	0.0	4.3	2.9	4.3	4.3	2.9	4.3
Prospect Island	0.0	0.0	3.2	2.9	3.2	3.2	2.9	3.2
Ryer Island	0.0	0.0	3.2	2.9	3.2	3.2	2.9	3.2
Grand Island	0.0	2.9	1.2	4.5	4.5	3.1	4.5	4.5
Andrus Island	0.0	0.0	2.5	1.3	2.6	2.6	1.3	2.6
Tyler Island	0.0	0.0	2.0	1.2	2.0	2.0	1.2	2.0
Twitchell Island	0.0	0.0	5.9	3.6	5.9	5.9	3.6	5.9
Sherman Island	0.0	0.0	5.2	2.9	5.2	5.2	2.9	5.2
Area between pocket & deep water ship channel (Rec District 302)	0.0	0.0	8.2	8.2	8.2	8.2	8.2	8.2
American River (North Fork)	0.0	0.0	0.0	2.3	2.3	0.0	2.3	2.3
American River (South Fork)	0.0	0.0	4.3	4.8	6.8	0.0	6.8	6.8
Lake Oroville	0.0	0.0	0.0	8.3	8.3	4.3	8.3	8.3
Systemwide Surface Storage	0.0	0.0	0.0	7.8	-28.3	0.0	7.8	7.8
Sacramento River Basin Systemwide Reoperation	0.0	0.0	0.0	2.8	2.8	0.0	2.8	2.8
Total net value index per alternative at largest scale (all opportunity areas)	**0.0**	**56.6**	**398.7**	**373.6**	**454.8**	**427.1**	**426.3**	**490.8**

A value ratio of the benefit value index to the costs and mitigation value index was also calculated for each alternative. Table D-11 summarizes the results. It should be noted that the value ratio provides only an approximate indication of the relative cost efficiency for the various opportunity areas and conceptual alternatives. Because the various types of benefits and costs used to calculate the value ratio were evaluated qualitatively and comparatively, and were not calibrated to the same monetary scale (i.e., a unit of benefit is not necessarily equivalent in magnitude to a unit of cost), a value ratio that is greater than 1.0 does not necessarily indicate that an alternative would be justified.

Table D-11 Conceptual Alternatives Scoring Results

	(0) No Action	(1) Non-Structural	(2) ER	(3) FRM	(4) ER + FRM	(4a) CVFPP + CS (LDP)	(5) FRM + WS	(6) FRM + ER + WS
Total benefit index per alternative at largest scale (all opportunity areas)	0	76.1	569.2	598.6	745.5	610.6	667.5	781.5
Total costs index, including mitigation, per alternative at largest scale (all opportunity areas)	0	-19.5	-170.5	-225.0	-290.8	-183.5	-241.3	-290.8
Total net value index per alternative at largest scale (all opportunity areas)	0	56.6	398.7	373.6	454.8	427.1	426.3	490.8
Value Ratio (Benefits index to Costs Index)	0	3.9	3.3	2.7	2.6	3.3	2.8	2.7

Table D-12 Alternatives Ranked by Net Value Index with Value Ratios

	(0) No Action	(1) Non-Structural	(3) FRM	(2) ER	(5) FRM + WS	(4a) CVFPP + CS (LDP)	(4) ER + FRM	(6) FRM + ER + WS
Net Value Index	NA	56.6	373.6	398.7	426.3	427.1	454.8	490.8
Value Ratio (Benefit Index to Cost Index)	NA	3.9	2.7	3.3	2.8	3.3	2.6	2.7

Alternative 6, which combines flood risk management, ecosystem restoration and water supply across the watershed, has the highest net value, while Alternative 1, the non-structural alternative, has the highest value ratio.

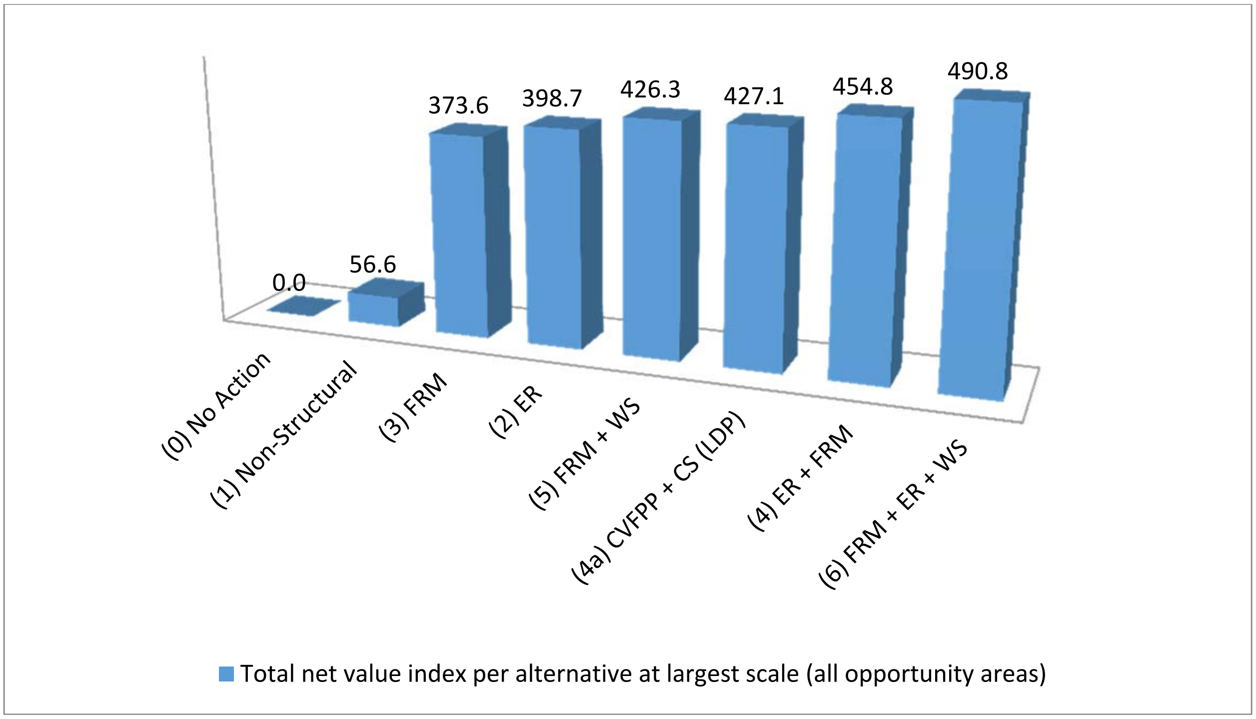

Figure D-2. Conceptual Alternatives Ranked by Net Value Index

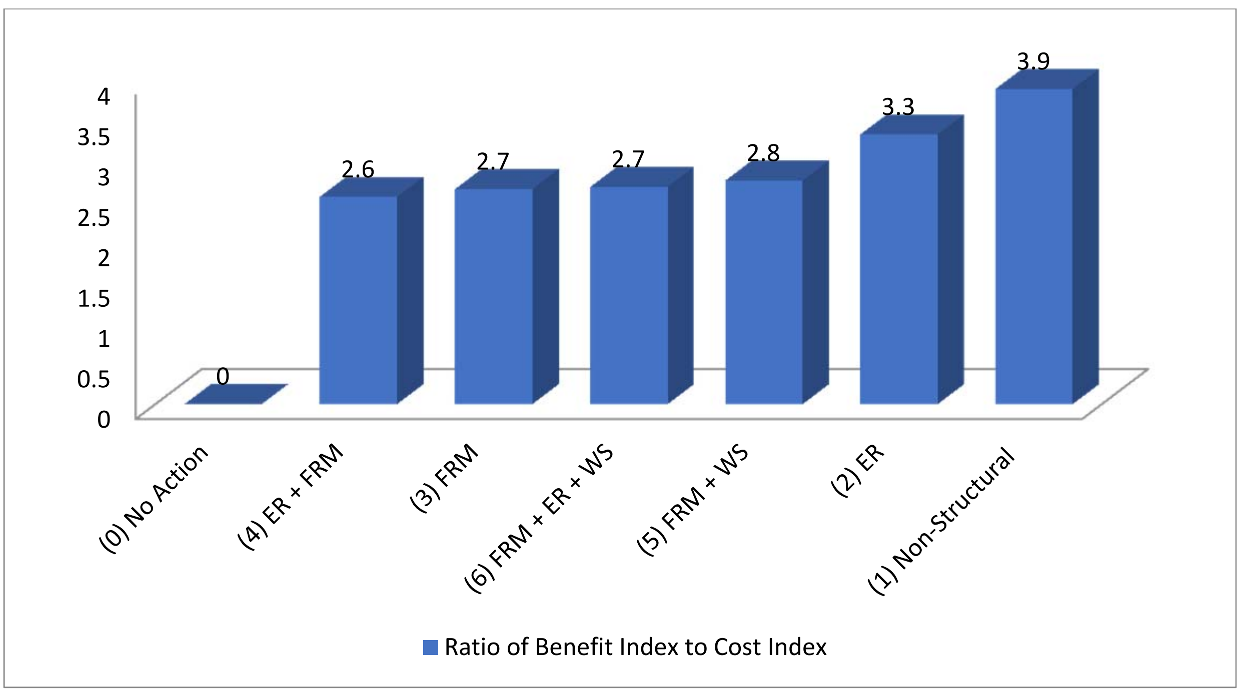

Figure D-3. Ranking of Conceptual Alternatives by Value Ratio

No conceptual alternatives were screened out as they all appear to have potential for federal interest (i.e. potential to provide benefits to the nation's economy and/or to nationally significant ecosystems).

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Attachment E Assessment of Federal Interest in Flood Risk Management Actions

E.1 Overview

This attachment assesses the potential for federal interest in federal, single purpose flood risk management (FRM) projects in the Sacramento River Watershed (shown in figure one below). The subsections titled limitations of the analysis and data limitations below describe important limitations to the presentation of the federal interest assessment provided in the following sections of this attachment. Section 2, titled historic flooding conditions, describes natural hydrologic, hydraulic and economic processes important to understanding the without-project flood risks. Section 3, titled measurement of flood risks, discusses the measurement of flood risk used by the Sacramento Valley CVFPP models and this report. Section 4, titled without-project flood risks, presents without-project flood risks. These conditions form the basis against which federal interest is assessed. Section 5, titled assessment of federal interest, assesses the potential for federal interest in single purpose FRM projects within the Sacramento River Basin.

E.1.1 Limitations of the Analysis

The assessment of federal interest contained in this attachment is imprecise and generally qualitative. Its analysis is based on pre-existing information of varying quantity, quality and applicability. The potential for federal interest is generally categorized as high, medium or low based on expert judgment; an evaluation of the applicability of existing models and data; and conclusions made after an examination of the existing information. This level of precision is appropriate given the flood risk management decisions that the watershed study will support, namely the decision to pursue related feasibility studies that will further investigate federal interest in a narrower and more specifically defined set of actions.

E.1.2 Data Limitations

The pre-existing information, upon which this attachment's conclusions are based, is limited in terms of quantity, quality and applicability. It is also not uniformly distributed across the watershed. For instance, significantly more data is available in the area covered by the Central Valley Flood Protection Plan's (CVFPP) analysis, published by DWR. This area is labeled with green polygons in the figure below. The assessment of federal interest outside of area labeled with green polygons is based on readily available open source information (such as US Census Bureau population estimates), expert judgment and stakeholder information.

