3.0 Problems and Opportunities

As discussed in Chapters 1 and 2, the landscape of the Central Valley, and its drainage area, has changed dramatically since the flood management system was initially built, including urban expansion, agricultural intensification, changes in societal values, and changes in land cover both in the valley and upper watershed source areas. As a result of these and other changes, problems have developed related to flood management and related resource conditions. This chapter describes flood management-related problems and associated opportunities that could be addressed through the Central Valley Flood Protection Plan (CVFPP).

In the context of this chapter, a "Problem" is an undesirable condition – something that is currently viewed as "broken" or will likely be so in the future. Problems provide the common focal point or reason for people to join together in the planning process.

An "Opportunity" is an undertaking that could further increase the value of CVFPP actions – a positive action that can be taken while addressing the identified problems. For example, efforts to reduce flood risk could provide opportunities for ecosystem restoration or other needs such as recreation and water supply.

For the CVFPP, problems and related opportunities were developed from input provided by local, regional, State, federal, and tribal interests. Many of these interests participated in the regional work groups and/or topic work groups convened to help articulate existing resource conditions for the CVFPP (described in Chapter 1), of which problem and opportunity identification was an important output. Key reference materials were also used to identify and define problems and opportunities.

The identified problems and opportunities contained in this chapter include the views, perspectives, and input of all participants. At this point in the planning process, there are differing opinions on whether all of the items included as problems and opportunities are in fact problems that should be evaluated further. There are also differing opinions about the magnitude, relative importance or underlying causes of the identified problems and opportunities. A good example of an item where there is significant disagreement about the factual basis of the statement is "Risks and Consequences of Flooding: Levee structural integrity has the potential to be compromised by any number of factors due to: f) large, woody vegetation". This statement is included to reflect that it is important to one or more

participant groups, but this summary document should not be interpreted to mean that DWR agrees with all of the statements included in the problems and opportunities chapter. In some instances, problems are the subject of ongoing study and evaluation, as noted in the problem discussion.

A broad listing of factors thought to contribute to flood problems and opportunities within the planning areas are included in this chapter, reflecting collective input from the multiple sources described above. Contributing factors were identified, refined, and amended by the work groups in an iterative fashion and then synthesized into five broad categories: (1) risks and consequences of flooding, (2) operations and maintenance, (3) ecosystem, (4) policy and institutional, and (5) integrated water management. A problem or opportunity statement was developed for each category of contributing factors to summarize key themes. Each problem or opportunity statement, and their associated contributing factors, is discussed in detail in this chapter.

Each discussion begins with a summary table that provides a graphical representation of how the contributing factors vary from region to region. The regional work groups provided input on the relative applicability of the contributing factors within their respective regions. For example, some of the contributing factors are applicable only in part of the region, while others are present throughout the region. The Delta Regional Conditions Work Group asked that its region be represented in the table as two subregions, tidal and riverine, to more accurately identify where these contributing factors are applicable.

Regional differences are reflected in the summary table using the following symbols:

- An “N/A” denotes that the contributing factor is not applicable to a region
- A half circle denotes that the contributing factor is relevant to parts of a region
- A full circle denotes that the contributing factor is relevant to an entire region

The term “relevant" indicates that a region is currently experiencing the problem or previously experienced problems associated with a particular contributing factor. In those instances where the problem was ‘previously experienced,’ the region may have resolved the problem, but concerns remain over the problem potentially recurring in the future. This chapter does not attempt to distinguish between current problems and previously

experienced problems. This level of refinement, evaluation, and prioritization is the subject of the next phase of the CVFPP development process.

The symbols assigned to each contributing factor are subjective, not meant to be scientifically precise, and not meant to imply that technical or scientific documentation about the condition is necessarily available (e.g., modeling to determine the effect of channel vegetation on meeting design flow). The symbols are meant to capture the views and perspectives of the participants and were used to synthesize input received from these participants in a simplified manner.

As mentioned previously, problems are the common ground that motivate collective participation in the planning process – the reason for undertaking the effort. As such, problems and opportunities are instrumental in shaping broad goals and specific objectives for the CVFPP, and are crucial building blocks for identifying, developing, and screening potential management actions and solutions, a major focus of the next phase of the CVFPP development process. Because of the close linkage between solutions and management actions, and problems and opportunities, the regional and topic work groups often provided input on potential solutions and management actions to help address their identified problem or opportunity. These initial solutions and management actions were captured and advanced for consideration during the next phase in the CVFPP development process.

As noted in the preface of this report, this is a ‘working document.’ As such, the information presented in this chapter is based upon the best available information at the present time. As new information becomes available, such as better data describing the magnitude, viewpoints, and perspectives of certain identified problems, it will be considered during subsequent phases of the CVFPP development process.

3.1 Risks and Consequences of Flooding

The Sacramento and San Joaquin river basins have been subject to flooding and increased flood risk to people and property due to physical and operational constraints of the existing flood management systems, reliance on flood management facilities that do not provide the level of protection currently desired, changing land uses in flood-prone areas and limited understanding of flood risk. Flood risk is likely to continue to increase in some areas of the river basins due to climate change.

Although flooding along the Sacramento and San Joaquin rivers and their major tributaries is a natural process, it also poses significant risks to human life, health, and safety. Table 3-1 lists contributing factors related to flood risk problems, and their relevance to each of the five planning regions. The following discussion reflects the views and perspectives of all participants and input received, recognizing that there are differing opinions on the magnitude, relative importance, or underlying causes of the identified problem and its contributing factors.

Table 3-1. Risks and Consequences of Flooding Problem Statement Contributing Factors Summary

Contributing Factors	Regional Differences*					
	Upper Sacramento	Lower Sacramento	Delta		Upper San Joaquin	Lower San Joaquin
			Tidal	Riverine		
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
Channels do not convey design capacity because of changed channel conditions:						
a) Vegetation growth in channels	◖	◖	◖	◖	◖	◖
b) Accumulations of sediment, snags, or debris	◖	◖	◖	●	◖	◖
c) Changed stream gradient due to subsidence	N/A	◖	◖	◖	◖	N/A
d) Decreased stream gradient due to channel meander	●	N/A	N/A	N/A	N/A	◖
e) Additional downstream restrictions	N/A	N/A	N/A	N/A	◖	◖
Levee structural integrity has the potential to be compromised by any of a number of factors, including:						
a) Erosion	◖	◖	◖	●	◖	◖
b) Seepage	◖	◖	◖	◖	◖	◖
c) Overtopping (wind, wave run-up, high flows)	◖	◖	◖	●	◖	◖
d) Subsidence/settling	◖	◖	●	◖	◖	◖
e) Animal burrowing activity	◖	◖	◖	◖	◖	◖
f) Large, woody vegetation	◖	◖	◖	◖	◖	◖
g) Contact damage (ships and abandoned vessels)	N/A	◖	◖	●	N/A	N/A
h) Human interaction on the waterside of levee	◖	●	●	●	◖	◖
i) Encroachments	◖	◖	◖	◖	◖	◖
j) Levee penetrations	◖	◖	◖	◖	N/A	◖
The performance and operation of other flood facilities (weirs, bypasses, gates, bifurcations, overflows) is constrained by the following:						
a) Accumulation of sediment	◖	◖	N/A	◖	◖	◖
b) Additional downstream restrictions	◖	◖	N/A	N/A	N/A	◖
c) Antiquated control systems	◖	◖	N/A	N/A	◖	◖
d) Subsidence	N/A	◖	N/A	N/A	◖	◖
e) Erosion	●	◖	N/A	N/A	◖	◖
f) Facilities not engineered to USACE/DWR standards	◖	◖	N/A	N/A	●	◖

Table 3-1. Risks and Consequences of Flooding Problem Statement Contributing Factors Summary (Contd.)

Contributing Factors	Regional Differences*					
	Upper Sacramento	Lower Sacramento	Delta		Upper San Joaquin	Lower San Joaquin
			Tidal	Riverine		
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
Prescribed reservoir releases under current water control manuals can result in flows that exceed downstream channel capacities because of the following:						
a) Insufficient flood storage capacity to regulate flood flows	●	●	●	●	●	●
b) Water control manuals not designed to accomplish systemwide coordinated operations	●	●	●	●	●	●
c) Water control manuals based on a limited period of record	●	●	●	●	●	●
d) Not using available forecasting technology in operations decisions	●	●	●	●	●	●
e) Inadequate snow and flow sensor data	●	●	●	●	●	●
Channels and levees no longer provide the expected level of protection they were originally designed to achieve because of the following:						
a) Changes in design standards and expectations for levee performance	◖	◖	◖	◖	◖	◖
b) Changes in hydrology/hydraulics and/or climate change	◖	◖	◖	◖	◖	◖
c) Changes within designated floodways and bypasses	◖	◖	◖	◖	◖	◖
d) Maintenance challenges	◖	◖	◖	◖	◖	◖
Existing flood management system does not provide the level of protection desired and/or required because of the following:						
a) System designed for different uses and levels of protection	●	●	●	●	●	●
b) Adequate funding for maintenance and improvements not available	●	●	●	●	●	●
c) New legislation increased protection requirements for urban and urbanizing areas	◖	●	●	●	◖	●

Table 3-1. Risks and Consequences of Flooding Problem Statement Contributing Factors Summary (Contd.)

Contributing Factors	Regional Differences*					
	Upper Sacramento	Lower Sacramento	Delta		Upper San Joaquin	Lower San Joaquin
			Tidal	Riverine		
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
Challenges to effective flood fight mobilization include the following:						
a) Confusion regarding flood fight roles and responsibilities	●	●	●	●	◖	◖
b) Insufficient funding	●	●	●	●	●	●
c) Financially punitive regulations governing non-jurisdictional response	◖	◖	◖	◖	◖	◖
d) Lack of comprehensive mutual aid agreements covering flood response	●	●	●	●	●	●
Limitations of emergency response capabilities to flood threats include the following:						
a) Institutional capacity, resources, and coordination	●	◖	●	●	●	◖
b) Local flood contingency planning and regional response planning challenges (access, egress, warning, and communications)	●	●	●	●	●	◖
c) Critical infrastructure located within the floodplain	◖	◖	◖	◖	◖	◖
Challenges to existing post-flood recovery plans and programs include the following:						
a) Debris removal	◖	◖	◖	◖	◖	◖
b) Timely restoration of utilities	◖	◖	◖	◖	◖	◖
c) Inefficient coordination	◖	◖	◖	◖	◖	◖
d) Agricultural recovery	◖	◖	◖	◖	◖	◖
e) Regional economic recovery	◖	◖	◖	◖	◖	◖
f) Ecosystem flood-related issues	◖	◖	◖	◖	◖	◖
Among the public there is a general lack of understanding of flood risk because of the following:						
a) Limited access to information	●	●	●	●	●	●
b) False sense of security	●	●	●	●	●	●
c) Undefined responsibility for education	●	●	●	●	●	●

Table 3-1. Risks and Consequences of Flooding Problem Statement Contributing Factors Summary (Contd.)

Contributing Factors	Regional Differences*					
	Upper Sacramento	Lower Sacramento	Delta		Upper San Joaquin	Lower San Joaquin
			Tidal	Riverine		
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
Limited understanding about the beneficial functions of floodplains	◖	◖	◖	◖	◖	◖
Floods can impair water quality because of the following:						
a) Groundwater contamination via unsealed wellheads	◖	N/A	N/A	N/A	N/A	N/A
b) Mobilization of hazardous materials and contaminants in floodplain and watershed	◖	◖	●	●	◖	◖
c) Mobilization of sediments	●	●	●	●	●	●
d) Contamination of water treatment and wastewater treatment facilities	◖	◖	N/A	N/A	◖	◖
Flood system maintenance, such as dredging and clearing, can disturb sediment and negatively impact water quality.	◖	◖	●	●	◖	●

Notes:
* Table is intended to graphically capture the regional differences. The identified problems and opportunities contained in this table include the views, perspectives, and input of all participants. At this point in the planning process, there are differing opinions on whether all of the items included as problems and opportunities are in fact problems that should be evaluated further. There are also differing opinions about the magnitude, relative importance or underlying causes of the identified problems and opportunities. This table is subjective, not meant to be scientifically precise and not meant to imply that technical or scientific documentation about the condition is necessarily available.
** "Relevant" indicates that a region is currently experiencing the problem or previously experienced problems associated with a particular contributing factor. In those instances where the problem was previously experienced, the region may have resolved the problem, but concerns remain over the problem potentially recurring in the future.

3.1.1 Channels Do Not Convey Design Capacity Due to Changed Channel Conditions

There are many channels within the flood management system that no longer convey flows to their designed capacity because of various changes in the channel conditions. These changes include: (1) vegetation growth in channels, (2) accumulations of sediment, snags, or debris, (3) changed stream gradient due to subsidence, (4) decreased stream gradient due to channel meander, and (5) additional downstream restrictions.

Vegetation Growth in Channels

Trees and brush grow on most levees and represent an important remnant of the riparian forest that once lined the Sacramento and San Joaquin rivers and tributaries. Vegetation growth can have a wide range of effects on channel capacity depending on its structure, location, level of management, and restriction to management. There are many perspectives on the impacts of vegetation growth on channel capacity and it is the subject of ongoing study and evaluation.

Some assert that smaller vegetation, like brush and weeds that extend into a stream or river's flow path, can create drag, thereby reducing the velocity of flow. Woody vegetation, such as shrubs and trees, along with debris that may collect in their branches, also creates drag and slows flow. Reduced flow rates, in general, can induce upstream flooding and increase sedimentation.