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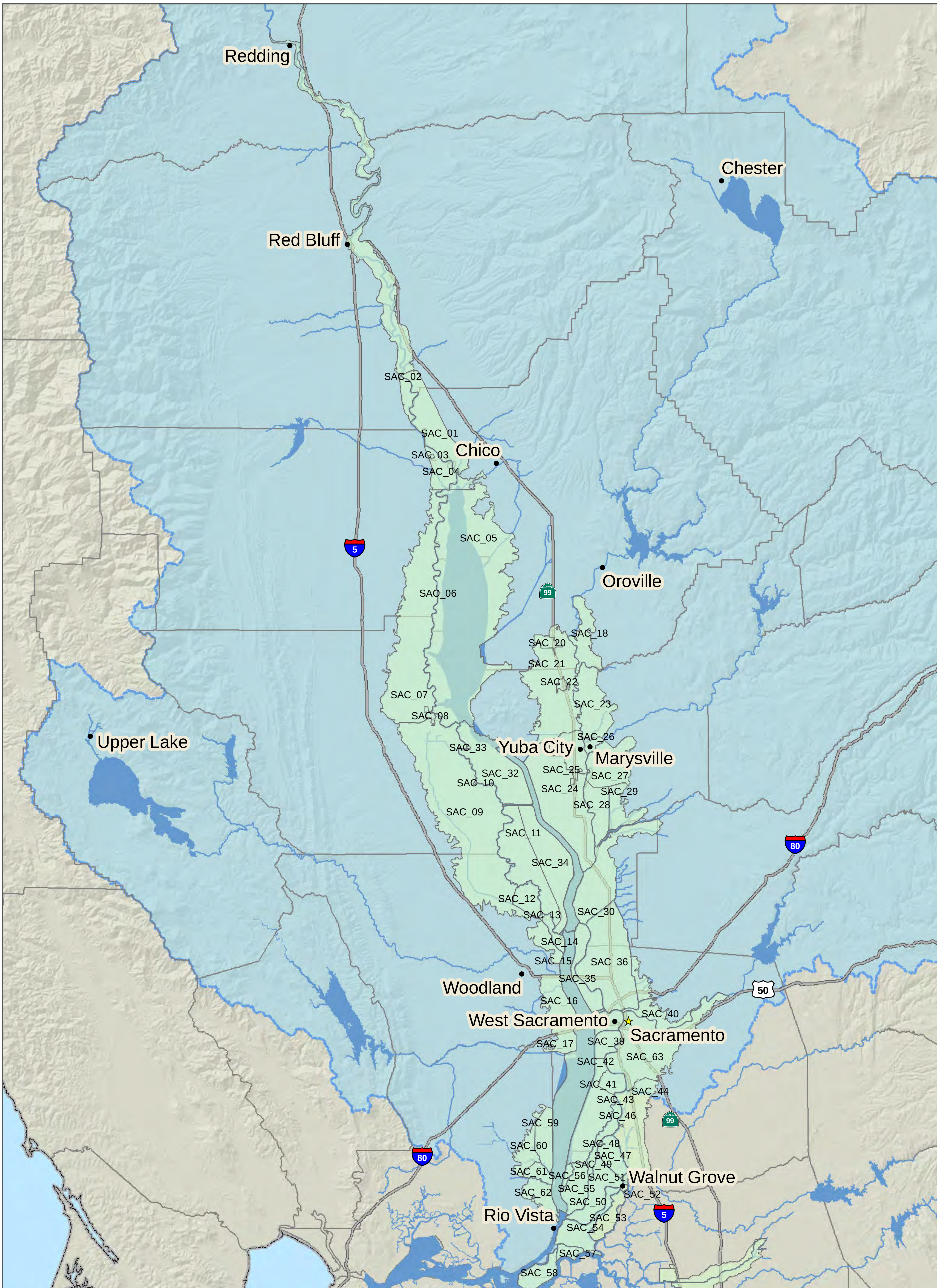

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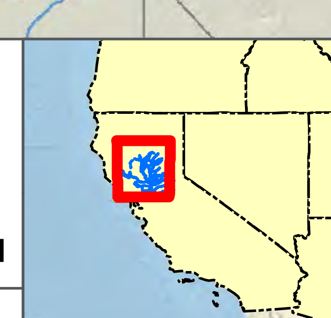
Sacramento River Watershed and CVFPP Impact Areas

Impact Areas

Sacramento Watershed

Figure 1



The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

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Within the area analyzed by the CVFPP the assessment of federal interest is largely based on without-project condition USACE Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) models, created by DWR for use in the CVFPP reports. This software is commonly used by the USACE in flood risk management investigations and the CVFPP HEC-FDA models are largely consistent with USACE standards of practice. However, three limitations are worth noting. First, some cases the without-project condition used in the model is not consistent with the without project condition identified in section 4 below. In these cases the CVFPP results have been replaced with those found in the relevant USACE feasibility reports. These cases are listed in section 4 below. Second, the existing without-project models also have specific weaknesses in evaluating the potential for federal interest in storage options and other measures that would depend upon achieving multi-reach benefits. These weaknesses reduce the applicability of the models in the federal interest assessment, particularly the assessment presented in section 5.2. Third, the CVFPP models assume that prior to the occurrence of a storm event the flood storage space at the reservoirs is full and delta water surface elevations match those that followed the 1997 flood event. These antecendent condition assumptions result in modeled events that are more extreme than is likely occur. The consequences associated with some events, in some locations are therefore likely to be overstated. In particular the consequences associated with high frequency events may be as much a function of the antecedent condtions as the modeled annual chance exceedence event (ACE) especially in the the delta region. In the sections that follow these weaknesses are described and taken into account in the federal interest determination.

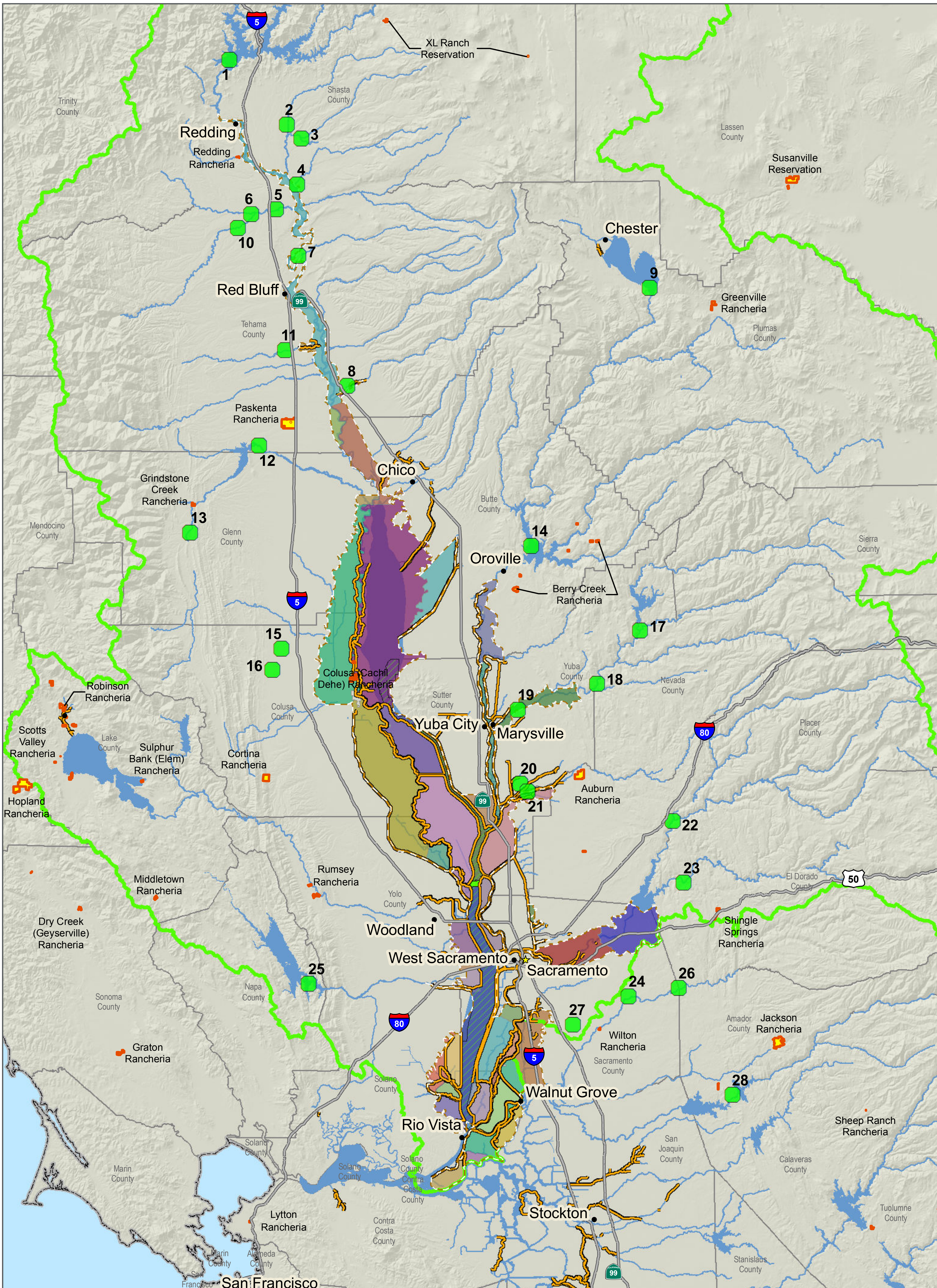
The data limitations described above (and below) are acceptable because they do not impede the report's ability generate a risk informed assessment of the potential for federal interest in FRM actions within the Sacramento River Watershed. The level of detail the data supports provides decision makers with the information needed to inform the decision to pursue the investigation of more specific FRM actions in a feasibility study.

E.2 Historic Flooding Conditions

Prior to settlement of the valley in the mid-1800's, centuries of natural aggradation of sediment in the Sacramento and Feather Rivers created a perched channels in the Sacramento Valley and Delta. This natural aggradation was greatly accelerated during the late 1800's as an estimated 1.3 billion cubic yards of mining debris was added to the system, as a result of hydraulic mining in the Sierra and Coastal Mountain Ranges. Sediment levels in the delta subsequently increased by 10 fold over their normal levels; and by the early 1900's the lower Sacramento River channel had aggraded between 10 and 25 feet (Hall, et al 2010). This accentuated the natural perch of the river channel, particularly in the most populous downstream reaches of the Sacramento River where pre-existing geological conditions and flatter land elevations lead to a natural decline in flow capacity and increased flood risks (James 1999). Survey conducted by the California River Commissioner in 1895 show that low water elevations of the river generally exceed those of the basin floor, a condition that persists today. These perched channels, which prevent flood overflows from re-entering the channel, in combination with the major rivers and tributaries general lack of capacity to convey seasonal floods created a naturally occurring expansive system of distributaries, lakes and Tule Marsh that functioned to store and convey seasonal flood flows through the valley floor and into the delta (Helley and Harwood 1985).).

In addition to the seasonal flooding described above the Sacramento Valley is also naturally prone to deep period flooding from large storm events. High intensity persistent rain events are occasionally generated from atmospheric river storms that deliver concentrated atmospheric moisture to the Sacramento Valley (and the West Coast in general). These atmospheric river events have been estimated to carry a greater flux (flow rate per unit of area and time) of water than the Amazon River (Zhu and Newell 1998); and have deposited a much as 8.5 feet of rain in the Central Valley in a single event (Masters 2014). These events combined with the shape and geographic orientation of the watershed, as well as the orographic impacts of watersheds mountainous boundaries result in some of the highest concentrations of peak flows proportional to mean flows and land area on earth. As a result the watershed is prone to occasional “valley filling” floods that transform the central valley into an “inland sea”. Such floods are known to have occurred in 1805, 1862, 1879 and 1902 and would likely have occurred in subsequent years had anthropogenic changes to the system not been made in the twentieth century.

Levee construction in the Sacramento Valley facilitating agricultural production and human settlement coincided with settlement of the valley, in the mid1800’s. However, the limitations of independent action were quickly made apparent during the flood of 1862, when the central valley was continuously inundated for an extent of 300 miles and an average breadth of 20 miles (DWR 2007). Flood depths throughout much of Sacramento during the event exceeded 10 feet, and for two years the state capital was moved to San Francisco. In response to the flood of 1878 State Engineer William Hammond Hall developed the first comprehensive flood management plan for the Sacramento Valley. This plan resulted in the construction of the system of levees, weirs and bypass channels that exist today and are shown in figure two below. By developing weirs and bypasses outside of the river channel to convey flood flows, the built system mimics the natural flood flow conveyance provided by the pre-existing marshes and sloughs (Leclerc 2013).



CVIFMS Project Surface Water Storage

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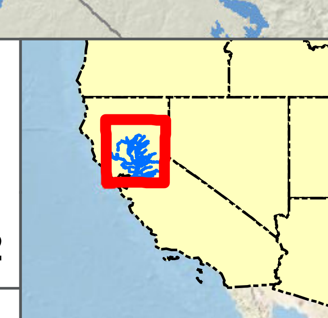
Tribal Lands	Weirs
CVIFMS Opportunity Areas	HUC4 Sac Basin Watershed
NLD SPK Levees	Bypasses

Figure 2



The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

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The construction of these elements accelerated in 1917 when Congress authorized the Sacramento Flood Control System, following damaging floods in 1902 and 1909. Later, larger storage reservoirs (e.g. Shasta, Oroville, Folsom, etc…) were added to the system, these elements are also shown in figure 2 above. These reservoirs greatly augmented the system's remaining natural storage, most notably in the Butte Sink where as much as 6 million acre feet of water is stored. It replaced storage lost due to levee construction that restricts flow to flood basins that previously contained systems of lakes, marshes and sloughs. Shasta Dam, located near the watershed's northern headwaters, contains the largest of these reservoirs. It has a storage capacity of approximately 4.5 million acre-feet and was completed in 1945. Many texts mark this date as the beginning of the river system's contemporary hydrologic era (Hall, et. Al. 2010). Folsom reservoir which regulates flows on the American River 25 miles upstream of Sacramento was authorized by congress one year earlier (in 1944) and constructed by 1956. It has a total storage capacity of over 1.1 million acre feet of water and produces a maximum controlled release of 160,000 cfs, during an event with a 0.5 percent annual chance of exceedence in any given year. This compares to estimated unregulated peak flow of over 318,000 cfs during the 1862 flood (Walker 2013). The construction of the Shasta Dam altered dry season (late summer flows) from 1,000 to 3,000 cubic feet per second (cfs) to 7,000 to 13,000 cfs; and created a regulated peak flow of 80,000 cfs near the town of Redding, just downstream of the dam (Buer 2007). Thus while it is accurate to state that the built flood management system mimic the geomorphologic processes of the natural system, it would be inaccurate to assert that current flooding conditions, risks or flow regimes resembles the natural flooding conditions, risks or flow regimes.