Others contend that recent research shows that some forms of herbaceous vegetation may increase flow rates by becoming horizontal, armoring the channel bottom, decreasing soil erosion and associated flow turbulence (Kavvas et al., 2009). This suggests that the impact of vegetation on channel capacity could be minimized with appropriate riparian vegetation that places trees and shrubs in areas of slow velocity and flexible-stem plants and grasses in areas of high velocity.

Accumulations of Sediment, Snags, or Debris

Sedimentation of natural channels reduces their flow-carrying capacity. Historically, hydraulic mining released great quantities of sediment into some foothill streams, which was carried into the valley and deposited wherever the gradient and flow rate no longer would support the bed load transport. Even though hydraulic mining is now discontinued, portions of these sediments remain in valley streams. Natural sedimentation also deposits large quantities of silt, sand, gravel, and rock where steep foothill streams become flat valley watercourses.

Specific areas in which sediment accumulation is an immediate problem include: Yuba River, Sycamore Creek, Cherokee Canal, Bear River, Middle River downstream from Old River, Paradise Cut, and the San Joaquin River. The worst cases of sedimentation, such as Cherokee Canal and the Yuba River, are associated with hydraulic mining debris from the 19th century. Sedimentation in other areas is from erosion of riverbanks and levees and runoff from agricultural fields. As a result of sedimentation, the San Joaquin River lacks the capacity to carry the combined design flows of the major tributaries from the Merced River confluence downstream to the Delta.

Snags are trees, limbs, or large bushes that have fallen into a stream or river. Once in the waterway, they can collect sediment or debris. While snags provide important ecosystem benefits (CALFED, 2009), they can also migrate downstream and become stuck in the channel, which creates snag "islands" and reduces channel capacity. Snags can also cause property damage by becoming caught on bridges, pumping plants, docks, and other infrastructure.

Debris also creates drag and reduces channel capacity. Small debris such as branches or trash can accumulate along the banks during normal flows, but become much more problematic during high-flow events. Large debris includes furniture, appliances, or other large items that have been illegally dumped into the flood channel. These items can easily be trapped on the river banks by snags, as well as by transportation bridges or other similar infrastructure. Large debris can create significant backwater effects that reduce flood flow capacity.

Changed Stream Gradient Due to Subsidence

Some areas of the Sacramento and San Joaquin river basins, mainly the Lower Sacramento, Delta and Upper San Joaquin River Regions, have experienced subsidence over the last 50 years. A portion of these areas, such as the central and western Delta, are a result of naturally occurring subsidence; however, the majority is due to groundwater overdraft. Within the Upper San Joaquin River Region, groundwater withdrawal and hydrocompaction of the soils by irrigation has led to accelerated subsidence since the 1920s.

Subsidence impacts flood management by changing stream gradients. When portions of rivers or streams sink due to subsidence, the gradient may decrease and a backwater effect can be created at the downstream edge of the subsidence; the decrease in gradient can reduce flood flow capacity. At the upstream edge of the subsidence, the gradients may increase, causing increased velocities and erosion within the system.

Efforts to address subsidence-related flood management problems could provide an opportunity to improve water supply reliability. Increased conjunctive use of surface water and groundwater can reduce the potential for subsidence from groundwater overdraft (i.e., replace groundwater usage with surface water). Agencies throughout the Central Valley are already conducting conjunctive use to primarily increase their water supply reliability. From the flood management perspective, recharging groundwater is beneficial because it can decrease subsidence and thus lessen impact on flood protection facilities.

Decreased Stream Gradient Due to Channel Meander

There are instances in the flood control system where streams and rivers were modified to improve flood flow capacity. Portions of those streams and rivers have been meandering back to their natural path. For example, erosion at Woodson Bridge (upper Sacramento River, Tehama County) is an example of an area where the river is attempting to migrate back to its historic channel through Kopta Slough. Channel meandering that decreases the stream gradient can significantly reduce the flood flow capacity from its original design level, as well as erode existing levees immediately adjacent to the river channel.

Others note that channel meandering is a natural process which, when restricted, changes the rate and pattern of channel movement both upstream and downstream. Partial river meandering is possible along reaches of rivers bounded by levees where the levees are set back a sufficient distance away from the main channel of the river (i.e., Sacramento River north of Colusa).

Additional Downstream Restrictions

Some flood management districts' capacity constraints are the result of flow restrictions downstream from the districts' boundaries. In such situations, a district is dependent on its downstream neighbor to increase flood flow capacity since it is outside of the upstream district's management authority. For example, the accumulation of sediment over time has flattened the northern downstream reaches of the San Joaquin River and decreased channel capacities. Because of this, operators of the Merced, Tuolumne, and Stanislaus river reservoirs upstream need to consider downstream conditions in the San Joaquin River before releasing their reservoir storage.

3.1.2 Stressors on Levee Structural Integrity

Erosion Can Damage Channel Banks and Levees

The potential for flooding along the Sacramento and San Joaquin rivers and its main tributaries is highly dependent on the levees that protect much of the Central Valley. To maintain this protection and prevent levee failure, it is vital that the levees retain their structural integrity. During the 1997 flood, levees on the Sacramento River sustained two major breaks and many levees were severely damaged. On the San Joaquin River, levees failed in more than 24 places and many levees were damaged by sloughing, slumping, and seepage (FEAT, 1997a). Levee structural integrity has been compromised by a number of factors including: (1) erosion, (2) seepage, (3) overtopping (wind, wave runup, high flows), (4) subsidence/settling, (5) animal burrowing activity, (6) large, woody vegetation, (7) contact damage (ships and abandoned vessels), (8) human interaction on the waterside of the levee, (9) encroachments, and (10) levee penetrations. These stressors can lead to several modes of failure, including: (1) internal erosion, (2) external erosion and (3) slope stability.

Erosion

In many levee reaches, the flood control channels were designed to flush out sediments that accumulated in the Sacramento River system from hydraulic mining activities in the late 1800s. These designs altered the natural balance of erosion and deposition in the channels and flushed out a majority of the mining debris. However, with much of the debris removed, the powerful flows are now eroding the natural channel banks and the flood protection levees placed on them. Furthermore, many of the earlier levees were not engineered and were made with readily available materials dredged from the adjacent river. Poor levee foundations, geometry, or soil materials in some areas have further exacerbated erosion problems. Without bank protection, this erosion can encroach on existing levees and ultimately result in levee failure and major flooding. Floodwaters are

erosive and, while moving along typically unprotected levees, need only encounter one weak spot in the system to cause a breach and potential loss of life or property. Extremely high hydraulic gradients can find other weak spots in the foundation materials and begin to migrate, or erode material from the foundation, creating unstable conditions quickly followed by total or significant structural failure (FEAT, 1997a). This ongoing erosion causes more damage than can be repaired by the State or levee maintaining agencies (LMA) using standard maintenance programs (DWR, 2005b).

Seepage

High hydraulic gradients during floods can force seepage through or under a levee where it can carry levee or foundation material with it. Some seepage through an earthen levee is relatively common, but when the seepage finds or creates a drainage path through erodible material, such as a sand stratum, material is gradually washed out through a "boil" on the landside of the levee. If unchecked, sufficient material can exit the levee through the boil resulting in a depression or "slump" in the levee. Even a limited slump can cause immediate formation of transverse cracks through the entire embankment. These cracks act as conduits for seepage flow through the levee, which can lead to a rapid deterioration of the embankment, and even complete levee collapse. Poor levee foundations, geometry, or soil materials can increase the vulnerability of a levee to seepage problems.

Overtopping (Wind, Wave Run-up, High Flows)

Overtopping occurs when the quantity of floodwater entering the channel is greater than channel capacity, and water spills over the top of the levee. Wind and wave runup during a high-flow event can also lead to overtopping. As water flows over the crown of the levee, it erodes the landside of the levee, gradually washing soil away until the full cross section is breached. Levees constructed of clay soil can withstand significantly more overtopping than levees constructed of silty or sandy soil (FEAT, 1997a). Vegetation cover has been found to prevent erosion on the back side of the levee by providing an initial protective cover and increasing the apparent cohesive strength of the surface (Gilbert and Miller, 1991).

Subsidence/Settling

Localized subsidence or settling can result in the loss of levee stability. Compression of soft underlying sediments subject to external loads (i.e., new levee construction) can be detrimental to levee stability. Subsidence caused by the collapse of voids present within the levee or its foundation also poses serious risks to the flood control system.

Subsidence through oxidation of the peat soils in the Delta has caused the tidally influenced islands to become holes in which the land surfaces are now 10 to 25 feet below sea level. Because of the decreasing island surface elevations, the levees are now required to hold back substantially more water than when they were originally constructed. The resulted increase in hydraulic pressures on levees that were constructed on foundations of sand, peat, and organic sediments have caused about 35 levee failures since the 1930s (DWR, 2009i). Expected sea level rise from climate change would further increase hydrostatic pressures on Delta levees.

Animal Burrowing Activity

The Sacramento and San Joaquin river basins support a diversity of wildlife species, including burrowing species. Pocket gophers, ground squirrels, beavers and other burrowing animals can create an extensive and interconnected maze of burrows in a levee or its foundation. These holes increase the potential for "piping," or water running through the burrow passage. Piping weakens levee structural integrity and can lead to potential levee failure. A combination of high tide, seepage, and rodent burrowing are believed to be the causes of the Upper Jones Tract Levee Failure in 2004 (DWR, 2009g).

Large, Woody Vegetation

Much of the 1,600 miles of State-federal project levees in the Central Valley is vegetated to some degree, ranging from grasses to shrubs and trees. There are multiple perspectives on the impacts of large, woody vegetation on levee structural integrity and it is currently the subject of ongoing research and review. Concerns about risks to levee structural integrity from large, woody vegetation include: (1) tree root penetration through and under levees that create voids and pathways for seepage (Gray, 1995), (2) uprooting of tree root balls in high wind or currents that could remove enough soil from the embankment to initiate levee failure (Nolan, 1981; Tschantz and Weaver, 1988), and (3) obstacles that may impair flood fight activities during a flood event. For additional perspectives on the impacts of vegetation on O&M, see Section 3.2.1.

On the other hand, several studies have shown that vegetation cover increases shear strength and erosion resistance (Simon and Collison, 2002) by increasing apparent cohesive strength by root reinforcement (Gray et al., 1991; Abernethy and Rutherford, 2001). Pollen and Shields (2007) found that, in cases where levees are composed of largely uncohesive materials, root reinforcement provides significant support to the soil matrix. Root reinforcement also reduces shear stresses acting on the soil from flowing water and protects the levee from rainfall impact and runoff. When studying a sandy channel levee adjacent to the Sacramento River near Elkhorn, Gray et al. (1991) found that woody vegetation did not adversely

affect the structural integrity and no open voids or conduits clearly attributable to plant roots were observed in the levee. Furthermore, clear-cutting woody vegetation can increase rates of erosion or higher frequencies of levee failure due to destruction and gradual decay of interconnected root systems (Bishop and Stevens, 1964; Wu et al., 1979).

Contact Damage (Ships and Abandoned Vessels)

Contact damage is primarily seen in the Delta region. Ships and vessels that are docked along the levees can be repeatedly slammed into the levees by high waters during a flood event. This constant impact can erode portions of the levee or remove riprap, making the levee more susceptible to failure.

Human Interaction on the Waterside of Levee

Regular human interaction with levees can cause levee damage. In some locations, mainly in the Lower Sacramento River Region and Delta Region, homes with swimming pools and other household structures have been constructed on the waterside of the levee. Activities associated with riverfront property features could cause erosion and reduce levee stability. Unregulated access to the riverfront for recreational purposes results in unlined trails, manmade beaches, roadways, and other features that could damage the levee. Recreation on the river, such as boating, could also induce waves that enhance levee erosion.

Encroachments

Another threat to the State-federal flood management system is encroachments that can cause problems with inspections, maintenance, or levee stability. Encroachments may include boat docks, ramps, bridges, sand and gravel mining, placement of fill, fences, retaining walls, pump stations, residential structures, and irrigation and landscaping materials/facilities. Many miles of encroachments exist in the State-federal flood management system.

California Department of Water Resources (DWR) inspects the construction or implementation of newly permitted encroachments to ensure that the work is done in accordance with the encroachment permit conditions (DWR, 2009j). More than 18,000 encroachment permits have been issued by the Central Valley Flood Protection Board (Board) since its inception and the majority of the open encroachment permits are properly maintained. However, there are hundreds of permitted encroachments that are not properly maintained and hundreds of unpermitted encroachments. In fall 2007, DWR identified approximately 129 miles of partially obstructing and 7 miles of completely obstructing encroachments (DWR, 2008e). Unmaintained or unpermitted encroachments may jeopardize levee integrity, raise the surface level of design floods or flows, increase the

damaging effects of flood flows, and impair inspection, maintenance and flood fighting.

DWR reports newly discovered unauthorized encroachments to the Board and works with LMAs to abate unauthorized encroachments. Each LMA is held responsible for preventing the construction of, or requiring the removal of, any illegally encroaching structures on the levee and for stopping any unauthorized modifications to the levee (DWR, 2008e). However, some LMAs can be reluctant to attempt to force the removal of illegal encroachments.

Levee Penetrations

In some portions of the Sacramento and San Joaquin river basins, irrigation lines, drainage outlets, and other utilities have been piped through the levee. Leaks from the penetrations can cause excessive ground loss. In some instances, a surface expression of the ground loss is visible soon after the leak manifests itself, especially on sandy levee embankments. However, if the levee composition is clayey, the leak may cause internal ground loss that may not be detected until a sinkhole appears on the levee surface. These hidden voids pose a serious threat to the protected areas.

3.1.3 Constraints on Other Flood Facilities

Flood facilities other than channels and levees, such as weirs, bypasses, gates, bifurcations, and overflows, serve to reduce flood pressures, similar to pressure relief valves in a water supply system. They allow flood flows in excess of the downstream channel capacity to escape into a bypass channel or basin. The performance and operation of these flood facilities are affected by: (1) accumulation of sediment, (2) downstream restrictions, (3) antiquated control systems, (4) subsidence, (5) erosion, and (6) facilities not engineered to U.S. Army Corps of Engineers (USACE)/DWR standards.

Accumulation of Sediment

Sedimentation upstream from flood control structures obstructs flow and reduces weir capacity. For example, sediment deposits reduced capacity of the Sacramento Weir and forced flows exceeding design capacity to remain in the Sacramento River when the weir gates were open. This resulted in higher flood stages in the Sacramento River downstream from the Sacramento Weir. DWR removed approximately 38,600 cubic yards of sediment from the Sacramento Weir approach to restore its flow to design capacity. The average depth of sediment removed at the Sacramento Weir was 4 feet with depths ranging from 2 to 5 feet along the length of the weir. Recent projects have also included removal of sediment at the Tisdale and Fremont weirs. Sedimentation is also an immediate problem at the Colusa Weir and Bypass.

Downstream Restrictions

Localized channel size reductions caused by bridges, roads, highways, railways and other infrastructure in the floodplain, have restricted conveyance of flood flows in many areas. Specific areas that have experienced a significant reduction in conveyance capacity because of obstruction include a number of bridge crossings on the lower San Joaquin River; the Garmire Road bridge over Tisdale Weir, which restricted the passage of debris during the January 1997 flood and previous high water events but has since been removed; the Town of Tehama (may be due to a railway obstruction); and the State Route 162 bridge near Willows where a large berm directs flood flows onto the highway. In the Lower Sacramento River Region, the Interstate 80 (I-80) causeway and railroad tracks are a significant downstream restriction to peak flood flows down the Yolo Bypass.

Antiquated Control Systems

Many operating flood facilities were designed and built early in the life of the Sacramento River Flood Control Project (SRFCP). Most weirs and flood control structures in both the Sacramento and San Joaquin river

basins were constructed in the 1930s and early 1940s. The system was designed based on historic flood flows, event magnitudes, and conveyance needs, and can no longer effectively pass the design flows in many areas. An increasing number of control structures are at or exceeding their useful life. Structural rehabilitation, retrofit, and/or total reconstruction of many facilities are needed. Deferred maintenance of these control structures, which some attribute to lack of funding (Section 3.4.5) and the increased costs of regulatory requirements (Section 3.2), has further degraded flood control structure conditions. Facing these challenges, the lack of either a comprehensive system design, or practical means to address redirected impacts of construction and maintenance activities, has resulted in a piecemeal approach that has frequently failed to address flooding on a systemwide basis.

Subsidence

Subsidence impacts the performance and operation of flood control structures by modifying the hydraulic characteristics of the stream through changes in stream gradient. These changes can either decrease or increase the capacities of flood facilities. In the Sacramento River Basin, subsidence, along with other factors, has reduced the capacity of the Knights Landing Ridge Cut, which conveys drainage from the Colusa Basin into the Yolo Bypass.

Erosion

Flood facilities are often located where high flows and velocities may impact the structural integrity of the facility. The Butte Slough Outfall Gates on the Sacramento River and Weir No. 2 in the East Borrow Canal of the Sutter Bypass (DWR, 2003b) are examples of flood facilities that currently have known erosion problems requiring replacement or repair. The Knights Landing Outfall Gates are also being investigated for possible erosion damage. As flood facilities continue to age, it is expected that erosion will continue to be a problem. Since most of the erosive damage is under water, problems can be difficult to detect and significant capital investment is required to repair and upgrade these flood facilities from damage.

Facilities Not Engineered to USACE/DWR Standards

Some of the critical structures that impact the operations of the State-Federal flood management system were not designed or constructed to USACE/DWR adopted standards. For example, flood flow from the Sacramento River enters the upper end of the Butte Basin at three overflow areas (known as 3-Bs, M&T, and Goose Lake) below Chico Landing on the Sacramento River. The Corps of Engineers designed this reach of river using a design flow of 210,000 cubic feet per second, designed the main river levees immediately downstream of the overflow section to carry 150,000 cubic feet per second. The remaining 60,000 cubic feet per second must be diverted from the river between Chico landing and the vicinity of Parrott Grant line to insure the safety of project levees south of the Parrott Grant line. While DWR performs some maintenance on these overflow areas, they are not part of the items comprising the Old Sacramento River Flood Control Project as described in the November 6, 1953 Memorandum of Understanding Respecting the Sacramento River Flood Control Project. The overflow areas were also not engineered to USACE or DWR standards. However, their continued operation is essential to flood management downstream along the Sacramento River. In the example of the 3-Bs, the overflow structure is an unprotected silt weir. Erosion due to head cut development during flood events allow the Sacramento River to enter Butte Basin when it is below flood stage, critically reducing available storage when flood flows are reached and increasing the duration of inundation to property, agriculture, and infrastructure. The M&T and Goose Lake relief structures have required additions of cement and riprap along their length to protect their structural integrity.

3.1.4 Prescribed Reservoir Releases under Current Water Control Manuals Can Result in Flows that Exceed Downstream Channel Capacity

Prescribed reservoir releases under current water control manuals can result in flows that exceed downstream channel capacities. Factors that contribute to this problem include: (1) insufficient storage capacity to regulate flood flows, (2) current water control manuals that are not designed to meet all current systemwide objectives, (3) water control manuals based on a limited period of record, (4) available forecasting technology is not being used when making operations decisions, and (5) inadequate snow and flow sensor data.

Insufficient Flood Storage Capacity to Regulate Flood Flows

Reservoirs with flood management functions are located on the Sacramento and San Joaquin rivers, as well as many of the major tributaries. Some of these reservoirs have insufficient storage capacity to fully capture average annual unimpaired runoff if no releases are made. The San Joaquin River,

in particular, lacks a large storage reservoir with a capacity similar to those operating on the Sacramento River system.

Folsom Dam

From a flood control perspective, maintaining sufficient flood reservation space within reservoirs becomes critical during the rainy season. The deep empty space requirements often drive mandated releases during the flood season to maintain flood storage within the operational flood encroachment curve (Hegedus and Shibatani, 2009). In the San Joaquin Valley, the first flood can fill some reservoirs, and flood releases are limited by the downstream channel capacities. This makes the likelihood of spilling large flood flows from the reservoirs much greater during subsequent flood events (Independent Review Panel to the California Department of Water Resources, 2007).

Water Control Manuals Not Designed to Accomplish Systemwide Coordinated Operations

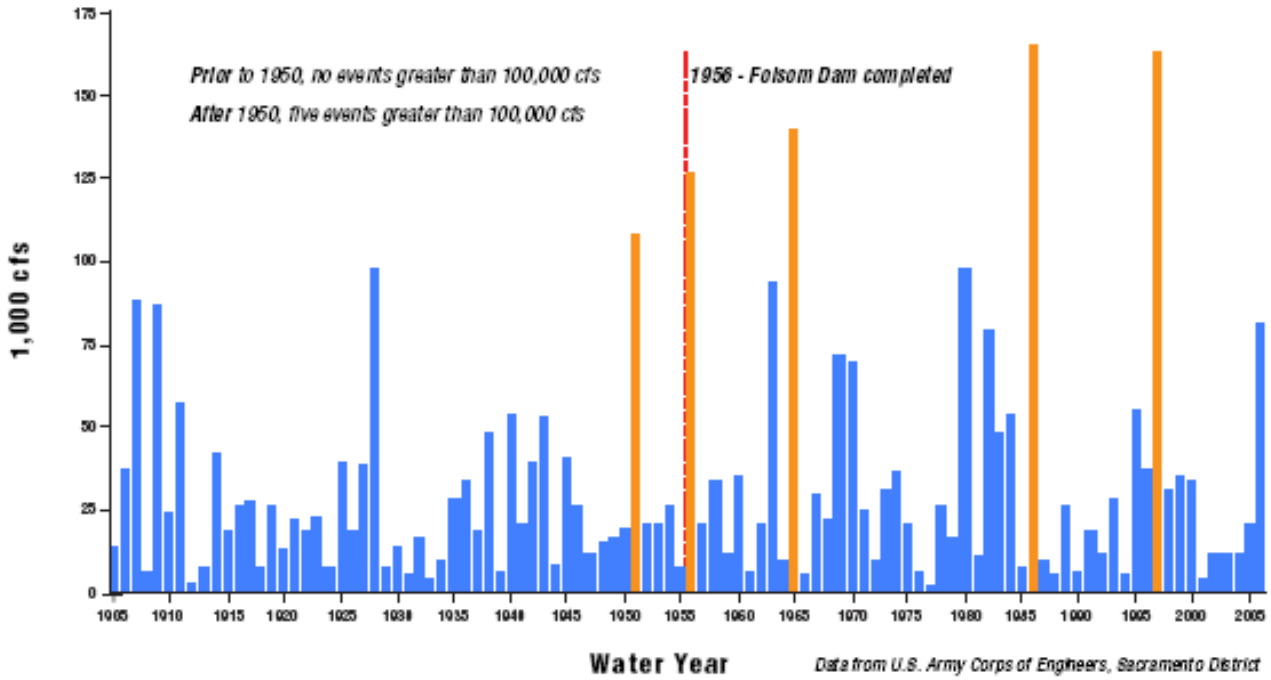
Reservoir operations are largely governed by water control manuals specific to each reservoir. These water control manuals guide the timing and amount of flood space throughout the year and establish objective releases. Many of these manuals apply rigid constraints to operational decisions, restricting flexibility in managing the reservoir to accomplish systemwide coordinated operations. Furthermore, many water manuals are based on outdated assumptions and are in need of revision. For example, the water control manuals for Oroville and New Bullards Bar reservoirs assumed creation of a Marysville Dam downstream from Englebright Dam. Marysville Dam was never built and there are no plans to build it.

The Lower San Joaquin River Region is an example in which systemwide coordinated operations are needed to prevent downstream flooding from prescribed releases. Lower San Joaquin River levee and diversion systems are not capable of containing the objective release (maximum control release that can be safely conveyed by downstream channels) from all of the major, upstream project reservoirs simultaneously due to reductions in channel capacity from sedimentation, debris, and vegetation.

There are currently no formal coordinated flood operations agreements in either the Sacramento River Basin or San Joaquin River Basin. However, operators of the principal flood control reservoirs participate with the DWR and USACE in daily operations conferences sponsored by the State-Federal Flood Operations Center (FOC) during high-water periods. Voluntary modifications of operations often result from these conferences.

Water Control Manuals Based on a Limited Period of Record

Reservoir operation rules, as defined by water control manuals, were based on historical precipitation and runoff data. The hydrological data was limited to the period of record available at the time, which in many cases was not long enough to accurately represent the true system flood probabilities, and did not account for climate change. Each time a large flood occurs in a watershed, the probabilities are recalculated using the historical data record then available. In the latter half of the 20th century, large storms occurred more frequently than during the first half. Consequently, the general trend is for reservoir inflows to be higher than anticipated during original design. Figure 3-1 shows 3-day peak flows of the American River runoff in the past century (DWR 2008b). Five events with 3-day peak flows greater than 100,000 cubic feet per second (cfs) have been observed since 1950. These high peak flow volumes have resulted in a recharacterization of the level of flood protection offered by Folsom Dam, which was designed in the 1940s (DWR 2008b).



Source: DWR 2008b (with top 5 annual maximum 3-day flow highlighted)

Figure 3-1. American River Runoff, Annual Maximum 3-Day Flow

Not Using Available Forecasting Technology in Operations Decisions

Utilizing available quantitative precipitation forecasts would allow system operators to make reservoir releases in advance of approaching storms. Reservoir inflow forecasts have been refined over the years taking advantage of satellite and other real-time telemetry to improve data accuracy and streamline data delivery to forecasters and reservoir managers. More robust notification processes and river stage forecast data to downstream emergency operation managers and LMAs are other benefits to using forecasting technology. Forecast-coordinated operations are currently being applied in the Feather-Yuba system. In addition, studies are underway to assess the viability of a similar project on the Sacramento River below Shasta and to expand the program to other reservoirs in the Central Valley. There is a need for forecast-coordinated operations for larger watersheds, such as the Sacramento and San Joaquin river basins.

Inadequate Snow and Flow Sensor Data

In rugged mountainous regions like the Sierra Nevada, physical measurements of snow water equivalent (SWE) are needed to predict the volume and timing of snow melt runoff (Mizukami et al., 2003). Increased quantity and accuracy of snow and flow sensor data would allow flood managers to reduce peak flows by making reservoir releases in advance of expected reservoir inflows from snowmelt. Accurate snow measurements

would also help monitor the potential impact of future climate change on snowpack patterns.