In short, anthropogenic changes have increased the risks associated with the natural flooding conditions in several key ways. First, settlement has largely concentrated in the downstream portions of the watershed (see figure 3 below), most notably in Sacramento near the confluence of Sacramento and American Rivers. As a result many of the people and infrastructure at risk of flooding are located where peak flows are largest; and the river's natural flow capacity is low, due to the decline in the downstream channel slope (described above). Second, land reclamation for agricultural production and human development, through levee construction, has increased the flood flows that are conveyed downriver during any given storm event. However, built levees in the Sacramento Valley are generally subject under seepage and piping failures due to the soils and naturally occurring system of sloughs upon which they were originally built. Thus levee construction has altering the primary mode of flooding from bank overtopping to levee breach, making flooding less predictable; while the increased conveyance of flood flows downstream has concentrated flooding, to fewer basins following any given event. These facts result a greater incidence of catastrophic depths in some areas and reduced warning times, thereby increasing property damages and loss of life risks.

These generalized conditions impact the conclusions drawn in the without-project flood risk and federal interest assessment sections below. For instance: (1) the construction or strengthening of localized conveyance structures (such as levees) along the river banks are unlikely to be effective in addressing systems based flood risks because: (a) significant flood flows are generally not conveyed in the river channels and (b) such structures are likely to transfer flood risks to downstream communities. (2) Flood flows are generally conveyed over weirs and through bypass channels. Thus conveyance improvements in these areas are likely to be more effective in reducing downstream flood risks, assuming they are cost effective relative to the flood risk reduction benefits they provide. (3) In many locations, perched channels, poor levee performance and high flux of water from periodic storm events result in extreme flood depths, long periods of inundation as well as short warning times even during event with a high annual probability of occurrence. As a result, in most areas measures that reduce the risks associated with high frequency flooding are likely to be more effective at reducing expected annualized flood damages and loss of life risks than measures that target reducing the risks associated with low frequency events.

E.3 Measurement of Flood Risk

Flood risk is measured as the sum product of the consequences associated with the occurrence of various storm events multiplied by the probabilities of those events occurrences. In the HEC-FDA software program which serves as the basis for the measurement of flood risks throughout most of this attachment, the probability associated with the occurrence of any given storm event is expressed as an annual chance of exceedance (ACE). This ACE represents the chance that a storm event as large as or larger than the one described will occur in any given year. A full range of ACE events and the consequences associated with those events are evaluated by the HEC-FDA[3] program. The resulting measure of flood risk, labeled expected annual damage (EAD) is therefore, a probability weighted annual average amount of flood damages expected to incurred; without prior knowledge of any flooding event will occur. As a result, EAD overestimates the damages that will occur in most years, since most years will result in non damaging flood event; while simultaneously underestimating the damages that will occur following most flood events, because it averages across many non-damaging events.

The EAD values presented in this report represent without-project flood risks, which are defined as the flood risks that could be expected to persist (or develop) in the absence of any new federal investment in FRM actions. This future without project condition serves as the benchmark against which federal interest is measured. Thus with project benefits are measured by reductions in risk, and federal interest is defined by relative change rather than absolute flood risk. Identification of with project conditions and benefits are beyond the scope of this report. Instead the potential for federal interest is identified. A future feasibility study will be tasked with the generation of alternative with-project conditions from which a FRM alternative could be selected.

In this report, annualized without-project EAD is reported in net present values, calculated at the current federal discount rate of 3.125 percent. Although this value

[3] The program considers events ranging from those with a greater than 99 percent chance of occurrence in any given year to those with 0.2 percent chance of occurrence in any given year.

results in a less precise and intuitive metric of flood risk it provides a better measurement of the potential for federal interest, by approximately corresponding to the largest cost FRM project that could be pursued and still generate federal interest, if it effectively eliminated the without-project flood risks measured in the EAD calculations.

E.4 Without Project Flood Risk

The figure below displays Sacramento Valley land uses, the locations of communities with greater than 10,000 inhabitants and the geographical extent of the CVFPP HEC-FDA models; with each polygon representing a separable impact area and flooding basin.

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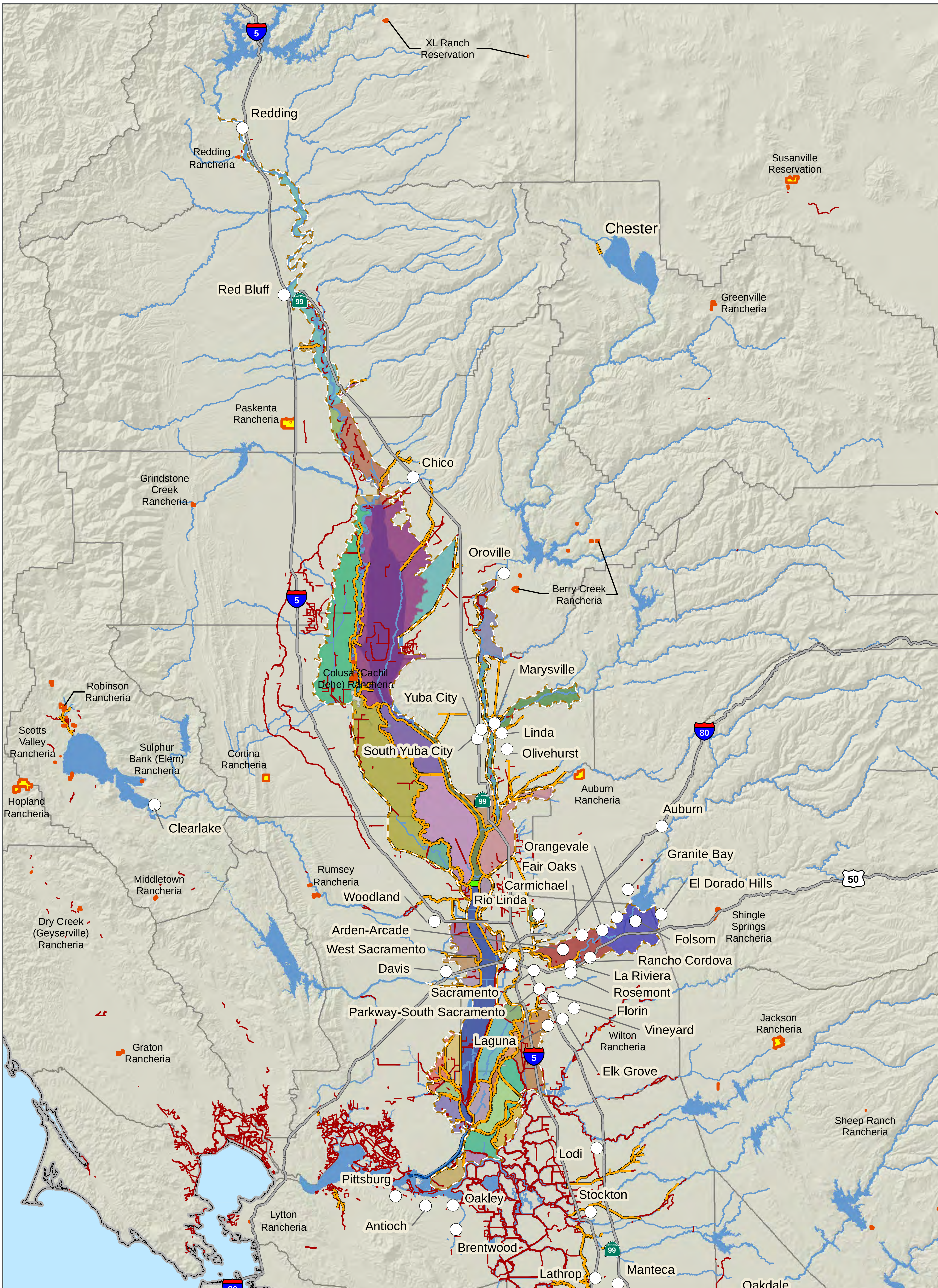

CVIFMS Project Opportunity Areas

CVIFMS Opportunity Areas
Tribal Lands
Cities/Locations with more than 10,000 Residents
Federal Levees
Non Federal Levees
Weirs
SAC River System

Figure 3

US Army Corps of Engineers® Sacramento District

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Tables 1 and 2, placed at the end of this document, displays population estimates for the watershed and various sub regions within the watershed. Table one shows the populations in each impact area (sorted in ascending order). Predominate land uses in each impact area are also reported under the urban, small community or rural category. It shows, that while the vast majority of watershed is rural, the majority of the population is located in urban areas; primarily in the greater Sacramento metropolitan area along the Sacramento and American Rivers south of the Freemont Weir. Outside of the greater Sacramento area (impact areas 36, 37, 38, 39, 40, 63) only Yuba City, Marysville and the surrounding community of Linda-Olivehurst are categorized as urban (impact areas 25, 26, 27). Figure 4 shows this information graphically.

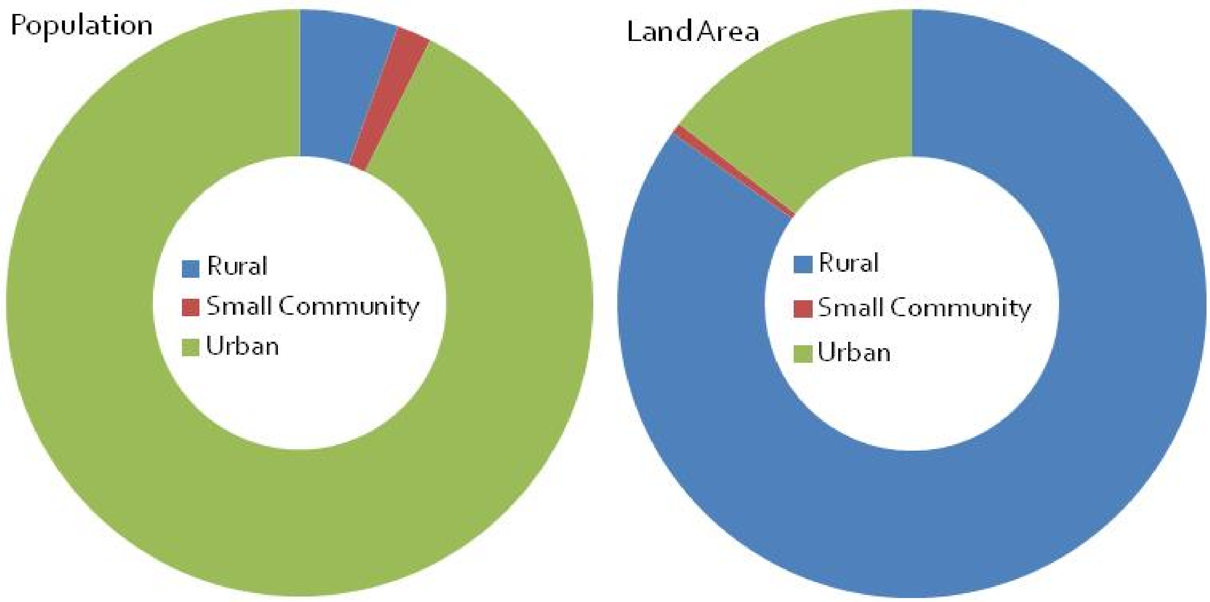

Figure 4. Portion of Population and Land Area in Sacramento Valley by Land Use Category

Table 2 describes the populations within the modeled areas of the Sacramento Valley located between major storage and diversion structures such as weirs and reservoirs. Specifically, it groups impact areas into the following FRM zones, those located: (a) upstream of the Colusa Weir on the Sacramento River; (b) between the Colusa and Freemont Weirs; (c) upstream of the Freemont Weir on the Feather River; and (d) downstream of the Freemont Weir and Upstream of the Delta. These delineations are made for the purpose of informing the federal interest assessment, as it relates to storage and diversion actions. They omit important regulating structures and the central valley flood protection infrastructure operates systematically, meaning none of these FRM zones are actually independent of the others. However, the delineations are useful to the extent that the benefits associated with modifications to storage and diversion structures diminishes significantly as flows are regulated (or re-regulated) through the reservoirs and over the weirs that delineate each zone.