SWE measurements have been made by ground-based or remote sensing methods (Mizukami et al., 2003). Both methods have limitations that make the timely collection of accurate SWE levels difficult. Remote sensing functions well in flat agricultural areas and is emerging as a valuable tool for SWE prediction (Bales and Harrington, 1995). But remote sensing functions less well in rugged areas due to problems in sensor sensitivity (Rango and Shalaby, 1999), validation of SWE retrieval algorithms (Cline, 1998), and scale-appropriate measurements. Current operational measurements of SWE in complex terrains rely on ground-based manual snow surveys or automated snow sensors (Elder et al., 1997). Snow surveys, while accurate, can only provide data infrequently and require large investments of time and effort to access remote snowpacks. Automated snowpack measuring sensors provide an excellent estimate of SWE distribution on a relatively large scale, such as SWE variation with elevation for the entire Sierra Nevada. At a single watershed scale, however, it is difficult to estimate accurate SWE from interpolation of point data (Elder et al., 1997; Balk et al., 1998). Currently, a large number of manual measurements within the watershed are necessary, in conjunction with interpolation between measuring points, to obtain estimates of the SWE distribution.

3.1.5 Channels and Levees no Longer Provide the Expected Level of Protection They Were Originally Designed to Achieve

Construction of flood management infrastructure on the Sacramento and San Joaquin rivers began in many places before the beginning of the 20th century. Physical conditions, as well as knowledge and expectations of flood system performance, have changed significantly over time. Changes that have impacted the level of protection provided by flood control structures over time include: (1) changes in design standards and expectations for levee performance, (2) changes in hydrology/hydraulics and/or climate change, (3) changes within designated floodways and bypasses, and (4) maintenance challenges.

Changes in Design Standards and Expectations for Levee Performance

Early levees were often constructed using material dredged from the adjacent river, which was then placed on untreated foundations using construction techniques available at the time. Since that time, much has been learned about levee failure mechanisms and how to design and construct levees that prevent levee failures. This new information has led to increased knowledge of flood risks in the flood management system and is reflected in continually changing design standards from the USACE. Some levees are not in compliance with the most current USACE standards because they were constructed prior to the adoption of these standards. The current level of protection provided by State Plan of Flood Control (SPFC) and associated nonproject levees that protect both urban and non-urban areas is being evaluated through the DWR Levee Evaluation Program to determine if they meet defined geotechnical criteria and, where needed, identify remedial measures to meet those geotechnical criteria.

Changes in Hydrology/Hydraulics and/or Climate Change

Existing levee heights and channel capacities were designed using either water surface profiles from historical storms (e.g., 1907), or historical data related to precipitation and runoff. Similar to the limited period of record used for water control manuals described in Section 3.1.4, the hydrological data used for channel and levee design were also limited to the period of record available at the time. This was likely not long enough to accurately represent the true distribution of flood probabilities, and did not account for future climate change.

Floodplain hydraulics also change over time due to the dynamic nature of watersheds. Runoff from upper watershed source areas has increased, in varying extents, due to increases in impermeable surfaces in developed areas, soil compaction from agriculture, reductions in vegetative cover, and losses of wetlands. In developed areas, rainfall that previously percolated

into the ground becomes collected by storm sewers that send the runoff into local streams and channels. Alluvial fans and moveable bed streams can cause channels to move during a flood, making flow paths difficult to predict (ASFPM, 2003).

Increased temperatures from climate change 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. Knowles and Cayan (2002) found that the combination of warmer storms and earlier snowmelt may cause April total snow accumulation in the Sacramento-San Joaquin watershed to drop by 5 percent of present levels by 2030, 36 percent by 2060, and 52 percent by 2090. Already, a greater proportion of annual runoff has been occurring earlier in the year for many rivers of the mountainous western United States (Knowles, Dettinger, and Cayan, 2006). 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). Climate change is also expected to change the magnitude and frequency of forest fires because of drier warm-season fuel conditions. Increased frequency and severity of wildfires (California Natural Resources Agency, 2009b) reduces the availability of vegetation that absorbs runoff, which results in further increased runoff, erosion and sedimentation.

A need exists to restudy the system hydrology and hydraulics, using the best available hydrologic data, a better understanding of climate change projections, and new physical data describing the levees and channels. Having the best available hydrologic and hydraulic data to evaluate flood probabilities would also benefit reservoir operations and water supply planning.

Changes Within Designated Floodways and Bypasses

Changes to river hydraulics from activities that occur within designated floodways may reduce flood carrying capacities, thereby impacting the intended protection for areas adjacent to the floodplain. Changes in land use within floodways and bypasses can be caused by agricultural practices, crop types, and vegetation encroachment. Floodways and bypasses that have been graded and developed for agricultural production can reduce flood carrying capacities. The transition from agricultural row crops to orchards in some floodplains can also impact flood hydraulics. Riverine erosion, debris and sediment blockage, natural or human-induced channel modification, and land subsidence also directly impact floodway hydraulics.

As mentioned previously, there are many perspectives on the impacts of vegetation on channel capacity and it is the subject of ongoing study and evaluation. While the impact of vegetation depends on vegetation structure, location, and level of management, some forms of vegetation encroachment in the channels can reduce flow velocities, obstruct debris movement, and increase sedimentation. Vegetation encroachment occurs when material, eroded from banks, form bars along the channel and when low-flow conditions prevent the natural removal of vegetation through erosion of the floodway or bypass. While attention to the importance of levee maintenance has increased, floodway and bypass capacity maintenance has not received the same level of attention and funding. For additional description on funding challenges associated with O&M, see Section 3.2.1.

Maintenance Challenges

The level of protection from the flood management system has also decreased in some areas due to deferred or inadequate maintenance. Some LMAs believe that the lack of sustainable funding, combined with challenges in complying with regulatory requirements, has limited their ability to conduct proactive maintenance or collaborate with other agencies in implementing regional maintenance and mitigation. For a more detailed discussion on flood system maintenance, see Section 3.2.

3.1.6 Existing Flood Management System Does Not Provide the Level of Protection Desired and/or Required

For many communities in the Central Valley, the existing flood management system does not provide the level of protection desired and/or required. The level of desired flood protection to protect Central Valley communities has increased significantly since much of the flood management system was originally constructed. Flood management agencies struggle with the following challenges in providing adequate flood protection: (1) the system was designed to protect different land uses and used design floods that are no longer appropriate for current land uses, (2) adequate funding for maintenance and improvements has not been available, and (3) new legislation increased flood protection requirements for urban and urbanizing areas in the Central Valley.

System Designed for Different Uses and Levels of Protection

The unprecedented population boom in California following the onset of the Gold Rush in 1849 created communities in previously unpopulated regions of the Central Valley and spurred significant agricultural development. By the turn of the 20th century, irrigation and agriculture had grown immensely in the San Joaquin River Basin, and the warm, dry climate positioned water supply at the forefront of public concern. In the more populous Sacramento River Basin, flood control and navigation were of higher concern. At that time, State and federal agencies agreed that a coordinated plan of flood protection was needed to replace the piecemeal and competitive system of local levees that had developed in the Sacramento River Basin, in a manner that did not adversely impact channel navigation. Consequently, agricultural development and the removal of mining debris to facilitate navigation had significant influence over the original planning and design of the SPFC.

By the middle of the 20th century, numerous facilities had been constructed and adopted as part of flood management projects in the Central Valley, including flood control reservoirs, levees, bypasses, and weirs. The various conveyance facilities were designed to pass specified river flows (design flows), rather than to provide specific levels of flood protection. As a result, the SPFC provides varying levels of flood protection throughout the Central Valley.

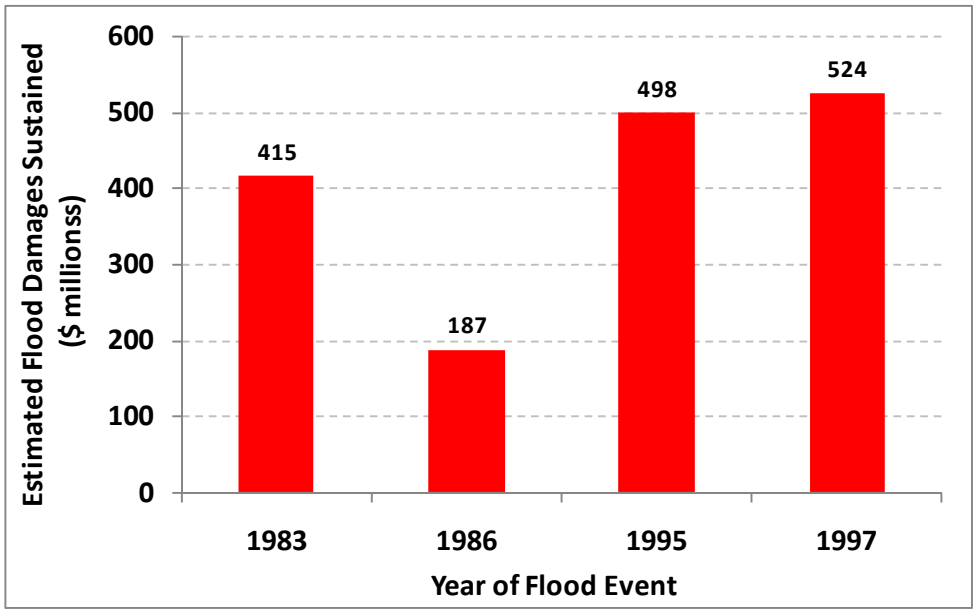
Today, California's flood protection system is more than 50 years old, with some components constructed more than 100 years ago. Throughout their lifespan, some facilities have been used for a wide variety of purposes beyond their original intent, including agricultural development, removal of mining debris, navigation, water supply, and flood control. For example,

levees in the Delta that were originally built for navigation and flood control are now used as conveyance for water supply as part of the State Water Project (SWP) and Central Valley Project (CVP).

Many challenges related to flood management in the Central Valley are due to an aging flood management system that in many areas was designed to protect much different land uses than now occur within lands protected by SPFC. Rapid development and land-use changes in the Central Valley have exposed deficiencies in this flood management system. Over time, historically agricultural lands and rural communities have been, and continue to be, converted to densely populated urban and suburban centers. Facilities originally constructed to reclaim and reduce flooding on agricultural lands may provide inadequate protection for these urban and urbanizing areas, even if improvements are made to pass original design flows or meet minimum federal design standards.

Much of the existing flood management system was designed to lessen the adverse economic and social impacts of seasonal flooding on largely agricultural lands, not to offer complete protection from flooding. Escalating urban development in floodplains increases the potential for flood damages to homes, businesses, and communities. This has been reflected in the increasing costs to respond to and recover from floods in the Central Valley in recent years.

Only more recently has the protection of urban areas moved to the forefront of flood protection planning. The Sacramento and San Joaquin river basins are recognized as having urban areas with some of the highest flood risk in the United States. In particular, federal emergency planners ranked the City of Sacramento second in flood risk vulnerability to New Orleans after Hurricane Katrina (O'Neill, 2006). Figure 3-2 shows the flood damages caused by flood events in the Sacramento and San Joaquin river basins in 1983, 1986, 1995 and 1997. Further, much of the State's newest development is occurring in areas that are susceptible to flooding. The flood management system does not provide the necessary level of flood protection for public safety, property, or economic values in today's Central Valley.



Note: Values represent conditions and price levels for the year of the event.
Source: Post-flood Assessment, USACE, March 1999

Figure 3-2. Flood Damages ($ millions) Caused by Flood Events in the Sacramento and San Joaquin River Basins

Adequate Funding for Maintenance and Improvements Not Available

Despite recognition of the risks and potential consequences of flooding in the Central Valley, adequate funding for needed maintenance and improvements to the flood management system has not been available. Before the increased awareness brought about by Hurricane Katrina, investment in flood management had declined in recent years at all levels of government. Federal cost sharing for flood control projects has dropped from 75 percent to 65 percent in recent years. At the State level, the disaster Preparedness and Flood Prevention Bond Act and the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act (Propositions 1E and 84) have allocated bond funding for the FloodSAFE California (FloodSAFE) program, including: $3.275 billion for repair and improvements to levees and flood projects in the SPFC and the Delta, $680 million for federal flood control projects outside of the Central Valley, and $935 million for floodplain mapping, flood corridors, stormwater grants, and other flood improvements statewide. However, economic decline and the recent fiscal crisis have generally decreased available funding from the State for maintenance, improvements, and management activities. And at the local level, reduced tax revenues and laws governing the use of property taxes and benefit assessments have hindered local efforts to maintain the existing flood management system and move forward with necessary improvements.

There is a need for sustainable funding for all aspects of flood management: maintenance, inspections, enforcement, critical repairs, improvements, education, emergency response, and recovery. With these trends in funding, and with increasing demands on the flood management system resulting from increased population and changing climate, traditional funding approaches may need to be replaced with new, more sustainable and financially efficient approaches to improving the flood management system that reduce long-term costs. For a more detailed analysis of funding challenges, refer to Section 3.4.5.

New Legislation Increased Protection Requirements for Urban and Urbanizing Areas

Legislation signed in 2007 included new requirements for providing flood protection to urban and urbanizing areas in the Central Valley. The flood legislation establishes protection from a 200-year flood event (flood with a 1-in-200 chance of occurring in any year) as the minimum level of flood protection to be provided in urban and urbanizing areas by 2025. Urban areas are defined as a developed area in which there are 10,000 residents or more. Urbanizing areas are defined as a developed area or an area outside a developed area that is planned or anticipated to have 10,000 residents or more within the next 10 years.

Cities and counties in the Central Valley are prohibited from entering into development agreements, approving permits, entitlements, or subdivision maps for construction within a flood hazard zone unless it is protected by an urban level of flood protection (CGC Section 65865.5). Furthermore, a city or county may be liable for its fair and reasonable share of property damage caused by a flood if the city or county has increased the State's exposure to liability by unreasonably approving new development protected by the SPFC (California Water Code (CWC) Section 8307). "Unreasonably approved" is defined as approval without appropriate consideration of known significant risks of flooding. The Legislature sets deadlines for cities and counties in the Central Valley to amend their general plans and zoning ordinances to conform to the CVFPP within 24 months and 36 months, respectively, of its adoption by the Board. Once the general plan and zoning ordinance amendments are enacted, the approval of development agreements and subdivision maps is subject to restrictions in flood hazard zones. Central Valley counties are obligated to develop flood emergency plans within 24 months of CVFPP adoption.

Another perspective notes that many in the agricultural community are concerned that improvements to urban flood protection over the past few decades have already resulted in "tiered" flood protection levels. The agricultural community asserts that relatively lower flood protection levels in rural and agricultural areas could benefit urban residents to the detriment

of the economic fitness and viability of rural communities. Increased protection requirements for urban and urbanizing areas raise concerns that agricultural communities could potentially be asked to further sacrifice their lands and their livelihoods in the process of improving urban flood protection. This perspective asserts that the future of agricultural viability in the Central Valley is dependent upon creation of a resilient flood management system that is managed in a way that meets the needs of both urban cities and their rural neighbors.

3.1.7 Challenges to Effective Flood Fight Mobilization

Flood fighting refers to those actions, procedures, and plans that bear on responding to threats to levee integrity to prevent failure, or are involved with containing flood waters in the event of a failure and returning the impounded water back into water channels or floodways. Challenges to effective flood fight mobilization include: (1) confusion regarding flood fight roles and responsibilities, (2) insufficient funding or delegated spending authority, (3) financially punitive regulations governing non-jurisdictional emergency response, and (4) lack of comprehensive mutual aid agreements covering flood response.

Confusion Regarding Flood Fight Roles and Responsibilities

Some LMAs assert that unclear roles for local (city and county) and State agencies in supporting flood fight operations impedes quick and effective flood fighting during a major flood. LMAs include flood control districts, Levee Districts (LD), Reclamation Districts (RD), private levee owners, and, in some State-federal project levee reaches, DWR.

There are multiple perspectives regarding why confusion exists over flood fight roles and responsibilities. One perspective asserts that the role of various jurisdictions to support flood fights is varied or ambiguous. Concerns about funding and potential for reimbursement have led most non-LMA jurisdictions to impose narrow interpretations of their roles in preventing levee failures or containing waters during a flood emergency. Many cities and counties view their roles as restricted to public safety, focusing on evacuations and maintaining law and order. The State's role in supporting flood fights can also vary. Under CWC Section 128, DWR assumes the role of coordinator for State-level flood fight activities including technical advisement, providing stockpiled supplies, coordinating mutual aid for flood fight crews, and, in some cases, directly taking charge of flood fight activities. However, it is sometimes unclear to LMAs under which role DWR personnel are acting during a flood fight: as technical advisors or as fellow responders acting directly on the levee using State resources. DWR's role can change depending on the type of incident and the type of requests for assistance made by the LMA. These uncertainties, reinforced by concerns over making pre-budget commitments when flood fight responsibilities are vague, make flood contingency pre-planning difficult and slows actual responses to flood emergencies, especially those that require more than basic sandbagging and levee patrol.

Another perspective asserts that flood fight roles are identified in numerous documents and policies that are well established and made publicly available, including the Flood Emergency Action Team (FEAT) documents, the CWC, and Public Law 84-99 criteria. Governments are

also required to utilize standardized systems for managing responses to multi-agency and multi-jurisdiction emergencies. To use State resources during an emergency, the State requires cities and counties to use its Incident Command System (ICS)-based Standardized Emergency Management System (SEMS), which also integrates the structure and processes of the federal government's National Incident Management System (NIMS). Flood fight roles and responsibilities are also reinforced annually at preseason flood meetings and training exercises with local, State, and federal agencies. This perspective asserts that the role of various jurisdictions to support flood fights is not varied or ambiguous. Instead, confusion over flood fighting roles and responsibilities may be caused by varying interpretations of existing policies and procedures or the need for greater education and outreach to increase awareness of these policies and procedures.

Insufficient Funding

Funding available to finance flood fight operations varies widely across LMAs. Most RDs and LDs can raise only limited funds due to the limitations described in Section 3.4.5. The vast majority of funding is expended on general maintenance activities and not held in an emergency reserve. At the time of a flood, the ability of these agencies to obtain loans to maintain cash flow to support response activities is extremely limited because banks are reluctant to lend when the tax base used to repay those loans is itself at risk. However, flood fights can be extremely costly endeavors; for instance, the American River Flood Control District (ARFCD) estimates that a 2- to 3-day flood fight in its jurisdiction would cost about $1 million (Sacramento LAFCO, 2003).

As noted previously, DWR is the LMA in some State-federal project levee reaches. While DWR may be able to mobilize large quantities of flood fight supplies (i.e., sandbags, lumber, personnel) quickly in response to a flood threat, both DWR and local LMAs are limited in their ability to quickly finance more expensive and complicated engineering responses. Some LMAs have only a handful of staff members and struggle to perform basic maintenance activities even under non-flood circumstances. For instance, the Lower San Joaquin Levee District (LSJLD) has about eight full-time employees, but is responsible for maintaining a service area of approximately 30,000 acres and 191 miles of levees along the San Joaquin River and bypass systems (Water Education Foundation interview with Reggie Hill, 2009).

As a result, flood fight responders must often seek assistance or funding for rock, supplies, and technical expertise from the next level of local, State, or federal jurisdiction. In the past, such requests have been elevated immediately to USACE due to State and local concerns over potential

disqualification from federal funding reimbursement and the lack of proper contingency funding by local and State authorities. Ultimately, overreliance on federal assistance has made the USACE hesitant to grant such requests, further slowing effective flood fights.

Most available State and federal funding sources related to floods are aimed at reducing risk and potential damages in advance of a flood or reimbursing the appropriate jurisdiction for eligible emergency response work—not at helping finance operations during flood fights. After a flood occurs, local governments can request State reimbursement for emergency response and repair costs under the California Disaster Assistance Act. Both State and local governments can also request emergency response and recovery cost reimbursement from Federal Emergency Management Agency (FEMA) under the Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288, as amended) (Stafford Act), contingent on their use of SEMS/NIMS during their responses (CalEMA, 2009a). However, both these assistance programs require documented use of federal and State emergency management approaches during the event, and neither would help an agency fund its activities during a flood.

Financially Punitive Regulations Governing Non-Jurisdictional Response

Concerns about funding and potential for reimbursement have promoted confusion and inaction at the State and local levels during a flood fight. FEMA regulations have created disincentives for agencies other than the LMA from acting directly on a levee to deal with threats to levee stability and prevent flooding. Under the FEMA policies governing federal reimbursement, only costs incurred by an agency within its jurisdictional and legal responsibilities will be reimbursed (FEAT, 1997). Thus, both DWR and local non-LMA jurisdictions may be reluctant to join a flood fight because of the unclear vested responsibility to do so and the resultant risk of uncompensated financial burden. For example, a transportation agency that provides rock to protect a highway from a flood might not receive federal reimbursement if FEMA determined that flood fighting a highway was not within the transportation agency's jurisdiction. Some have noted that inconsistent applications of the Stafford Act by FEMA have added to the confusion.

These FEMA regulations create incentives for every agency to avoid involvement unless another agency has already made a financial commitment. As described previously in this section, fears of absorbing the full cost of a flood fight drives maintenance district funding requests to be passed rapidly to the federal level. SEMS and NIMS generally encourage local and State governments to exhaust their own flood emergency funds before providing federal assistance. This creates a moral hazard for LMAs

by giving them an incentive to reduce their flood contingency funding in hopes of maximizing federal assistance. There is a need for establishing clear thresholds that define the respective flood emergency funding obligations from local, State, and federal agencies before a flood fight. Lack of such thresholds can lead to further confusion and delays in funding flood fights.

Lack of Comprehensive Mutual Aid Agreements Covering Flood Response

Mutual aid agreements facilitate the sharing of materials and services among local agencies, and in some instances between local agencies and state agencies, during an emergency. But mutual aid agreements that respond specifically to flood-related threats are not in place in all flood-prone communities. In addition to maintaining levees, LMAs are responsible for preparing for a flood fight and responding directly at the scene, and they usually absorb the initial costs associated with both. Flood fighting and responding to threats to levee integrity include, in many cases, engineering services or materials not normally maintained by many LMAs.

Although all counties and most cities in the Central Valley participate in California's statewide Master Mutual Aid Agreement (MMAA), the agreement is aimed at assisting emergency response from a traditional public safety perspective and is not focused on the specific needs of responding to threats to levee integrity or floods (CalEMA, 2009a). For instance, repairing a levee break might require specialized materials or engineering services more than it requires the assistance of public safety personnel; but these types of resources are not included in the MMAA and must be purchased rather than shared.

3.1.8 Limitations of Emergency Response Capabilities to Flood Threats

Emergency response refers to all actions, procedures, plans, and resources used or implemented for public safety at the time of a flood or at the time that the potential for levee failure is recognized. Effective emergency response to flooding is limited by: (1) institutional capacity, resources, and coordination, (2) inadequate local flood contingency planning and regional response planning (access, egress, warning, and communications), and (3) critical infrastructure located within the floodplain.

Institutional Capacity, Resources, and Coordination

There are multiple perspectives regarding the capabilities of agencies and organizations for responding to flood emergencies. Some agencies and organizations charged with responding in the field during a flood emergency lack the capacity, resources and interagency coordination necessary to carry out these duties effectively. Due to the long length of time between major floods, only a limited number of federal, DWR, and local staff have the flood response experience, technical expertise, or local understanding to provide assistance to problem sites. Some assert that the availability of these technical experts and engineers may only be sufficient for smaller floods in which problem sites are concentrated in a small number of locations. But for floods with widespread threats to levee stability, such as the 1997 New Year's floods, the demand for qualified technical staff often outstrips supply. Others assert that while there can be no substitute for true emergency response experience, training and exercises have provided interim experience in responding to major floods.

DWR holds a number of regional preseason flood emergency response preparation meetings open to all LMAs. However, LMAs and other agencies have achieved varied levels of institutional coordination for flood response. Some LMAs have pre-emergency relationships with cities, counties, city or county agencies, private utilities, or the State that could facilitate emergency response activities during a flood. Coordination with private utilities, in particular, can be challenging because their emergency response plans, procedures and capabilities are generally not publicly available. The City and County of Sacramento both include RD 1000 and the ARFCD in their emergency operations plans and cooperates under mutual aid (City of Sacramento, 2005; Sacramento County, 2008). In the City of Sacramento's flood evacuation plan, the city identifies how its utilities department and personnel would work with RD 1000, ARFCD, and DWR during a flood watch or to patrol levees; and coordinate with Reclamation, DWR, Sacramento Municipal Utility District (SMUD), and Pacific Gas and Electric Company (PG&E) to monitor dam water levels and stability (City of Sacramento, 2008). The County of San Joaquin has

worked with its RDs to develop flood contingency and evacuation maps that establish mutual aid processes, identify options for responding to a levee failure, provide evacuation information, and provide a basis for joint response. San Joaquin County also maintains large stockpiles of basic flood fight supplies that can be provided to LMAs to support a flood fight. Nonetheless, these examples are not universal and many LMAs have not achieved this level of coordination and planning before a flood.

Inadequate Local Flood Contingency Planning and Regional Response Planning

Local emergency response and flood contingency planning varies considerably in depth, comprehensiveness, and accessibility across Central Valley communities. Regional emergency planning aimed at establishing regional and multiagency coordination systems to better manage resources and share information is far less common.

All of California's 58 counties and most of its cities maintain at least some form of emergency plan because it is a requirement for participating in the State's master mutual aid system (CalEMA, 2009a). NIMS and SEMS require Continuation of Government plans and Continuation of Operations plans, which detail all of the procedures that define how a government and the community will continue or recover constitutional governance and essential government functions in the event of a disaster.

However, few local governments have engaged in detailed flood contingency planning addressing flood fight operations or prepared flood-specific evacuation plans, either locally or regionally. Some local jurisdictions have produced flood evacuation plans that identify the range of involved agencies and personnel, notification procedures, public and private transportation options, evacuation routes, and other related information for flood emergencies (City of Sacramento, 2008). Others integrate these plans into their overall emergency plans (Shasta County, 2000). Finally, some jurisdictions have distilled flood emergency preparedness and evacuation information into succinct summaries easily accessible and digestible by the public (Tehama County, 2009; San Joaquin County, 2009).

The type of regional, multijurisdictional planning that would help adjacent communities and jurisdictions to coordinate more effective emergency response is not required or funded at the State or federal levels and does not fit cleanly into the standard emergency planning structure of SEMS/NIMS. Nonetheless, certain local agencies have spearheaded efforts to develop regional flood contingency plans and maps that specifically address flood fight operations, and evacuation and rescue options. Certain local efforts

have also produced multi-agency coordination procedures to enhance local flood fight operations if implemented regionally.