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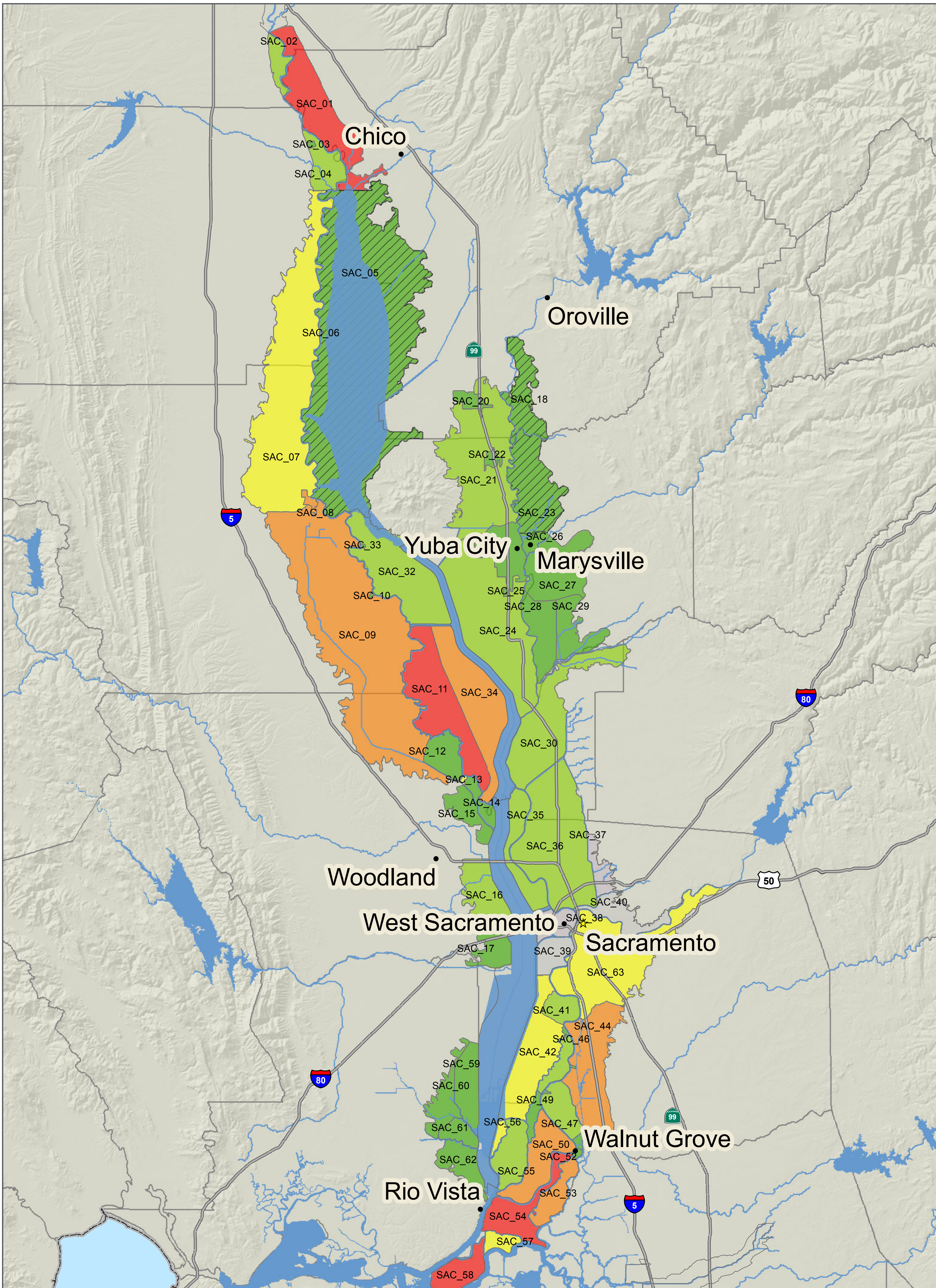

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Without Project EAD Estimates

in thousands of net present dollars

- $0 - $25,000
- $25,000 - $75,000
- $75,000 - $100,000
- $100,000 - $250,000
- $250,000 - $26,743,553
- EADs not applicable
- EAD and AEP are under reported

Figure 5

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983, CA State Plane II Feet

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The figure above displays estimated without-project Net Present Value (NPV) of EAD produced in the current CVFPP HEC-FDA models. Table 3, located at the end of this document shows this information in a tabular format. The values in figure 5 above are color coded from red to green (with red being the highest EAD areas and green being the lowest). Grey polygons denote areas where an existing USACE study, authorized project or project in construction is unaccounted for in the CVFPP models and due to differences in the size of the modeled impact areas EADs produced in USACE reports (such as feasibility studies) could not be applied to the CVFPP polygons. Grey polygons include impact areas 20, 22, 37, 38 and 39, and 40 corresponding with portions of the the Sutter Basin, West Sacramento and American Common Features investigation's study areas, respectively. Impact areas 24, 25, 26, 36 and 63 corresond with the study areas for portions of the Sutter Basin, Marysville, Natomas and American River Common Features feasibility studies, respectively. In these impact areas, the EADs and AEPs (presented in later figures) represent values published in USACE feasibility reports. In these and grey impact areas a federal FRM plan has been developed, and designed to maximize federal net benefits; or is currently being investigated, as part of an ongoing feasibility study. Figure 9, and table 4 the end of this report display information displayed in figure 5 above, as it existed in the 2012 CVFPP report. The summary statistics (e.g. EAD, AEP) in many impact areas have changed substantially since the 2012 CVFPP was published, as a result of new, more detailed and updated data; as well as the use of modern analytical techniques and tools. However the trends displayed in these two datum remain largely consistent, for this reason the current CVFPP models form the basis for most of the remainder of the analysis.

The polygons displayed in figure 5 above delineate the study area for a single HEC-FDA model, which in most cases corresponds with a separable flooding basin. As is alluded to in the sections above with the exception of a few isolated places on the periphery of the Sacramento metropolitan area and far upstream reaches of the Feather River, flooding in these basins is generally deep. In many impact areas the annual probability of flooding (AEP) is also high due to the susceptibility of levee breech, resulting from under-seepage and piping failures. The current CVFPP AEPs for each of the impact areas are shown in figures 7 and 8 as well as tables 4 and 6 below. Note in a few cases the polygons in the figures below are covered in a cross hatch patern. In these cases the modeled flood source differs from that with they hightest probability of overtopping or breach. As a result the probability of flooding in these areas are understated. In general, deep flood depths throughout much of the Sacramento Valley results realatively similar damages across a broader range of events.[4] As a result EADs (and benefits) in the Sacramento Valley are particularly sensitive to relatively small changes in the frequency of flooding (AEP)[5].

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[4] In other words, large infrequently occurring storm events and smaller flood events can produce similarly catastrophic flood depths.

[5] This is in contrast to other areas where EADs (and benefits) are sensitive to mitigation against the risks posed by the largest (and less frequently occurring) storm events.

E.5 Assesment of Federal Interest

This section describes the assessment of federal interest in single purpose FRM actions. The first sub-section discusses the potential for federal interest in FRM measures that benefit a single impact area. The second sub-section focuses on the potential for federal interest in more systematic flood risk management actions. In other words, risk reduction measures intended to benefit multiple impact areas. The third subsection briefly describes how these results could be applied to federal interest assessments for multi-purpose projects.

E.5.1 Risk Reduction Measures Benefiting a Single Impact Area

In the absence of more systematic flood risk mitigation measures (e.g. those designed to simultaneously benefit multiple flooding basins) the most expedient flood risk mitigation measures address the probable mode of flooding within a single flooding basin, generally new levee construction or levee strengthening designed to reduce the risks of breach. In this report federal interest in measures that reduce flood risks in a single basin are assessed by comparing the without-project EADs, presented in the previous section, to potential levee costs. To estimate potential levee costs historical levee costs ranging from $10 to $30 million per mile, were applied to the entire or half the flooding basin's perimeter length; depending on the alignment of various flood sources, relative to each basin. The figure below displays the relative likelihood of federal interest in structural measures designed to (exclusively) reduce flood risks in each impact area; under the current CVFPP baseline conditions, using the low levee cost ($10 million/mile). The points on the figure, labeled with the impact area identification number, are color coded according to the predominate land use in each impact area (blue for rural, red for small communities and green for urban areas).

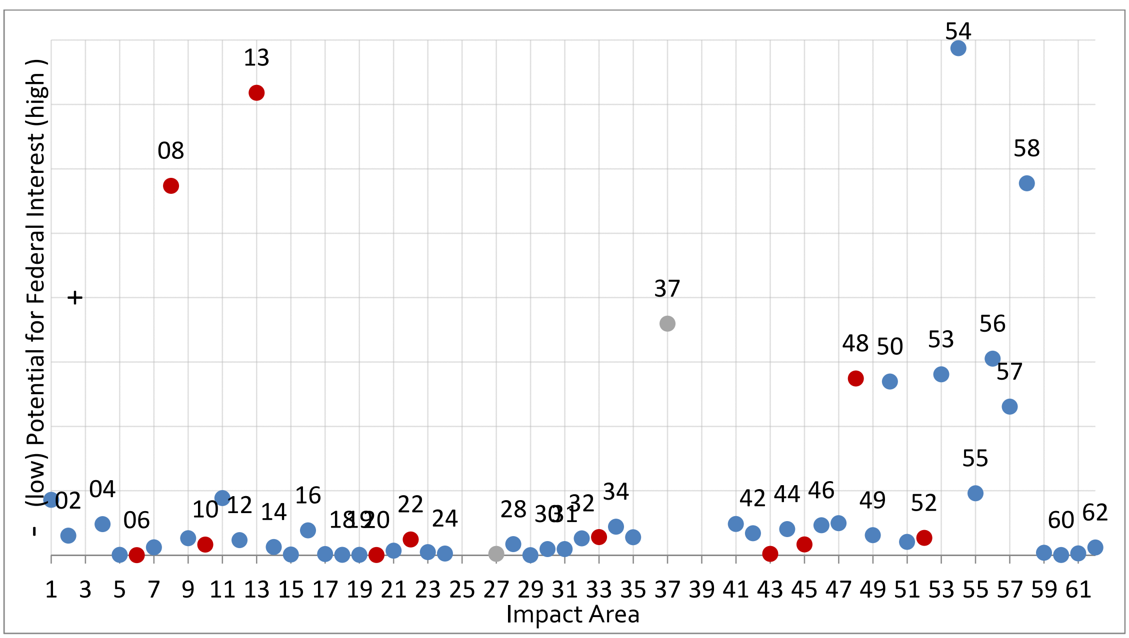


Figure 6. Potential for Federal Interest in Structural FRM Measures by Impact Area

Table 5, located at the end of this report, expands upon the information presented in figure 6 above. In the table impact areas where the potential for federal interest exists under baseline or future year and high or low levee cost assumptions are bolded. The bolded impact areas include 2 small communities: Colusa (08) and Knights Landing (13); 3 delta islands: Grand Island (50), Andrus Island (54) and Sherman Island (58). These locations are discussed more below. Note Grand Island (50) displays the potential for federal interest under future year low levee cost conditions; and not under the baseline year low levee cost conditions shown in figure 6 above.

Delta Islands and Rural Areas

The potential for federal interest is most robust, given the current CVFPP model results and rudimentary levee cost analysis described above, in Andrus Island (54). Under baseline and future conditions as well as both levee cost assumptions the without-project EADs exceed the costs. This suggest that if a ring levee which would eliminate (or nearly eliminate) the modeled without-project flood risks could be built within the described cost range (between $10 and $30 million per mile) federal interest may exist. In the Sherman (58) and Grand (50) Island impact areas without-project EADs exceed costs under certain but not all (base or future) conditions and costs assumptions.

Despite this result two obsticales to federal interest in these areas exists. First, the antecedent delta water surface elevations in the without project CVFPP models match the 1997 flood event's peak water surface elevations. This assumption produces overestimates of peak water stages in the delta, particularly for high frequency flood events, since as the 1997 flood event represented on of the largest events of the 20th century. A second obstacle to federal interest in these and all rural impact areas is the potential land use changes that could occur as a result of the construction of a federal FRM project. Federal policies and executive orders (e.g. EO11988) governing the formulation of federal FRM plans mandate the 'wise' use of floodplains. In practice these policies and orders place a burden of proof on the feasibility study project delivery team to convincingly demonstrate that the construction of a federal project would not lead to development of the historic floodplain. Accordingly, the federal interest in FRM action on these islands is likely to depend upon measures designed to prevent future development of the without-project floodplains.

Small Communities

The potential for federal interest in Knights Landing (13) is robust to the modeled baseline and future conditions as well as the two cost assumptions. Federal interest in Colusa is dependent upon future conditions and the lower cost assumption. In both communities the potential for federal interest in non-structural action may also exist. Risk of loss of life concerns in these communities may further bolster federal interest in measures with benefits in these communities.