Critical Infrastructure within the Floodplain

In many Central Valley communities, the infrastructure needed to facilitate the flow of resources into, or evacuees out of, a flooded area would itself be incapacitated in the event of a flood. For instance, under various flood scenarios in the City of Sacramento, most transportation infrastructure, such as major highways, egress routes, lightrail, and Sacramento International Airport (SMF) would be partially to completely inundated, hindering both orderly and timely evacuation and access for emergency response personnel; and the city could experience a shortage or shutdown of the fuel supply or electrical distribution system, which could also impact water supply and wastewater distribution systems (City of Sacramento, 2008).

3.1.9 Challenges to Existing Post-Flood Recovery Plans and Programs

Existing post-flood recovery plans and programs are often inadequate. The variability in flood emergency planning throughout the Central Valley's communities is mirrored in the range of comprehensive post-flood recovery plans documented. Where they exist, these plans are driven, generally, by the eligibility requirements of the Stafford Act. Debris removal and economic recovery operations are often conducted well after floods, but often only to the extent that they are eligible for federal reimbursement.

Urban Flooding

Debris Removal

Debris removal is the responsibility of affected local jurisdictions and is normally conducted in accordance with public law and eligibility criteria of the Stafford Act. Without a controlled strategy in place to guide the cleanup process, debris removal can require significant time and resources.

Removal of debris on private property that originated on that property remains the responsibility of the property owner. Depending on the severity and extent of the damage, local communities can receive State and federal funding or assistance with debris removal following a flood. But some work group members assert that in the event of widespread flooding, the formal coordination necessary to secure such assistance may be unreasonable and overly bureaucratic. Environmental regulations can also impact or otherwise limit debris removal within the flood channels. In addition, flood waters and uncleared debris can invite onlookers and pose safety threats to curious members of the public (City of Vacaville, 2007).

Timely Restoration of Utilities

Post-flood recovery plans do not always identify how affected public utilities and services will be restored following a flood event. Shutdown of utilities such as electricity, telephone service, and water service can severely impede flood response and recovery. Identifying plans and procedures for utility restoration requires significant coordination, especially if the utility provider is a private company.

Debris from Flooding

Inefficient Coordination

In any given community, the range of agencies with legal or voluntary responsibilities for disaster recovery often cross jurisdictions and levels of government. Confusion in recovery roles and responsibilities can cause inefficiencies.

Some assert that coordination between State and federal agencies involved in administering post-flood disaster recovery and public assistance has frequently been poorly executed in the past. These agencies, including FEMA, California Emergency Management Agency (CalEMA), DWR, USACE, and the Natural Resources Conservation Service (NRCS) share many damage assessments or repair responsibilities but have different policies and procedures they must follow in carrying out their duties. This perspective asserts that poor coordination and conflicting policies in the past have slowed the process of completing damage survey reports or levee inspections, which consequently delayed the flow of cash to fund debris removal and levee repairs (FEAT, 1997a).

Agricultural Recovery

Agricultural lands and rangeland are often considered a lower priority during a flood emergency and are frequently omitted from post-flood recovery operations due to lower flood risk compared to other land uses. For instance, the cost of pumping excess water during a flood fight to prevent flooding is only eligible for cost reimbursement by FEMA if “there is a threat to health and safety or improved property,” (FEAT, 1997a). However, since FEMA does not consider agricultural lands to be “improved,” an LMA that operates its pumps continually to protect farmland from being inundated must bear the full cost on its own (FEAT, 1997a).

Assessing the economic damages to crops from a severe flood may only be possible several months or years after flood waters have receded, at which point the damages may no longer be eligible for disaster recovery assistance funds. For instance, several thousand acres of tree crops in Sutter and Yuba counties remained under water for nearly 2 months following the 1997 New Year's floods; problems from waterlogging or phytophthora diseases were only discovered months, or years, after the initial flooding occurred (California Agriculture, 1997).

Agricultural Damage from the 1997 Flood

Regional Economic Recovery

Both the U.S. Small Business Association and the U.S. Department of Agricultural (USDA) provide low-interest loans to individuals, households, businesses and organizations in declared disaster areas (CalEMA, 2009a). However, the impacts of flood-related disasters on a region's economy can linger for years and leave holes in communities that cannot be patched by State and federal programs designed to assist victims. For instance, the New Year's flooding in 1997 resulted in $2 billion in damages, but the overall statewide costs associated with the disaster were estimated at more than $5 billion (California Floodplain Management Task Force, 2002a).

Ecosystem Flood-Related Issues

Flooding or flood-related emergency response activities can cause damage to habitat and other ecosystem resources. Repairing these damages through restoration is rarely included in post-flood recovery efforts. Although effects to ecosystems can be severe, post-flood recovery generally prioritizes a community's economic and social recovery over restoration of its ecosystems.

3.1.10 Limited Understanding of Flood Risk

Among the public there is a limited understanding of flood risk. The public often underestimates flood risks due to: (1) limited access to information, (2) false sense of security, and (3) uncertainty regarding responsibility for education.

Limited Access to Information

With much of the Central Valley's new development occurring in areas that are susceptible to flooding (DWR, 2005b), good floodplain mapping and related flood hazard data serve a crucial role in identifying properties prone to high flood risk. Local communities, State government, and the private sector require accurate, detailed maps to guide development, prepare plans for community economic growth and infrastructure, utilize the natural and beneficial function of floodplains, and protect private and public investments. Floodplain maps are often the main resources used by the public and decision makers to understand flood risks.

Floodplain boundaries often change, pushing properties once thought to be outside a flood hazard area inside the flood zone. Shifting properties in and out of floodplains sends conflicting messages to the public about flood risk and can undermine the credibility of floodplain maps in the eyes of the public.

As described in Section 3.1.5, floodplain boundaries are dynamic because of changes in the hydrological record and hydraulic changes in the watershed. Section 3.4.2 describes how some maps can also contain poor or outdated information. Another source of public confusion is inconsistencies between the floodplain boundaries of multiple agencies. Floodplain boundaries provided by USACE, FEMA, and DWR are often different from each other due to variation in the available data and levee design criteria used. Levee design criteria are used by a combination of State, federal, and local parties to certify levee flood protection. Approximately 10 to 15 years ago, USACE switched from FEMA's deterministic design approach to a semi-probabilistic approach that USACE developed. Notwithstanding, the USACE levee design standards are still evolving and appear to be years away from developing an acceptable risk-based geotechnical approach for levee design (DWR, 2009h). Meanwhile, many communities in the Central Valley protected by State-federal project levees will need to demonstrate by 2012 that the levees provide at least 100-year flood protection, or risk being mapped inside the 100-year floodplain as part of FEMA's Map Modernization Program. In addition, as described in Section 3.1.6, California Senate Bill (SB) 5 requires that all Central Valley urban and urbanizing areas achieve 200-year flood protection. To avoid delays in providing urgently needed flood protection, DWR provided its

own interim levee design criteria to comply with the 200-year flood protection standard of SB-5, but the criteria does not necessarily ensure compliance with FEMA 100-year certification. The lack of specificity in the USACE levee design standards and potential conflict with DWR levee design standards has created significant uncertainty on the level of flood protection provided and certification status of many Central Valley levees. This leads to public confusion about which floodplain maps should be used to make informed decisions on managing flood risk.

False Sense of Security

While the public's lack of flood awareness can be partially attributed to constantly evolving and confusing floodplain maps, the public also bears responsibility for underestimating the risks of flooding. Misunderstandings over the binary, "in or out" nature of floodplain maps has sometimes caused development to cluster just outside of the 100-year floodplain boundary (Independent Review Panel, 2007). Although residences built to minimum standards on the border of 100-year floodplains are not required to purchase flood insurance, they often face significant flood risk from more severe floods.

Many people who have heard the term 100-year flood mistakenly believe that it means their home will not be flooded for 100 years. In actuality, it is possible that a 100-year flood or larger can occur more than once per year or in back-to-back years. For those who live in the 100-year floodplain, over the lifetime of a 30-year mortgage, there is a 26 percent chance of being flooded by a 100-year flood (California Floodplain Management Task Force, 2002b).

Some of the public also wrongfully assumes that 100-year-certified levees will protect them against any level of flooding. While levees reduce the occurrence of flooding, they do not protect against the consequences of more severe floods. For example, a home built behind a levee designed to provide 100-year flood protection is at greater risk than a home built to the 100-year flood elevation. The home behind the levee could become completely inundated from a flood that exceeds 100-year levels. The home also has a residual probability of levee failure during floods that are even less severe than the design flood (Independent Review Panel, 2007) due to unforeseen factors such as poor construction, poor maintenance, undetected rodent activity, undetected geotechnical problems, or seismic events. Unfortunately, most of the public views a flood as something for the government to fix or for the government or insurance companies to pay for

after it happens (ASFPM, 2008a), a sentiment reinforced by the Paterno decision,[22] which is explained in detail in Section 3.4.4.

Flood awareness is important for property owners outside of the regulatory floodplain as well. Not only are these property owners at risk from more severe floods, but they can also be subject to devastating economic and public safety impacts that extend beyond the regulatory floodplain. Public funds are needed for flood fighting, rescue, cleanup, repair, and recovery efforts. Flooding can also impede transportation routes and negatively impact local businesses and employers.

Undefined Responsibility for Education

Educating the public about the risks of flooding is critical to successful flood management, especially since public support is needed to approve the higher special taxes and assessments necessary to support adequate flood control infrastructure. Flood risk is a dynamic and complex topic because it is impacted by changes in the hazard (including climate change uncertainties), reliability of the data used to assess the hazard, reliability of the flood protection structures, and changes in the consequences of a flooding event. The public must be educated to understand these flood risks and what they can do to mitigate the consequences should flooding occur.

State, federal, and local flood control agencies have struggled to educate the public with a comprehensive and consistent message on flood management. Governments and flood control managers are generally more adept at operating and maintaining flood systems than communicating the needs and challenges of flood management to the public. At the same time, the public must assume greater responsibility for decisions they make about where they decide to live and work, especially in flood-prone areas. Residents are often greatly concerned over whether their properties require flood insurance, but few take the initiative in raising their own flood risk awareness. Since neither government agencies nor the public is playing an effective leading role in flood education, the popular media sometimes fills the void as the public's primary source of flood education. Unfortunately, the popular media tends to provide coverage of flood management issues only immediately after a flood and lacks any kind of sustained message.

[22] In 2003, the Third District Court of Appeals ruled in Paterno v. State of California that the State was liable in inverse condemnation on the basis that a levee, constructed by others years earlier but accepted by the State of California into the SRFCP, had been constructed improperly.

Greater flood control education outreach is needed from State, federal, and local governments to regularly educate the public on flood risks and to explain what households and businesses can do to reduce or mitigate risk to acceptable levels, such as purchasing flood insurance or retrofitting buildings. The Yolo Basin Foundation's Discover the Flyway Program, for example, educates K-12 students in Sacramento, Yolo, Solano, and El Dorado counties about the flood protection system, flood risks, levees, and even elementary planning concepts.

3.1.11 Limited Understanding about the Beneficial Functions of Floodplains

Floods are commonly perceived as destructive forces of nature that must be tamed and controlled by the confinement of waterways and levees to keep flood waters away from people and their property (ASFPM, 2008b). This common view has led to a minimal understanding among the general public of the natural processes that take place in riverine areas and the natural and beneficial functions of floodplains.

Another perspective views flooding as a natural process that forms and maintains floodplains. In addition to mitigation for the environmental impacts of flood infrastructure, floodplains have a natural capacity for flood storage and conveyance which reduces flood velocities and peak flows. Floodplains receive flood flows that exceed the conveyance capacity of the stream channel and disperse them over an expansive area. Floodplains with generally flat topography and alluvial soils provide favorable conditions for local ponding and infiltration into the subsurface. Stored surface or subsurface water flows to the stream channel gradually, increasing the lag time of a flood and reducing flood peaks and velocities. Decreases in flood velocity can also reduce erosion and subsequent sedimentation in the stream channels (TFNBBF, 2002).

With a limited understanding of floodplains, some assert that floodplain management decisions have often been made outside of the context of watershed-level planning and without adequate consideration for natural and beneficial floodplain functions. Altering natural floodplain processes for flood management purposes can lead to unintended consequences that can actually increase flood risk in some locations. For example: levees that constrict or expand the channel can cause sedimentation and scour in unanticipated places due to changes in sediment transport dynamics; erosion controls can increase lateral channel migration downstream, which, in turn, require additional erosion controls; reservoirs can reduce downstream flows and promote channel aggradation which reduces channel capacity (ASFPM, 2008b).

Restoring and preserving natural floodplains faces several challenges. Some assert that natural floodplains and their beneficial functions continue to be lost to encroaching development, mining, agriculture and other activities (TFNBBF, 2002). The Federal Interagency Floodplain Management Task Force found that the difficulty in quantifying the value of natural and cultural resources of floodplains has made it difficult to justify government expenditures to preserve floodplains in their natural state (FIFMTF, 1992). Some assert that restoring natural floodplain processes may also conflict with existing urban development, geographical constraints, lack of funding, local zoning regulations, local economic considerations, private property rights, water rights, and urban and agricultural uses.