Urban Areas

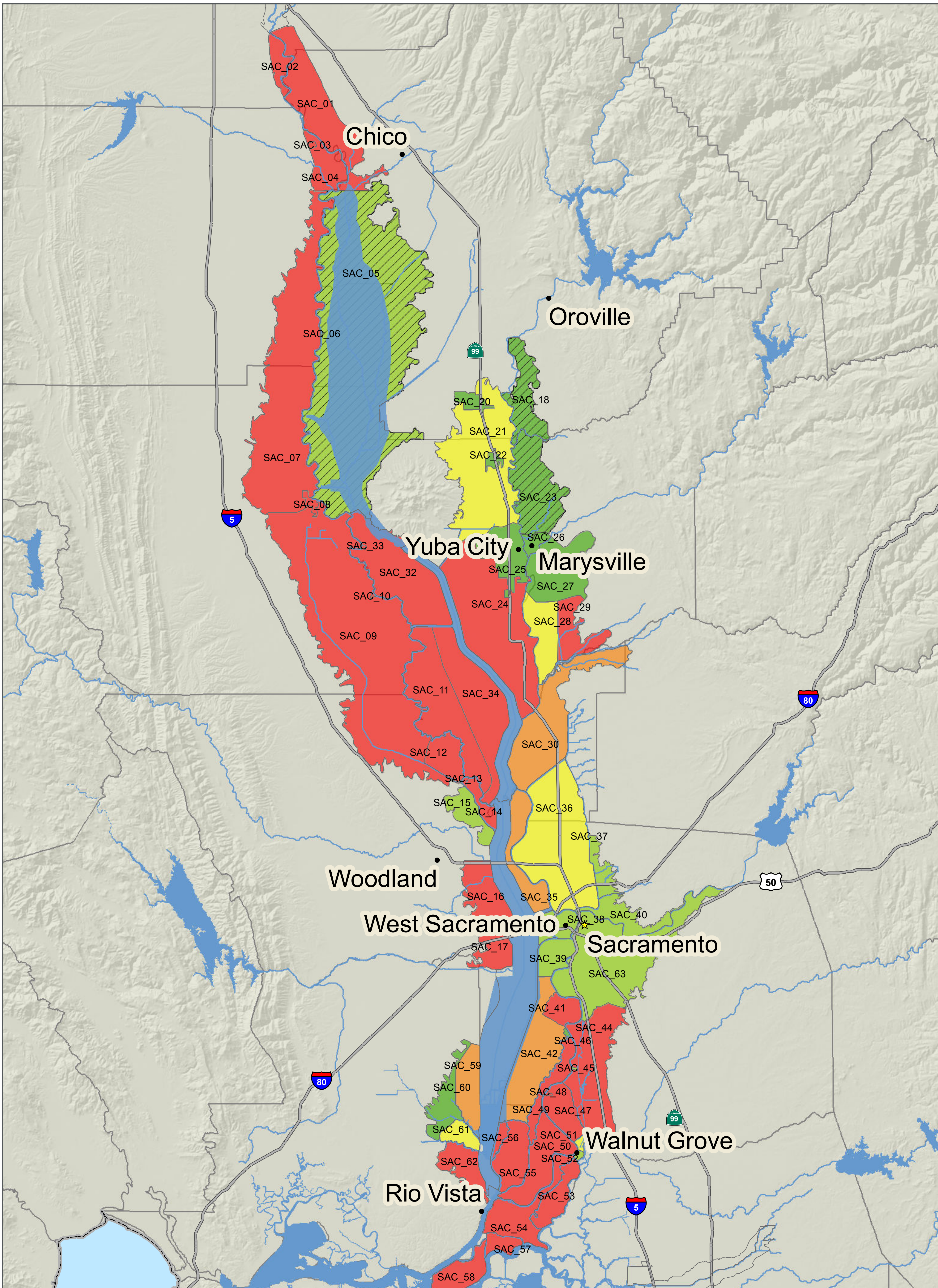
Although most of the CVFPP without-project HEC-FDA models demonstrate a strong potential for federal interest in urban FRM actions, many of the modeled without-project conditions do not include alternatives that are likely to occur as a result of the Sutter Basin, American Common Features, West Sacramento and Natomas Feasibility

Studies. As a results, the without-project EADs in these models (and AEPs) are overstated, from the perspective of this federal interest assessment. Replacing these CVFPP EADs with those presented in USACE feasibility reports and excluding others where replacement is not possible no urban area show potential for federal interest.

E.5.2 Risk Reduction Measures Benefiting Multiple Impact Areas

The figure below displays the long-run average return period for flooding, defined as the inverse of the annual probability of flooding (1/AEP) for the impact areas modeled in the current CVFPP base year HEC-FDA files. As is described above the annualized probability of flooding in many Sacramento Valley impact areas is high. In fact, across all impact areas the arithmetic average AEP in the Sacramento Valley is 0.10, which corresponds with a 1-in-10 chance of flooding in any given year. Furthermore, the flood depths that result for relatively frequent and infrequent events alike are generally deep throughout the central valley. Consequently, projects that provide relatively modest reductions in the annual probability of flooding across a large number of impact areas have the potential to generate federal interest.

New or expanded flood storage, reservoir reoperation, transitory storage, weir and bypass improvements all have the potential to reduce channel stages and therefore levee breach probabilities across multiple impact areas. In other words, they have the potential to generate systematic flood risk reduction benefits. As is noted in previous sections, the benefits associated with some of these measures decreases substantially as flood flows are regulated and diverted by reservoirs and weirs. Accordingly, the areas between major storage and diversion structures serve as natural points at which without-project EADs can be grouped and evaluated. For this reason, EADs and AEPs are summarized under base and future year condition by FRM zones in table 6 at the end of this document.



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Current CVFPP Base Year Average Return Periods of Flooding

1 - 25	101 - 200
26 - 50	201 - 10,000
51 - 100	EAD and AEP are under reported

Figure 7

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Figure 8 below displays the average return period of flooding by impact area under the future year (2064) conditions modeled in the current CVFPP HEC-FDA models. It shows a significant increase in flood probabilities in many impact areas as a result of expected rates of sea level rise, rising temperatures and increased rainfall variability. Sea level rise impacts the delta impact areas and islands directly, by increasing the tidally influenced water surface elevations and chance of levee failure. It also increases base water surface elevations in the downstream reaches of the Sacramento River. Increased temperatures decrease snow fall increasing run-off during storm events. Increased rainfall variability results in deeper rainfall during storm events, thereby increasing storm flows and flood stages.

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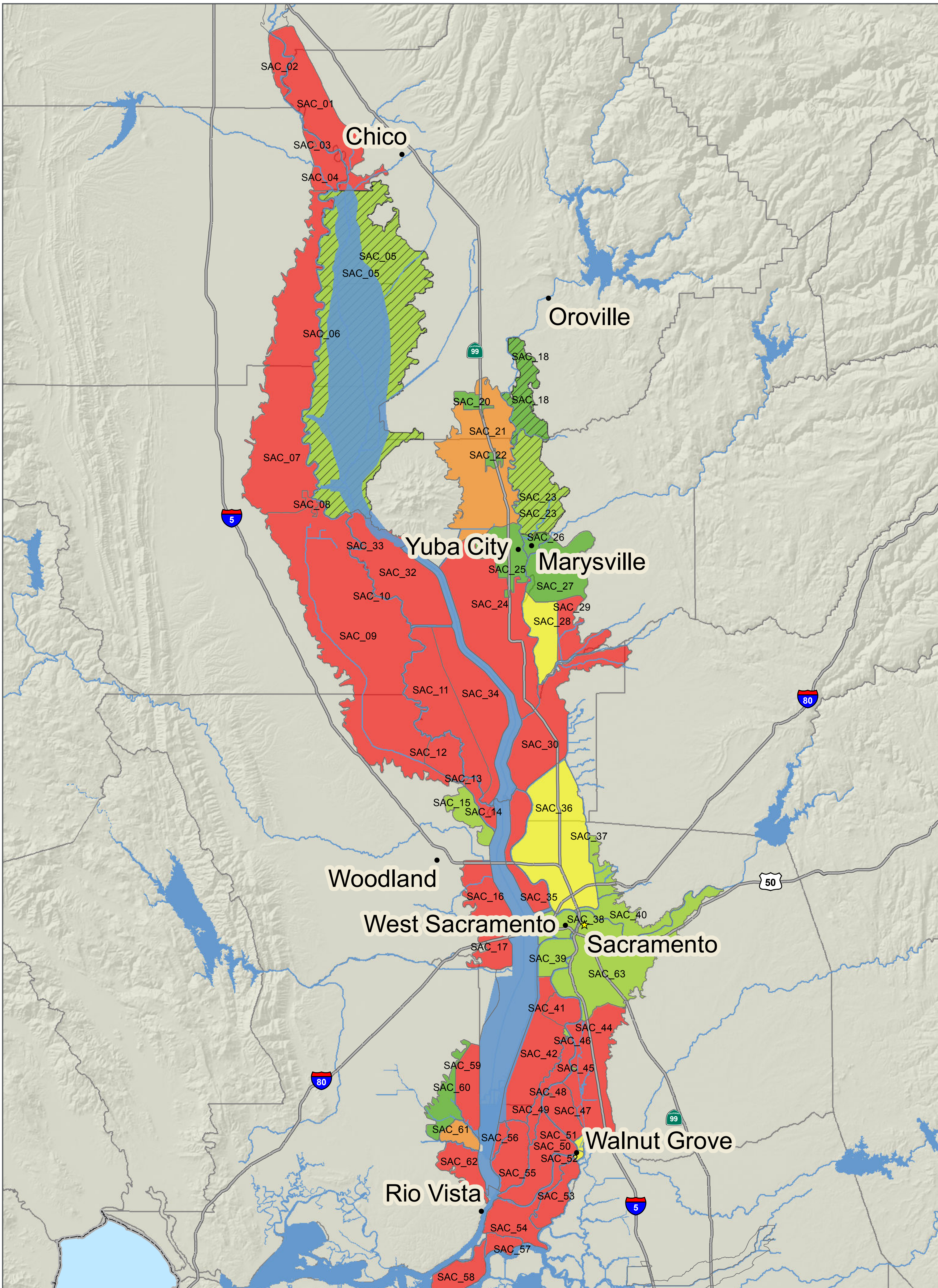

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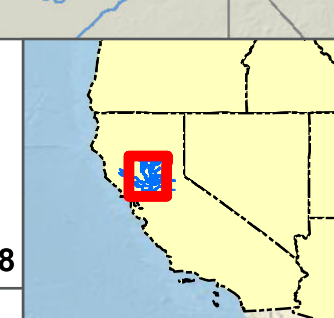
Current CVFPP Future Year Average Return Period of Flooding

1 - 25	101 - 200
26 - 50	201 - 10,000
51 - 100	EAD and AEP are under reported

Figure 8



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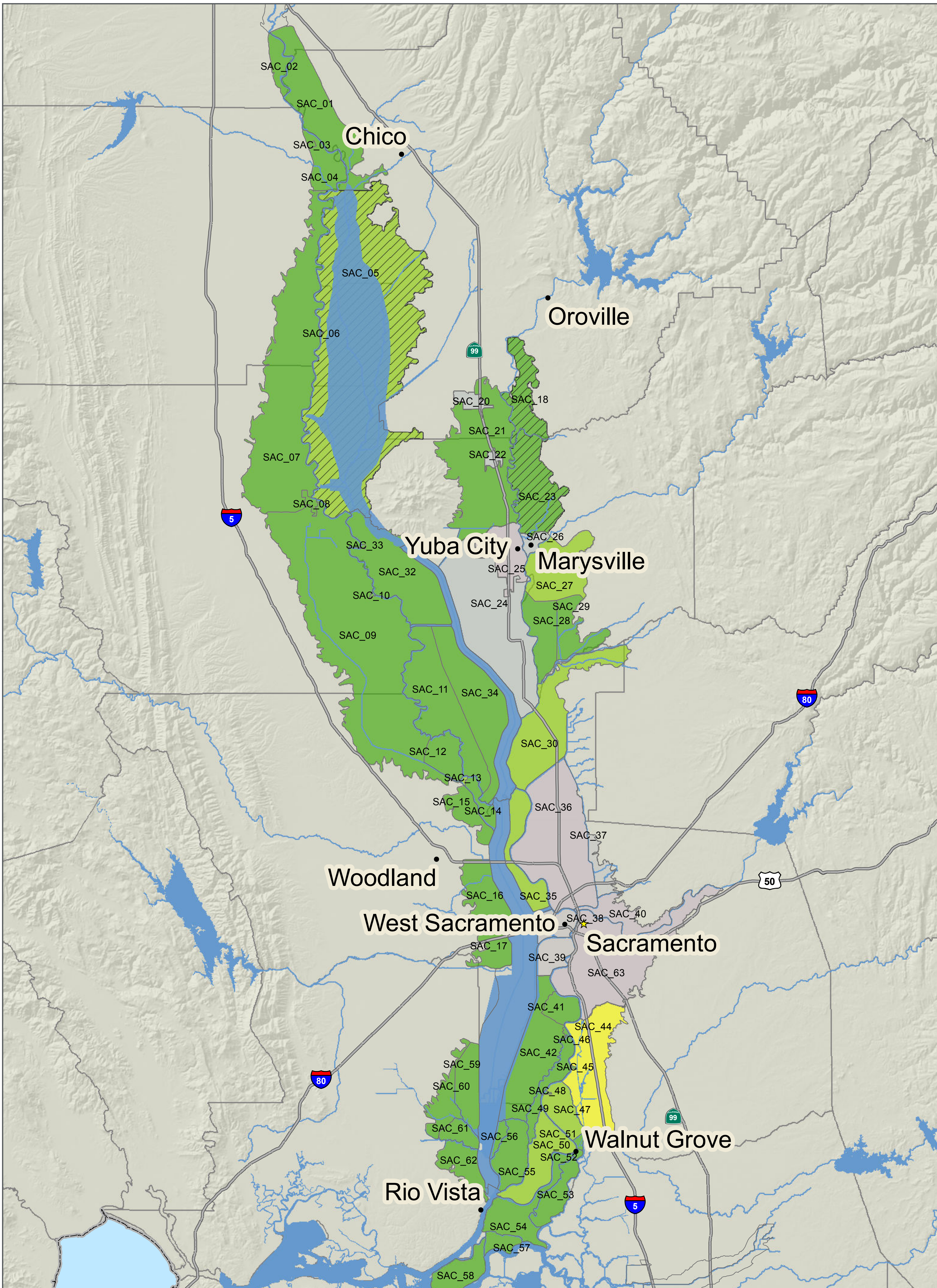