3.1.12 Impairments to Water Quality from Floods

Floods can impair water quality due to: (1) groundwater contamination via unsealed wellheads, (2) the mobilization of hazardous materials and contaminants in the floodplain, (3) mobilization of sediments, and (4) contamination of water and wastewater treatment plants.

Groundwater Contamination via Unsealed Wellheads

Flooding may impair water quality by contaminating groundwater supplies through unsealed wellheads. Improperly built wells can establish a pathway or a conduit for pollutants entering a well from surface drainage or between aquifers of varying water quality.

Mobilization of Hazardous Materials and Contaminants in Floodplain and Watershed

Another way in which flooding can impair water quality is through the mobilization of hazardous materials or contaminants. These materials or contaminants may come from mines, feed lots, fuel tanks, septic systems, landfills, illegal dumping, or other sources.

Flood-related reservoir releases during the flood season that temporarily inundate floodways can also impact water quality by increasing methyl mercury levels. Flooded soils release inorganic mercury, which then become methylated by anoxic bacteria to form methyl mercury (Porvari and Verta, 1987). Once methylated, the mercury has 10 times the toxicity of inorganic mercury and accumulates in fish (Hecky et al., 1991).

In addition, prolonged droughts interrupted by intensified flooding events from climate change may result in increased runoff and inundation episodes and, thus, increased water quality impacts from pollutants in the watershed being carried by the runoff.

Mobilization of Sediments

During a flood event, depths and flow velocities are increased in rivers and channels. The increases in flow velocities increase the sediment transport and erosive capacities along stream corridors, resulting in scouring of channel beds and erosion along unstabilized channel banks. The sediment loads associated with flood flows under these conditions cause turbidity and impair water quality.

Contamination of Water Treatment and Wastewater Treatment Facilities

Urban areas within the Sacramento and San Joaquin river basins use treatment facilities to process wastewater, discharge treated wastewater into rivers, and/or evaporate the treated wastewater in large open ponds. Smaller communities and individual homes use septic tanks and leach fields for dispersion of wastewater effluents. Many of these leach fields are located within the floodplain and many wastewater treatment facilities are located adjacent to waterways. During flood events these wastewater treatment facilities are susceptible to damage. In addition to damaged facilities, untreated or partially treated wastewater could spill or be discharged into waterways, affecting source water quality. Spills upstream could also affect the water quality of the Delta, which provides water to two-thirds of the State's population. Expected sea level rise from climate change may increase the risk of storm surge and flooding to some infrastructure, including wastewater treatment plants (DWR, 2008b).

Many water and wastewater treatment facilities are located adjacent to waterways

Drinking water treatment plants are also traditionally built near rivers or waterways to have access to source water for treatment. A water treatment plant often comprises operations buildings, large underground finished-water clearwells and aboveground water storage tanks. If these get flooded, the water becomes contaminated and the plant becomes inoperable, which could render a community without water for extended periods.

3.1.12

3.1.13 Flood System Maintenance Can Disturb Sediment and Negatively Impact Water Quality

Flood system maintenance, such as dredging and clearing, can disturb sediment and negatively impact water quality. Dredging projects are ongoing activities necessary to remove sediment and improve flood control, keep ship channels open, and control riverbank erosion. While dredging activities increase the channel capacity for flood flows, they can also disturb sediment and contribute to several water quality impacts. Specifically, dredging can potentially increase high suspended solids and turbidity. Oxygen-consuming compounds that are potentially released can decrease dissolved oxygen (DO) levels and harm aquatic species. Dredging can also mobilize metals such as mercury from the sediment (Humphreys, 2005). Dredging or clearing operations must be properly permitted and monitored so that potential water quality impacts are minimized.

Pesticide and herbicide runoff from vegetation management on levees can also negatively impact water quality. Pesticide and herbicide runoff are influenced by many factors including: adsorption, solubility, and persistence of the pesticide or herbicide, soil characteristics, topography, and usage and application patterns.

3.2 Operation and Maintenance

O&M (including significant repairs) of the flood management systems in the Sacramento and San Joaquin river basins are difficult and often deferred due to limitations from original system design, prevalent system encroachments, inconsistent standards and practices, complex and onerous permitting and mitigation requirements, and lack of reliable funding sources and financial instruments.

Effective O&M of the flood management systems in the Sacramento and San Joaquin river basins faces several challenges. Table 3-2 lists contributing factors related to operation and maintenance problems, and their relevance to each of the five planning regions. The following discussion reflects the views and perspectives of all participants and input received, recognizing that there are differing opinions on the magnitude, relative importance, or underlying causes of the identified problem and its contributing factors.

3.2.1 Difficult to Adequately Maintain Levees and Channels According to Operation and Maintenance Manuals

It is often difficult to adequately maintain levees and channels as prescribed in O&M manuals. Factors that contribute to O&M challenges include: (1) permitting and mitigation requirements and/or restrictions, (2) vegetation growth, (3) lack of sustainable funding for proactive maintenance, and (4) inconsistent federal, State, and local maintenance standards, practices, and implementation.

Permitting and Mitigation Requirements and/or Restrictions

Challenges associated with permitting and mitigation requirements and/or restrictions include the cost and timeliness of the process and restrictive construction work windows, and uncertainty regarding permitting and mitigation requirements for routine maintenance.

Table 3-2. Operation and Maintenance Problem Statement Contributing Factors Summary

Contributing Factors	Regional Differences*					
	Upper Sacramento	Lower Sacramento	Delta		Upper San Joaquin	Lower San Joaquin
			Tidal	Riverine		
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
It is often difficult to adequately maintain levees and channels according to operation and maintenance manuals because of the following:						
a) Permitting and mitigation requirements and/or restrictions						
i) Cost and timeliness of process	●	●	●	●	●	●
ii) Restrictive construction work windows	●	●	●	●	●	●
iii) Uncertain permitting and mitigation requirements for routine maintenance	●	●	●	●	●	●
b) Vegetation growth	◖	◖	◖	◖	◖	◖
c) Lack of sustainable funding for proactive maintenance						
i) Insufficient revenue generation	●	◖	●	●	●	◖
ii) Disproportionate cost of permitting	●	◖	●	●	●	◖
d) Inconsistent and/or conflicting federal, State, and local maintenance standards, practices and implementation	◖	◖	◖	◖	◖	◖
e) System design characteristics (designed to flush sediment, but now impacting levees)	●	●	◖	◖	◖	◖
Institutional and financial arrangements hinder systemwide approaches to major repairs.	●	●	●	●	●	●
Incorporating environmental benefits into flood management system maintenance, repair and improvement projects may increase local responsibilities and costs.	●	●	●	●	●	●

Notes:
* Table is intended to graphically capture the regional differences. The identified problems and opportunities contained in this table include the views, perspectives, and input of all participants. At this point in the planning process, there are differing opinions on whether all of the items included as problems and opportunities are in fact problems that should be evaluated further. There are also differing opinions about the magnitude, relative importance or underlying causes of the identified problems and opportunities. This table is subjective, not meant to be scientifically precise and not meant to imply that technical or scientific documentation about the condition is necessarily available.
** "Relevant" indicates that a region is currently experiencing the problem or previously experienced problems associated with a particular contributing factor. In those instances where the problem was previously experienced, the region may have resolved the problem, but concerns remain over the problem potentially recurring in the future.

Cost and Timeliness of Process There are many perspectives on the influence of permitting and mitigation requirements on maintenance practices. One view holds that the current process for obtaining permits and mitigating potential impacts involves coordination with multiple agencies to comply with unfunded mandates that can exceed the budgets of smaller LMAs. Most LMAs have limited funding sources, and some have expressed that they are spending an increasingly larger portion of their operating budget obtaining permits to perform required maintenance activities. With multiple permits required for most maintenance and mitigation activities, and no central location for coordinating the process, obtaining the necessary permits can take much longer than the actual work. In addition, many permitting agencies are understaffed, which increases the duration for obtaining permits. The terms and conditions from one permitting agency can sometimes be incompatible or conflict with those from another agency. Also, permits only apply for a limited time period, requiring LMAs to reapply for permits to implement long-term mitigation over multiple years. While site-specific permitting is more costly and ineffective over the long-term, it remains a common practice because the large majority of LMA's lack the upfront funding needed for programmatic permitting practices. Although habitat compensation ratios often vary to account for factors specific to each project and mitigation site, some LMAs assert that a technically defensible criterion that allows consistent inclusion and valuation of habitat is lacking.

Another perspective holds that much of the increased cost of complying with permitting and mitigation requirements stems from the fact that the original flood management system was constructed at a time when current societal values for environmental sustainability were not in place. This increased the cost and difficulty of operating and maintaining the existing flood system to achieve the multiple benefits modern society now expects from its flood management system. Similarly, traditional funding mechanisms were also established during a time when maintenance activities were less sensitive to environmental impacts and therefore did not cost as much as they do today. The increased cost of complying with current permitting and mitigation requirements reflects the real costs associated with achieving the multiple benefits (including environmental benefits) that the public now expects from its flood management system. These costs can also be reduced if ecosystem processes are incorporated as part of the design of a sustainable flood management system.

Restrictive Construction Work Windows Various construction work windows, including environmental constraints and agricultural operations, can often restrict the timing and duration of effective levee maintenance. Confined work windows can result due to: federal and State Endangered Species Acts (ESA) species, flow/reservoir operations, water quality,

temperature, precipitation, farming operations, funding, and equipment availablity. Figure 3-3 provides a conceptual example of seasonal biological constraints for potential construction activities. These can lead to deferral of important maintenance or repair activities, or construction delays that can significantly increase the cost of the projects. Because of the restricted work window for levee maintenance or improvements, LMAs must wait for their spring inspection to determine the full extent of the damage from the previous flood season. However, once the inspection is completed and the appropriate permits are obtained, it is often too late to perform the construction within the work window.

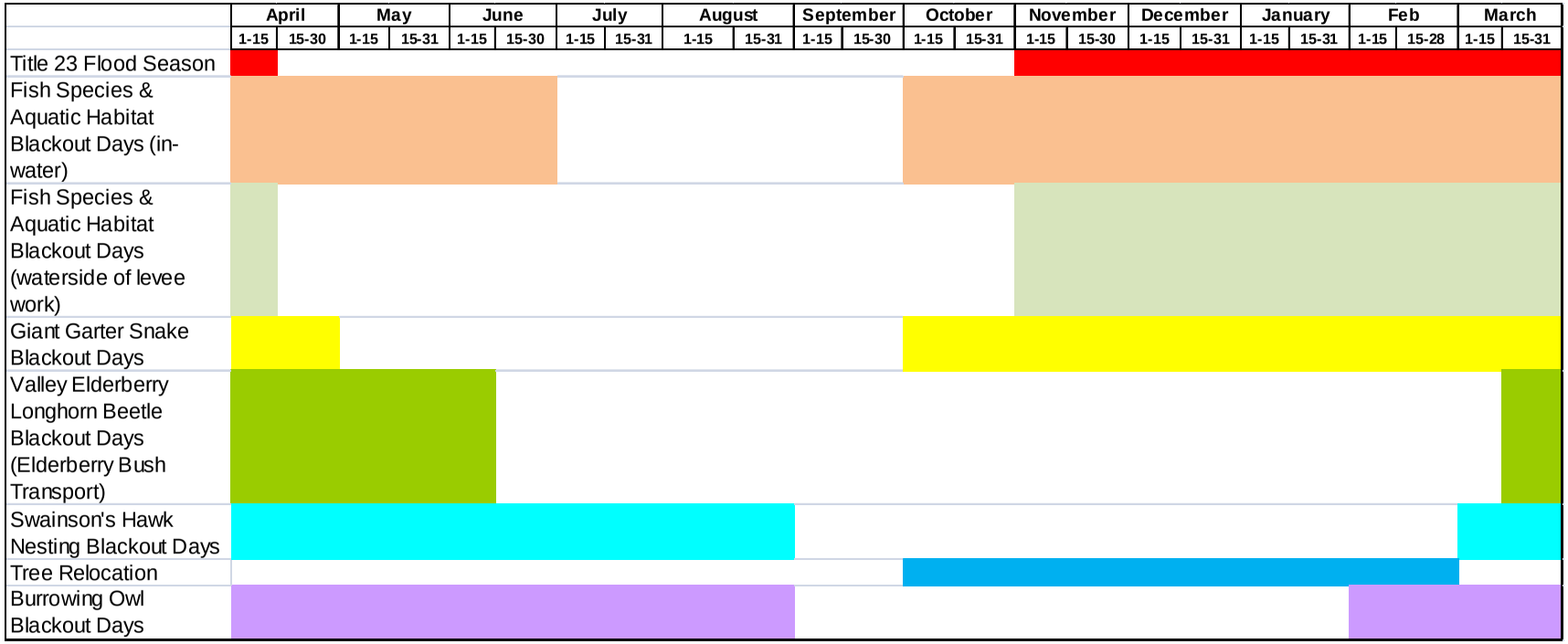


Figure 3-3. Example of Seasonal Biological Constraints for Construction Activities

3.2.1

For example, preconstruction surveys for raptor nests are required, as are measures to avoid disturbing any identified nests during construction. If Swainson's hawks are observed nesting within 0.5 mile of a project site, construction may not begin until the offspring have fledged the nest, or until after a specified date agreed upon through consultation with California Department of Fish and Game (DFG). Furthermore, in such a case, all measures in the DFG's Draft Mitigation Guidelines for Swainson's Hawk (*Buteo swainsoni*) in the Central Valley of California (DFG, 1993), and DWR's standardized protocol for Swainson's Hawk impact avoidance and mitigation measures must be implemented. Similarly, in-water construction activities must occur during the U.S. Fish and Wildlife Service (USFWS)- and National Marine Fisheries Service (NMFS)-approved work window for special-status fisheries species.