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2012 CVFPP Base Year Without Project NPV of EAD

in thousands of net present dollars

- $1 - $25,000
- $25,000 - $75,000
- $75,000 - $100,000
- $100,000 - $250,000
- $250,000 - $1,638,077
- CVFPP not representative of CVIFMS without project condition

Figure 9

The accuracy of the information presented is limited to the accuracy of the database used for this analysis. Reasonable efforts have been made to ensure the accuracy of the data collected. The USACE Sacramento District GIS Unit disclaims responsibility for damages or liability resulting from the use of this data. This product is the property of the USACE Sacramento District and its use is restricted.

Coordinate System: Datum: NAD 1983 CA State Plane II Feet

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The federal interest in FRM actions intended to benefit multiple impact areas are difficult to assess due to: HEC-FDA's limitation is evaluating multi-reach (e.g. multi-impact area) studies; the appropriate lack of detail associated with conceptual alternatives evaluated in watershed studies; the lack of a modeled with-project condition; and the complexities of the Sacramento Valley storage, diversion and conveyance systems. However, table six shows a near universal combination of low performance (e.g. high AEPs) and high NPV of EAD in the impact area groupings, described above. Between the Colusa and Freemont Weirs the probability of flooding ranges between 1-in-8 and 1-in-6 in any given year, under the base and future year conditions, respectively; and NPV of EAD ranging between $750 million and $1,120 million. This suggests the potential for federal interest in relatively high value investments, depending upon the risk reduction that is achieved in these impact areas. Downstream of the Freemont Weir, without-project EADs and AEPs are misidentified due to the exclusion of FRM actions that will be recommended as part of the Natomas, American Common Features and West Sacramento Feasibility Studies. However, significant residual risks, associated with less frequent events will continue to persist. Alternatives that may mitigate against these multi-impact area residual risks such as increased or new storage, bypass widening and/or weir modifications have a high potential for generating net federal benefits, and federal interest.

E.5.3 Multi-Purpose Benefits

This report assesses federal interest in single purpose FRM actions. However, in the Sacramento Valley there is a vast potential to generate benefits associated with water supply and ecosystem improvements. In instances where water supply or ecosystem restoration actions have the ability to simultaneously reduce flood risks (or vice versa) an overall actions cost is apportioned to each project purpose. By essentially splitting the cost of the action between multiple project purposes, it becomes more likely that net federal benefits in the FRM component will be generated. The tables and figures in this report can inform the federal interest in multi-purpose projects by reporting the maximum potential flood risk management benefit that can be achieved in any given impact area, particularly if the proposed project would generate FRM benefits through the impact area. However, the tables in this report should not be used indiscriminately to evaluate the potential for multi-purpose benefits. In particular, multipurpose FRM projects that generate a large number of non-FRM benefits or address localized flooding within a flooding basin may be economically justified even if the potential for federal interest in single purpose FRM action is low. Chapter 3 of the main report provides a qualitative assessment of the potential for federal interest in multipurpose actions by impact area.

E.5.4 Conclusions

The Sacramento Watershed is naturally prone to flooding. The flux of water associated with storm events in the Central Valley is among the highest in the world. Prior to anthopogenic changes flood flows were naturally conveyed through a system of sloughs, distributaries, marshes and lakes. Natural and man-caused aggradation of sediment created a perched channel in the Sacramento Valley, resulting in deep flood depths. The construction of levees intensified flood risks in many areas, particularly due to structures' susceptibility to failure. Population is primarily centered in the downstream reaches of the Sacramento River, where a natural loss of channel capacity and inflows from major tributaries amplify flood risks. Due to the naturally extreme storm flows, deep flood depths and fragility of the levees, most areas are subject to catastrophic flooding across a broad range of storm events. Thus, relatively minor reductions in the frequency of flooding can often lead to relatively large reductions in EAD.

The potential for federal interest in risk reduction measures that benefits a single impact area are limited to a few impact areas in the delta, namely: Andrus (54), Sherman (58) and Grand (50) islands; 2 small communities: Knights Landing (13) and Colusa (08); but no urban areas. This is largely due to the unpopulated nature of much of the watershed, as well as ongoing FRM studies in the urban areas. The potential for federal interest in risk reduction measures benefiting a single impact area is further complicated by 'wise' use of floodplain policies and executive orders that guide FRM plan formulation. Risk reduction measures in the delta islands would likely be contingent upon the planning delivery team demonstrating that any flood risk reduction measure would not lead to land use changes in the historic floodplain. Anticident delta water surface elevation conditions in the without project CVFPP models further mitigates against the without project delta area EADs presented in this report.

The potential for federal interest in risk reduction measures benefiting multiple areas is more promising. The addition or expansion of storage, modifications to weirs and bypasses as well as the reoperation of existing storage and diversion structures may have the ability to reduce peak stages in multiple impact areas resulting in much larger FRM benefits. These benefits may be obtainable in areas where levee improvements and other less systematic projects have been built or are being considered, particularly in the greater Sacramento area where substantial residual flood risks remain.

The potential for federal interest in multi-purpose projects is also substantial. The water supply and ecosystem related water resource problems exist throughout the watershed. Projects that solve these issues while providing FRM benefits may generate federal interest by defraying the costs associated with each individual project purpose.

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Table 1. Population of the Watershed by Impact Area

Impact Area	Impact Area Title	Land Use Type	Population	Area (sq mi)	Population Density (persons/sq mi)
01	Woodson Bridge East	rural	330	51.8	6.4
02	Woodson Bridge West	rural	155	8.3	18.6
03	Hamilton City	rural	1573	0.4	3595.7
04	Capay	rural	50	15.4	3.2
05	Butte Basin	rural	191	282.9	0.7
06	Butte City	small community	40	0.1	327.0
07	Colusa Basin North	rural	424	143.3	3.0
08	Colusa	small community	1479	1.9	765.7
09	Colusa Basin South	rural	316	215.4	1.5
10	Grimes	small community	74	0.2	369.9
11	Rec Dist 1500 West	rural	77	54.4	1.4
12	Sycamore Slough	rural	1	14.1	0.1
13	Knight's Landing	small community	234	0.5	486.1
14	Ridge Cut (North)	rural	1	6.7	0.2
15	Ridge Cut (South)	rural	4	12.6	0.3
16	Rec Dist 2035	rural	31	22.0	1.4
17	East of Davis	rural	584	18.6	31.4
18	Upper Honcut	rural	485	23.6	20.5
20	Gridley	small community	7101	4.9	1451.6
21	Sutter Buttes East	rural	1584	83.4	19.0
22	Live Oak	small community	2671	2.2	1194.8
23	Lower Honcut	rural	1171	39.6	29.6
24	Levee Dist. #1	rural	2372	92.4	25.7
25	Yuba City	urban	62817	22.9	2743.0
26	Marysville	urban	12432	4.2	2962.0
27	Linda-Olivehurst	urban	27491	35.1	783.5
28	Rec Dist 384	rural	7105	21.5	330.6
29	Best Slough	rural	258	17.8	14.5
30	Rec Dist 1001	rural	315	55.1	5.7
32	Rec Dist 70-1660	rural	85	58.1	1.5
33	Meridian	small community	96	0.2	484.4
34	Rec Dist 1500 East	rural	63	50.3	1.3
35	Elkhorn	rural	17	20.6	0.8
36	Natomas	urban	43459	85.6	507.4
37	Rio Linda	urban	26495	9.2	2873.7
38	West Sacramento	urban	18127	10.1	1797.2
39	Rec Dist 900	urban	6451	11.8	548.4
40	Sacramento North	urban	75017	15.9	4711.0
41	Rec Dist 302	rural	21	9.6	2.2
42	Rec Dist 999	rural	84	45.2	1.9
43	Clarksburg	small community	111	0.4	276.9
44	Stone Lake	rural	13929	52.1	267.5
45	Hood	small community	69	0.2	456.4
46	Merritt Island	rural	28	8.2	3.4
47	Rec Dist 551	rural	42	15.1	2.8
48	Courtland	small community	75	0.2	328.3
49	Sutter Island	rural	7	4.4	1.6
50	Grand Island	rural	282	27.5	10.3

table continued on next page...

Impact Area	Impact Area Title	Land Use Type	Population	Area (sq mi)	Population Density (persons/sq mi)
continued from previous page...					
51	Locke	rural	31	1.2	25.8
52	Walnut Grove	small community	126	0.8	160.4
53	Tyler Island	rural	4	14.2	0.3
54	Andrus Island	rural	421	24.4	17.2
55	Ryer Island	rural	75	19.6	3.8
56	Prospect Island	rural	not available	3.2	not available
57	Twitchell Island	rural	2	5.9	0.3
58	Sherman Island	rural	34	16.2	2.1
59	Moore	rural	48	18.4	2.6
60	Cache Slough	rural	48	15.7	3.1
61	Hastings	rural	8	7.6	1.1
62	Lindsey Slough	rural	2378	17.8	133.4
63	Sacramento South	urban	316873	81.8	3874.0

Table 2. Population of Watershed by FRM Sub-Region

Location	Impact Area Title	Land Use Type	Population	Area (sq mi)	Population Density (persons/sq mi)
Upstream of Colusa Weir			**4242**	**504**	**8**
01	Woodson Bridge East	rural	330	52	6.4
02	Woodson Bridge West	rural	155	8	18.6
03	Hamilton City	rural	1573	0	3595.7
04	Capay	rural	50	15	3.2
05	Butte Basin	rural	191	283	0.7
06	Butte City	small community	40	0	327.0
07	Colusa Basin North	rural	424	143	3.0
08	Colusa	small community	1479	2	765.7
Between Colusa and Freemont Weirs on Sacramento River			**951**	**412**	**2**
09	Colusa Basin South	rural	316	215	1.5
10	Grimes	small community	74	0	369.9
11	Rec Dist 1500 West	rural	77	54	1.4
12	Sycamore Slough	rural	1	14	0.1
13	Knight's Landing	small community	234	0	486.1
14	Ridge Cut (North)	rural	1	7	0.2
15	Ridge Cut (South)	rural	4	13	0.3
32	Rec Dist 70-1660	rural	85	58	1.5
33	Meridian	small community	96	0	484.4
34	Rec Dist 1500 East	rural	63	50	1.3
Upstream of Freemont Weir on Feather River			**125802**	**403**	**312**
18	Upper Honcut	rural	485	24	21
20	Gridley	small community	7101	5	1452
21	Sutter Buttes East	rural	1584	83	19
22	Live Oak	small community	2671	2	1195
23	Lower Honcut	rural	1171	40	30
24	Levee Dist. #1	rural	2372	92	26
25	Yuba City	urban	62817	23	2743
26	Marysville	urban	12432	4	2962
27	Linda-Olivehurst	urban	27491	35	784
28	Rec Dist 384	rural	7105	21	331
29	Best Slough	rural	258	18	14
30	Rec Dist 1001	rural	315	55	6
Downstream of Freemont Weir Upstream of Delta			**487054**	**276**	**14345**
16	Rec Dist 2035	rural	31	22	1.4
17	East of Davis	rural	584	19	31.4
35	Elkhorn	rural	17	21	0.8
36	Natomas	urban	43459	86	507.4
37	Rio Linda	urban	26495	9	2873.7
38	West Sacramento	urban	18127	10	1797.2
39	Rec Dist 900	urban	6451	12	548.4
40	Sacramento North	urban	75017	16	4711.0
63	Sacramento South	urban	316873	82	3874.0

table continued on next page...

Location	Impact Area Title	Land Use Type	Population	Area (sq mi)	Population Density (persons/sq mi)
continued from previous page…					
Delta			**17823**	**308**	**58**
41	Rec Dist 302	rural	21	10	2.2
42	Rec Dist 999	rural	84	45	1.9
43	Clarksburg	small community	111	0	276.9
44	Stone Lake	rural	13929	52	267.5
45	Hood	small community	69	0	456.4
46	Merritt Island	rural	28	8	3.4
47	Rec Dist 551	rural	42	15	2.8
48	Courtland	small community	75	0	328.3
49	Sutter Island	rural	7	4	1.6
50	Grand Island	rural	282	27	10.3
51	Locke	rural	31	1	25.8
52	Walnut Grove	small community	126	1	160.4
53	Tyler Island	rural	4	14	0.3
54	Andrus Island	rural	421	24	17.2
55	Ryer Island	rural	75	20	3.8
56	Prospect Island	rural	not available	3	not available
57	Twitchell Island	rural	2	6	0.3
58	Sherman Island	rural	34	16	2.1
59	Moore	rural	48	18	2.6
60	Cache Slough	rural	48	16	3.1
61	Hastings	rural	8	8	1.1
62	Lindsey Slough	rural	2378	18	133.4

Table 3. Current CVFPP Base Year Without-project NPV of EAD (in $000's) by Impact Area and Damage Category

Location	Impact Area Title	Portion of EAD by Damage Category				
		Agricultural	Residential	Commerical & Industrial	Other	NPV of EAD
Upstream of Colusa Weir		**0.68**	**0.14**	**0.11**	**0.06**	**$ 595,130**
01	Woodson Bridge East	0.96	0.02	0.03	0.00	$ 282,814
02	Woodson Bridge West	0.85	0.07	0.07	0.01	$ 29,025
03	Hamilton City	0.00	0.44	0.51	0.05	$ 6,283
04	Capay	0.93	0.01	0.06	0.00	$ 59,759
05	Butte Basin	0.95	0.03	0.00	0.01	$ 3,870
06	Butte City	0.00	0.00	0.00	0.00	$ -
07	Colusa Basin North	0.67	0.11	0.07	0.15	$ 78,356
08	Colusa	0.00	0.50	0.33	0.18	$ 135,024
Between Colusa and Freemont Weirs		**0.63**	**0.10**	**0.19**	**0.08**	**$ 757,446**
09	Colusa Basin South	0.79	0.04	0.13	0.04	$ 184,907
10	Grimes	0.04	0.75	0.15	0.05	$ 2,010
11	Rec Dist 1500 West	0.70	0.08	0.16	0.06	$ 265,751
12	Sycamore Slough	0.98	0.02	0.00	0.00	$ 21,285
13	Knight's Landing	0.01	0.27	0.65	0.07	$ 93,057
14	Ridge Cut (North)	0.97	0.03	0.00	0.01	$ 10,856
15	Ridge Cut (South)	0.96	0.04	0.00	0.00	$ 1,231
32	Rec Dist 70-1660	0.84	0.08	0.01	0.07	$ 66,318
33	Meridian	0.01	0.30	0.27	0.42	$ 3,493
34	Rec Dist 1500 East	0.51	0.13	0.13	0.23	$ 108,537
Upstream of Freemont on Feather		**0.34**	**0.39**	**0.16**	**0.11**	**$ 189,104**
18	Upper Honcut	0.80	0.14	0.02	0.02	$ 1,231
20	Gridley	0.29	0.29	0.43	0.00	$ 176
21	Sutter Buttes East	0.85	0.09	0.05	0.01	$ 32,619
22	Live Oak	0.05	0.53	0.19	0.22	$ 13,520
23	Lower Honcut	0.47	0.39	0.08	0.06	$ 9,826
24	Levee Dist. #1	0.72	0.14	0.01	0.12	$ 8,268
25	Yuba City	0.02	0.55	0.35	0.08	$ 30,935
26	Marysville	0.00	0.45	0.34	0.21	$ 38,198
27	Linda-Olivehurst	0.02	0.56	0.21	0.21	$ 3,418
28	Rec Dist 384	0.19	0.68	0.03	0.10	$ 23,471
29	Best Slough	0.00	0.00	0.00	0.00	$ -
30	Rec Dist 1001	0.68	0.22	0.01	0.08	$ 27,442
Downstream of Freemont before Delta		**0.01**	**0.56**	**0.24**	**0.19**	**$38,495,131**
16	Rec Dist 2035	0.27	0.00	0.62	0.11	$ 59,257
17	East of Davis	0.11	0.69	0.12	0.08	$ 2,915
35	Elkhorn	0.86	0.08	0.03	0.04	$ 25,030
36	Natomas	0.01	0.66	0.10	0.24	$ 26,743,553
37	Rio Linda	0.00	0.66	0.13	0.22	$ 505,215
38	West Sacramento	0.00	0.32	0.61	0.07	$ 10,375,379
39	Rec Dist 900	0.00	0.85	0.08	0.07	$ 60,212
40	Sacramento North	0.00	0.61	0.23	0.16	$ 83,256
63	Sacramento South	0.00	0.66	0.17	0.17	$ 640,314

table continued on next page…

Location	Impact Area Title	Portion of EAD by Damage Category				NPV of EAD
		Agricultural	Residential	Commerical & Industrial	Other	
continued from previous page...						
Delta		**0.31**	**0.19**	**0.17**	**0.33**	**$ 2,582,015**
41	Rec Dist 302	0.73	0.22	0.00	0.04	$ 33,624
42	Rec Dist 999	0.71	0.20	0.05	0.04	$ 80,818
43	Clarksburg	0.00	0.76	0.18	0.00	$ 427
44	Stone Lake	0.44	0.13	0.01	0.43	$ 112,960
45	Hood	0.00	0.33	0.49	0.16	$ 1,834
46	Merritt Island	0.83	0.17	0.00	0.01	$ 47,144
47	Rec Dist 551	0.61	0.14	0.18	0.07	$ 49,054
48	Courtland	0.00	0.47	0.25	0.27	$ 20,682
49	Sutter Island	0.96	0.04	0.00	0.00	$ 21,939
50	Grand Island	0.50	0.37	0.03	0.10	$ 227,678
51	Locke	0.02	0.12	0.37	0.49	$ 5,730
52	Walnut Grove	0.00	0.20	0.52	0.27	$ 5,328
53	Tyler Island	0.72	0.02	0.19	0.06	$ 174,554
54	Andrus Island	0.16	0.24	0.29	0.30	$ 1,265,400
55	Ryer Island	0.69	0.22	0.00	0.09	$ 55,311
56	Prospect Island	0.00	0.00	0.00	1.00	$ 86,674
57	Twitchell Island	0.25	0.03	0.00	0.72	$ 77,451
58	Sherman Island	0.19	0.04	0.00	0.77	$ 287,212
59	Moore	0.74	0.23	0.00	0.03	$ 4,523
60	Cache Slough	0.39	0.11	0.00	0.50	$ 452
61	Hastings	0.85	0.14	0.00	0.03	$ 1,834
62	Lindsey Slough	0.29	0.11	0.20	0.40	$ 21,386

Table 4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
1805	Central Valley	Slow-rise	Flood reportedly inundated the entire valley floor.	Shasta, Tehama, Glenn, Butte, Colusa, Sacramento, El Dorado, Sutter, Yuba, Yolo, Placer
1846	Sacramento	Slow-rise	A New York Times article in 1862 noted that in Sacramento in 1846, the water was 7 feet deep for 60 days.	Sacramento
1849	Sacramento	Slow-rise	Major floods were recorded during this time.	Sacramento
December 1861-January 1862	Regionwide	Slow-rise, structure failure	The “Great Flood” produced regionwide damages along the Sacramento River Basin.	All counties
December 1937	Regionwide	Slow-rise	Many places in the region suffered damage, including Chester, Downieville, Gerber, Tehama, and agricultural areas in Tehama, Glenn, and Colusa counties	All counties
January-February 1942	Regionwide	Slow-rise, coastal,	A Sutter County levee failed in the floods of January-February 1942,	All counties

Table 4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
		structure failure	inundating developed lands.	
November-December 1950	Lowlands south of the Yuba River, Olivehurst, Del Paso Heights, suburban Sacramento	Slow-rise, structure failure	A Yuba River levee breach flooded 43,000 acres of suburban and developed lands south of Marysville, damaging homes in Olivehurst and closing U.S. Highway 99 East (SR 99).	Nevada, Yuba, Sacramento
December 1955	Feather and Yuba Rivers, Yuba City, Nicolaus, and in the Delta: Dead Horse Island, McCormack-Williamson Tract, and an area west of Galt	Slow-rise, structure failure	The flood was characterized by extremely high flows, including record flows at some locations.	Butte, Yuba, Sutter, Nevada, Sacramento
February 1958	Northern Sacramento Valley, Stony Creek, Colusa Trough, Clear Lake, Cache Creek, and in the Delta: Prospect Island, Liberty Island, and Little Holland Tract	Slow-rise, structure failure	Levees breached in an area east of McCormack-Williamson Tract and west of Galt, flooding about 5,800 acres.	Yolo
October 1962	Sacramento and Sacramento Valley, Oroville, Redding, Roseville, Chic, Alturas, Adin, Tobin, Wheatland, and in the Delta: Prospect Island, Liberty Island, Little Holland Tract	Slow-rise, coastal, stormwater, structure failure	Local flooding caused crop inundation, substantial property damage, and 20 lives were lost. The Southern Pacific Railroad and State Highways 40A, 99W, and 99E were closed. The North Fork Pit River flooded Alturas. Ash Creek and Dry Creek rose and flooded Adin, damaging infrastructure. The North Fork Feather River flooded Tobin and two trailer courts. Cattle drowned in the Feather River near Oroville. A levee breached on Yankee Slough near Wheatland and flooded walnut orchards. A total of about 7,300 acres were flooded in the Delta.	Sacramento, Yolo, Solano, Yuba, Plumas, Modoc, Butte, Shasta
January-February 1963	Sacramento Valley, Portola, Quincy, Chester, Johnsville, Daguerre Point Dam, American River and Yuba River Basins, Sierraville, and in the Delta: Prospect	Slow-rise, structure failure	Numerous communities were flooded and damaged in the American and Yuba River Basins. A total of about 7,300 acres were flooded in the Delta.	Sacramento, Plumas, Yuba, Nevada, Sierra, Solano, Yolo

Table 4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
	Island, Liberty Island, Little Holland Tract			
December 1964-January 1965	Sacramento River and tributaries, and in the Delta: Prospect Island, Liberty Island, Little Holland Tract, Egbert Tract, McCormack-Williamson Tract	Slow-rise, coastal, structure failure	Severe flooding occurred in the mountain communities of Chester, Downieville, and Coloma. Mountain highways, roads, bridges, public recreation areas, and cabins were extensively damaged. USACE estimated 383,500 acres in the region were flooded by stream overflow. The Southern Pacific Railroad suspended service over the Sierra Nevada due to flood damage. Highway damage closed I-5 at the Oregon border and north of Redding. Daguerre Point Dam, a debris dam on the Yuba River, underwent a partial failure. Hell Hole Dam, under construction on the American River, collapsed. A total of about 14,100 acres were flooded in the Delta. USACE estimated $39 million flood damages in the Sacramento River Basin.	Shasta, Tehama, Colusa, Sacramento, Solano, Yolo
December 1966-March 1967	Morrison Creek, Stone Lake, Feather River, Colusa Basin, Fairfield	Slow-rise	About 219,000 acres were inundated, nearly all of which was on the valley floor and used for agriculture. Developed properties were inundated by streams of the Fairfield Streams group. USACE estimated about $2,700,000 in flood damages.	Sacramento, Butte, Yuba, Sutter, Colusa, Solano
December 1969-January 1970	Regionwide	Slow-rise, coastal, structure failure	Major flooding especially on the valley floor.	All counties
1972	In the Delta: Andrus Island	Structure failure	The failure of 5,200-acre Andrus Island resulted in significant seawater intrusion.	Sacramento
March-April 1974	Upper Sacramento River area, Upper Lake, and in the Delta: Liberty Island, Little Holland Tract	Stormwater, structure failure	Major flooding occurred with significant localized damage to railroads and agricultural areas.	Sacramento, Lake, Solano, Yolo
January-February 1980	Clear Lake, and in the Delta: Prospect Island, Dead Horse Island	Coastal, structure failure	A combination of high tides and flood- level flows caused breaches and rapid deterioration of private levees. Clear Lake rose to flood stage and damaged low-lying lakeshore development. In the Delta, approximately 1,400 acres	Lake, Solano, Sacramento

Table 4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
			of agricultural land were inundated when the levees of Prospect and Dead Horse Islands breached.	
September 1980	The Delta	Structure failure	An Old River levee failed causing the 5,200-acre Lower Jones Tract to flood.	Sacramento
November and December 1981	Shasta County, and in the Delta: Prospect Island	Slow-rise, structure failure	Homes and infrastructure in Redding, Palo Cedro and Bella Vista were damaged twice by overflow of numerous local streams, including Olney, Dry and Cow Creeks. East of Anderson, the Sacramento River eroded its banks, washing away substantial property and destroying seven homes.	Shasta, Solano
January-March 1983	Regionwide, and in the Delta: Prospect Island	Slow-rise, flash, debris flow, coastal, stormwater, structure failure	Major flooding along Cache Creek inundated the Capay Valley. Flood waters overtopped Hamilton City levees, flooding farmland, and closed nearly every road in Colusa County.	All counties
1986	Delta: Prospect Island and Glanville Tract	Structure failure	There was flooding of 8,228 acres in the Delta.	Solano, Sacramento
February 1986	Regionwide, Thornton, and in the Delta: Dead Horse and Tyler Islands, McCormack-Williamson Tract	Slow-rise, stormwater, structure failure	The floods caused extensive damage to the flood management system of the Sacramento Valley and led to a substantial reassessment and repairs to flood management infrastructure.	All counties
Winter and Spring 1995	Regionwide	Slow-rise, structure failure	Widespread stormwater and small stream flood damage was common. Numerous roadways and bridges washed out at Red Bluff. SR 32 was inundated between Chico and Hamilton City. I-5 and SR 99 were also closed. Dry Creek overflows caused extensive damage in Roseville and suburban Sacramento. Orchards were flooded at Hamilton City. Several local levees were breached on Pine Creek and flooded the area south of Nord. A local levee breach near Wilson Landing received a repair using 43,000 sandbags. Cache Creek rose and stranded homeowners at Yolo.	All counties
December 1996-January 1997	Regionwide, and in the Delta: Dead	Slow-rise, structure	Storms caused one of the worst floods of the century. There was	All counties

Table 4. Selected Flood Events, Sacramento River Hydrologic Region

Date	Location	Flood Type	Description	County
	Horse Island and McCormack-Williamson Tract	failure	widespread flooding and flood damage in the region from the major rivers and creeks in the Sierra Nevada.	
June 2004	In the Delta, Lower Jones Tract	Structure failure	The Lower Jones Tract levee failed, inundating the 5,894-acre island.	San Joaquin

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Attachment F Cultural Resources

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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 1 2 2015

Environmental Resources Branch

Mr. Anthony Jack, Chairperson
Big Valley Band of Pomo Indians
of the Big Valley Rancheria
2726 Mission Rancheria Road
Lakeport, CA 95453

Dear Mr. Jack:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

We would like to invite your consultation under Section 106 of the National Historic Preservation Act of 1966, as amended. Although the study is still in its early phases, we would like to invite you to participate in our upcoming plan formulation workshops where we will be discussing the problems, opportunities, goals, objectives, and possible solutions that could be recommended to address the needs in the watershed.

For more information about the project and upcoming events regarding the project, please visit our website at www.bitly.com/cvifmstudy. We are sensitive toward the protection of traditional cultural properties and sacred sites and make every effort to avoid them. We look forward to working closely with you as this study develops and progresses.

If you have knowledge of locations of archaeological sites or areas of traditional cultural value or concern within the watershed or if you have any other comments, suggestions, or questions, please contact Ms. Stefanie Adams at (916) 557-7283 or by email at stefanie.l.adams@usace.army.mil. Please contact Mr. Glen Reed, Project Manager at (916) 557-5332 or by email at anthony.g.reed@usace.army.mil with any project specific questions.

Sincerely,

for Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 12 2015

Environmental Resources Branch

Mr. Jason Hart, Chairperson
Redding Rancheria
2000 Redding Rancheria Road
Redding, CA 96001

Dear Mr. Hart:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

FOR Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 1 2 2015

Environmental Resources Branch

Mr. Daniel Gomez, Chairperson
Cachil DeHe Band of Wintun Indians
3730 Highway 45
Colusa, CA 95932

Dear Mr. Gomez:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

for Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Mr. Andrew Freeman, Chairperson
Paskenta Band of Nomlaki Indians
P.O. Box 398
Orlando, CA 95963

Dear Mr. Freeman:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

FOR Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 1 2 2015

Environmental Resources Branch

Mr. Nicholas H. Fonseca, Chairperson
Shingle Springs Band of Miwok Indians
P.O. Box 1340
Shingle Springs, CA 95682

Dear Mr. Fonseca:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

for Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Mr. James Edwards, Chairperson
Berry Creek Rancheria of Maidu Indians
5 Tyme Way
Oroville, CA 95966

Dear Mr. Edwards:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

for Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Mr. Stacy Dixon, Chairperson
Susanville Indian Rancheria
745 Joaquin Street
Susan, CA 96130

Dear Mr. Dixon:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

for ~~Alicia~~ Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Mr. Phillip Del Rosa, Chairperson
Alturas Rancheria
P.O. Box 340
Alturas, CA 96101

Dear Mr. Del Rosa:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

FOR Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Mr. Raymond Brown, Sr., Chairperson
Elem Indian Colony of Pomo Indians
of the Sulphur Bank Rancheria
P.O. Box 757
Lower Lake, CA 95457

Dear Mr. Brown:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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FOR Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 1 2 2015

Environmental Resources Branch

Mr. Donald Arnold, Chairperson
Scotts Valley Band of Pomo Indians
1005 Parallel Drive
Lakeport, CA 95453

Dear Mr. Arnold:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Mr. Gary Archuleta, Chairperson
Mooretown Rancheria of Maidu Indians
1 Alverda Drive
Oroville, CA 95966

Dear Mr. Archuleta:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Chairperson
Robinson Rancheria Band of Pomo Indians
P.O. Box 4015
Nice, CA 95464

Dear Chairperson:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch FEB 12 2015

Chairperson
Cedarville Rancheria
300 West 1st Street
Alturas, CA 96101

Dear Chairperson:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Andrew Franklin, Chairperson
Wilton Rancheria
9300 W. Stockton, Suite 200
Elk Grove, CA 95758

Dear Chairperson Franklin:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Mr. Charlie Wright, Chairperson
Wilton Rancheria
P.O. Box 1630
Williams, CA 95987

Dear Mr. Wright:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Mr. Gene Whitehouse, Chairperson
United Auburn Indian Community
of the Auburn Rancheria
10720 Indian Hill Road
Auburn, CA 95603

Dear Mr. Whitehouse:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Ms. Sherry Treppa, Chairperson
Habematolel Pomo of Upper Lake
P.O. Box 516
Upper Lake, CA 95485

Dear Ms. Treppa:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Mr. Jose Simon, III, Chairperson
Middletown Rancheria of Pomo Indians
P.O. Box 1035
Middletown, CA 95461

Dear Mr. Simon, III:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

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U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 1 2 2015

Environmental Resources Branch

Mr. Kyle Self, Chairperson
Greenville Rancheria
P.O. Box 279
Greenville, CA 95947

Dear Mr. Self:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Mr. Dennis Ramirez, Chairperson
Mechoopda Indian Tribe of Chico Rancheria
125 Mission Ranch Boulevard
Chico, CA 95926

Dear Mr. Ramirez:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Ms. Dolores Raglin, Chairperson
Pit River Tribe
36970 Park Avenue
Burney, CA 96013

Dear Ms. Raglin:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

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U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 1 2 2015

Environmental Resources Branch

Ms. Rhonda Morningstar Pope, Chairperson
Buena Vista Rancheria of Me-wuk Indians
1418 20th Street, Suite 200
Sacramento, CA 95811

Dear Ms. Morningstar Pope:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Mr. Bernold Pollard, Chairperson
Fort Bidwell Paiute Indian Reservation
P.O. Box 129
Fort Bidwell, CA 96112

Dear Mr. Pollard:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Ms. Glenda Nelson, Chairperson
Enterprise Rancheria of Maidu Indians
2133 Montevista Avenue
Oroville, Ca 95966

Dear Ms. Nelson:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

We would like to invite your consultation under Section 106 of the National Historic Preservation Act of 1966, as amended. Although the study is still in its early phases, we would like to invite you to participate in our upcoming plan formulation workshops where we will be discussing the problems, opportunities, goals, objectives, and possible solutions that could be recommended to address the needs in the watershed.

For more information about the project and upcoming events regarding the project, please visit our website at www.bitly.com/cvifmstudy. We are sensitive toward the protection of traditional cultural properties and sacred sites and make every effort to avoid them. We look forward to working closely with you as this study develops and progresses.

If you have knowledge of locations of archaeological sites or areas of traditional cultural value or concern within the watershed or if you have any other comments, suggestions, or questions, please contact Ms. Stefanie Adams at (916) 557-7283 or by email at stefanie.l.adams@usace.army.mil. Please contact Mr. Glen Reed, Project Manager at (916) 557-5332 or by email at anthony.g.reed@usace.army.mil with any project specific questions.

Sincerely,

for
Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 1 2 2015

Ms. Yvonne Miller, Chairperson
Ione Band of Miwok Indians
P.O. Box 699
Plymouth, CA 95669

Dear Ms. Miller:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

For Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Mr. Marshall McKay, Chairperson
Yocha Dehe Wintun Nation
P.O. Box 18
Brooks, CA 95606

Dear Mr. McKay:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

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Sincerely,

FOR Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

FEB 12 2015

Mr. Ronald Kirk, Chairperson
Grindstone Indian Rancheria
of Wintun-Wailaki Indians
P.O. Box 63
Elk Creek, CA 95939

Dear Mr. Kirk:

We are writing you with regard to a jointly-led Watershed Study that the U.S. Army Corps of Engineers, Sacramento District (Corps) and the State of California Central Valley Flood Protection Board (CVFPB) will be conducting. The Central Valley Integrated Flood Management Study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

We would like to invite your consultation under Section 106 of the National Historic Preservation Act of 1966, as amended. Although the study is still in its early phases, we would like to invite you to participate in our upcoming plan formulation workshops where we will be discussing the problems, opportunities, goals, objectives, and possible solutions that could be recommended to address the needs in the watershed.

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Sincerely,

FOR Alicia E. Kirchner
Chief, Planning Division

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

FEB 12 2015

Water Resources Branch

TO NATIVE AMERICAN TRIBES:

On behalf of the U.S. Army Corps of Engineers and our non-Federal sponsor, the Central Valley Flood Protection Board, we would like to make you aware of a jointly-led watershed study, the Central Valley Integrated Flood Management Study. This study covers the Sacramento River Basin, and will focus on system-based solutions to water resources related problems.

If you are interested in learning more about this project, signing up for our mailing list and/or participating in upcoming workshops, please visit our website at www.bitly.com/cvifmstudy. We are planning to hold these events in early 2015 to engage with you in a discussion about the problems, opportunities, goals, objectives, and possible solutions that could be recommended to address the needs in the watershed. We look forward to hearing from you. Your input is invaluable to the process.

If you think there is another person within your organization or network that should be aware of this study, please forward this to them and/or send us their contact information. Thank you for your time and consideration.

Sincerely,

Alicia E. Kirchner
Chief, Planning Division

Attachment G Letters of Support from Sponsors

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DEPARTMENT OF WATER RESOURCES
DIVISION OF FLOOD MANAGEMENT
P.O. BOX 219000
SACRAMENTO, CA 95821-9000

November 20, 2015

Colonel Michael J. Farrell
District Engineer
Sacramento District
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Subject: Letter of Support for the Release of the Central Valley Integrated Flood Management Study, Draft Watershed Plan

Dear Colonel Farrell:

The California Department of Water Resources (DWR), as a non-federal sponsor, supports the Central Valley Integrated Flood Management Study (CVIFMS) Draft Watershed Plan for the Sacramento River watershed. CVIFMS is a multipurpose federal study conducted by the U.S. Army Corps of Engineers (USACE) under a federal Cost Share Agreement with the Central Valley Flood Protection Board (CVFPB) and DWR signed on July 21, 2010 and amended on August 30, 2013.

Through extensive partnership and data sharing efforts, USACE has produced a comprehensive assessment of the watershed that will help determine future actions to improve resources in the Central Valley watershed and assess federal interest in those actions. The CVIFMS Draft Watershed Plan lays the foundation for future partnership between federal agencies, tribes, local entities, DWR, and CVFPB, on water resource studies that include flood risk management, ecosystem restoration, and water supply, in the Sacramento River watershed.

The DWR supports the release of the CVIFMS Draft Watershed Plan and looks forward to future partnership with the USACE and CVFPB.

If you have any questions, please contact me at (916) 574-0601 or Keith.Swanson@water.ca.gov, or Christopher Williams at (916) 574-2375 or Christopher.Williams@water.ca.gov.

Sincerely,

Keith E Swanson

Keith E. Swanson, Chief
Division of Flood Management

cc: Leslie Gallagher, Executive Officer
Central Valley Flood Protection Board
3310 El Camino Avenue, Room 151
Sacramento, California 95821

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