In addition to the constraints mentioned above, the State budget cycle can also restrict construction work windows due to the timing of State funds authorization. For State agencies, funding is often frozen around the change of the fiscal year until a budget is signed. For the last several years, delays in passing the State budget have handicapped construction during the summer months when construction could be taking place.

Uncertain Permitting and Mitigation Requirements for Routine Maintenance There are different perspectives on the conditions in which permitting and mitigation may or may not be required for routine maintenance. Most routine maintenance has historically been exempt from permitting and mitigation requirements. However, some routine maintenance activities identified as necessary when the system was originally constructed have today become incompatible with regulations put in place to protect native habitats and the threatened and endangered species they support. The definition of what constitutes routine maintenance is also subject to interpretation. This situation creates regulatory uncertainty for both the LMA's and regulatory agencies. Creation of a general permit for routine maintenance that would define clear routine maintenance guidelines over a multiple-year period is difficult because biological conditions evolve over time and it is challenging to predict which species will become threatened or endangered in the future.

Vegetation Growth

As mentioned previously, the impact of vegetation growth on levees and channels is the subject of ongoing study and evaluation. One perspective notes that vegetation growth can impede access for levee maintenance and inspection and obscure visibility of the levee surface. In some cases vegetation growth on levees may increase maintenance and repair costs by hiding structural problems or deficiencies that if identified earlier, could have been fixed more quickly and cost effectively. Vegetation may also

provide cover for burrowing rodents to develop burrow networks within levees. If vegetation management has been deferred for several years due to funding or other constraints, vegetation growth can result in the establishment of habitat that requires additional permits or mitigation before maintenance activities can be resumed.

Furthermore, some forms of vegetation in the channels can reduce flow velocities, obstruct debris movement, and increase sedimentation (as described in Section 3.1.1). Channel ownership and responsibility for vegetation management is ill-defined for most channels, which further complicates channel maintenance.

Another perspective asserts that vegetative growth can help reduce maintenance on levees by reducing erosion through root reinforcement and vegetative cover (see Section 3.1.2). Impacts to levee inspections can be reduced by taking greater account of vegetation in initial levee planning and design. Vegetation planted in rows can allow for access and visual inspection of the levee (River Partners, 2010). Similarly, impacts of vegetation in the channels can be reduced by planting flexible-stem plants and grasses that bend and armor the channel bottom, as described in Section 3.1.1. Pocket gophers and ground squirrels are unlikely to be attracted by woody vegetation because they are known to prefer open grassland habitat where they can view predators approaching (River Partners, 2010).

Channel Vegetation

A unique example of channel vegetation management in the lower Sacramento River Basin is the partnership between agricultural operations and flood control in the Yolo Bypass. Agricultural operations, such as discing, plowing, and harvesting, keep thousands of acres of the Yolo Bypass clear of vegetation that would otherwise slow down flood flows and obstruct debris movement. This partnership with agriculture reduces the cost of vegetation management and does not require outside funding from LMAs. However, others assert that these partnerships may not be possible where land ownership is by private parties and flood easements provide only for the passage of seasonal flood flows and certain limited maintenance activities.

Lack of Sustainable Funding for Proactive Maintenance

Many LMAs lack sustainable funding sources for routine repairs, let alone proactive maintenance. With tax laws limiting the ability to increase local revenue, and increasing costs of permitting and maintenance, the LMAs are facing more obstacles to creating stable funding sources for proactive maintenance. For additional discussion of funding challenges, refer to Section 3.4.5.

Insufficient Revenue Generation Funding for flood management is derived from a number of State, federal, and local sources, primarily through tax revenues and assessments or emergency declarations. At the local level, there are a large number of LMAs with a wide variety of funding levels and sophistication, but all with similar responsibilities.

Local governments are restricted by two constitutional amendments governing the use of property taxes or benefit assessments: Propositions 13 and 218. Originally intended to prevent government agencies from raising taxes without sufficient input from the public, these propositions require a two-thirds majority vote to raise special taxes and can restrict the use of taxes for flood management purposes. Special benefit assessments can be passed with a weighted majority of affected property holders. But Proposition 218 rules governing the calculation of assessments lowers the amount local governments can collect through assessments and also increases the costs of carrying out an assessment.

Smaller communities especially suffer from an inability to generate enough revenue to provide proactive maintenance. Smaller LMAs often do not have the money, staff, or expertise to mount a successful special assessment campaign and election. Smaller communities are often dependent on the State or federal government to help fund projects, yet worry that lack of local revenue generation limits their ability to perform maintenance, and thus to maintain Public Law 84-99 eligibility, which can in turn jeopardize these communities' State and federal emergency funding.

Failure to properly maintain levees and other facilities can result in significant threats to public safety as well as catastrophic damages that subject the entire State to financial liability. Ultimately, all taxpayers carry the financial burden of catastrophic flood damages through State and federal subsidized disaster assistance and recovery programs, such as FEMA's National Flood Insurance Program (NFIP). Loss of Public Law 84-99 funding for inadequate maintenance would place the entire financial burden for post-flood recovery efforts on the State and local interests.

Disproportionate Cost of Permitting Most permits cost the same, regardless of the magnitude of the maintenance or repair. With smaller

projects, this can often create instances where the cost of the permit to execute the work exceeds 20 percent of the total project cost. When permitting costs make up a large proportion of the project costs, it can often reduce the cost-benefit ratio to less than 1, thus rendering the project no longer feasible for federal cost sharing.

Inconsistent and/or Conflicting Federal, State, and Local Maintenance Standards, Practices, and Implementation

Maintenance of the State-federal project levees is administrated differently from non-project levees, which leads to inconsistency in system maintenance and performance. The State relies heavily on a large number of LMAs to maintain State-federal project levees consistent with USACE standards (to maintain Public Law 84-99 eligibility), State guidance, and conditions set by environmental regulatory agencies. Local entities and private landowners also conduct maintenance on numerous private levees and other non-project facilities throughout the Central Valley and the Delta, for which there are no federal standards, even if they provide flood protection for the same land area as State-federal project levees. Some LMA's view that although non-project levees provide some statewide benefits, they are not funded or prioritized commensurately. Poorly maintained non-project levees can limit the effectiveness of adjacent or associated State-federal project levees.

Conflicting guidance in relation to vegetation and debris management can make it difficult for local agencies with limited budgets to conduct maintenance activities efficiently. As mentioned previously, USACE has national standards that limit vegetation on levees. This policy is in conflict with the vegetation management policies of other State and federal agencies. As an interim step in meeting these national standards, DWR prepared interim levee vegetation management criteria for trimming and thinning of vegetation for use until 2012. In the long-term, the State will seek to conserve and enhance riparian habitat on the waterside of levees and aggressively pursue compliance with the national levee standards through the use of improved maintenance inspections, phased vegetation management practices, regional variances, and other management tools that would be consistent with a multi-species and floodplain conservation strategy for the ecosystem (California Levees Roundtable, 2009).

There are multiple perspectives on the consistency of State and federal levee inspections. Some assert that the application of rules and regulations sometimes varies, depending on the inspector. They also contend that differences in State and federal O&M standards can also result in conflicting inspections results between State and federal inspectors. Others assert that while inconsistencies existed in the past, recent improvements in

the inspection process and better coordination have helped significantly reduce inconsistencies between State and Federal inspectors.

Some LMAs believe that evolving standards and interpretations can lead to a lack of agreement on various issues such as erosion protection within the floodway and distinguishing between maintenance deficiencies and design deficiencies. Consequently, there is a need for standardized maintenance policies, processes, and responsibilities for LMAs, and a standardized approach to inspections, oversight, permitting, and enforcement.

System Design Characteristics (Designed to Flush Sediment, but Now Impacting Levees)

As described previously in Section 3.1.2, in many levee reaches, the flood control channels were originally designed to flush out sediments that accumulated in the Sacramento River Basin from hydraulic mining activities in the late 1800s. Levees were constructed on the river banks in direct contact with the river to channelize flow. The powerful flushing flows are now eroding the natural channel banks and the flood protection levees placed on them. The narrow channels often require bank protection and other maintenance to reduce erosion and avoid potential levee failure.

3.2.2 Institutional and Financial Arrangements Hinder Systemwide Approaches to Major Repairs

Levees are currently evaluated and repaired in a piecemeal fashion rather than looking more broadly at the entire flood protection system. Unfortunately, if one levee is not maintained properly, the entire levee reach can be compromised. A systemwide approach to major repairs is needed because a project-by-project approach precludes opportunities for integrating structural and nonstructural techniques to improve and maintain the entire system.

There are several institutional and financial impediments to implementing systemwide approaches to major repairs. A systemwide approach is difficult to coordinate across numerous LMAs who are each responsible for their own jurisdictions. The fragmented structure of LMAs also results in a lack of adequate funding for each LMA to conduct systemwide repairs. Furthermore, federal funding for rehabilitation assistance authorized through USACE Public Law-84-99 is limited to repair or restoration of the damaged levee to its pre-disaster condition and level of protection (e.g., the actual elevation of the levee, allowing for normal settlement). Rehabilitation of the levee beyond this level or for levees in other areas that would improve system performance would not receive federal assistance. Some note that a new emphasis is being placed on ensuring protected areas are notified of any levee segments not meeting inspection standards within the overall system.

3.2.3 Incorporating Environmental Benefits into Flood Management System Maintenance, Repair, and Improvement Projects May Increase Local Responsibilities and Costs

Flood management system maintenance, repair, and improvement projects are increasingly incorporating environmental objectives into their design and implementation. It is not uncommon for new flood management projects to include riparian habitat restoration activities that go beyond mitigation requirements. These additional restoration activities serve to preserve and improve floodplain and related habitat and promote integrated water management.

There are several real and perceived barriers to incorporating environmental benefits into flood management projects. The risk of future liability and mitigation requirements can motivate local agencies and private landowners to remove and/or prevent reestablishment of riparian habitat. If the restoration area becomes habitat for endangered species over time, federal ESA requirements could prevent the landowner from conducting routine vegetation maintenance. The long-term monitoring and maintenance costs of managing restoration areas may also be a deterrent if these costs fall on local maintaining agencies. Some agricultural landowners have also expressed concerns regarding the potential for restoration activities to affect their property values, taxes, crop losses due to pests, and friction with neighboring property owners.

There is a need to coordinate with and consider the effects on neighboring landowners during design and management of restoration areas. Safe harbor agreements may provide a means to provide assurances to landowners. While safe harbor agreements have not been widely implemented yet, a recent safe harbor agreement program has been created to cover 222 miles of the Sacramento River from Red Bluff Diversion Dam to Verona.

3.3 Ecosystems

Many management actions that could be taken to improve flood risk management and O&M can also provide significant opportunities for improvements to native habitats and species, and important natural hydrologic, geomorphic, and biologic processes in the Sacramento and San Joaquin river basins.

In many parts of the Sacramento and San Joaquin river basins, dynamic, self-sustaining hydraulic and biological processes are severely compromised. Several factors have caused a decline in the health of the riverine ecosystem over the last 150 years to the point today that the system is no longer able to support sustainable populations of many species. Table 3-3 lists contributing factors related to ecosystem problems, and their relevance to each of the five planning regions. The following discussion reflects the views and perspectives of all participants and input received, recognizing that there are differing opinions on the magnitude, relative importance, or underlying causes of the identified problem and its contributing factors.

Table 3-3. Ecosystem Problem Statement Contributing Factors Summary

Contributing Factors	Regional Differences*					
			Delta			
	Upper Sacramento	Lower Sacramento	Tidal	Riverine	Upper San Joaquin	Lower San Joaquin
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
There has been a loss, fragmentation, and degradation of native habitat and species because of the following:						
a) Loss and fragmentation of habitat and lack of connectivity between floodplains and river systems	●	●	●	●	●	●
b) Introduction and establishment of invasive species	◖	◖	●	●	◖	◖
c) Limited environmental regulation coordination	●	●	●	●	●	●
d) Conflicts between maintenance practices and ecological processes	●	●	●	●	●	●
e) Obstacles to successful mitigation (coordination, funding, monitoring, and adaptation)	●	●	●	●	●	●
Flood system development and regulated dams and reservoirs have negatively impacted natural hydrologic, geomorphic, and biologic processes because of the following:						
a) Engineered/constrained channels and related facilities	●	●	●	●	●	●
b) Changes in flow regime (duration and timing)	●	●	●	●	●	●

Notes:
* Table is intended to graphically capture the regional differences. The identified problems and opportunities contained in this table include the views, perspectives, and input of all participants. At this point in the planning process, there are differing opinions on whether all of the items included as problems and opportunities are in fact problems that should be evaluated further. There are also differing opinions about the magnitude, relative importance or underlying causes of the identified problems and opportunities. This table is subjective, not meant to be scientifically precise and not meant to imply that technical or scientific documentation about the condition is necessarily available.
** "Relevant" indicates that a region is currently experiencing the problem or previously experienced problems associated with a particular contributing factor. In those instances where the problem was previously experienced, the region may have resolved the problem, but concerns remain over the problem potentially recurring in the future.

3.3.1 Loss, Fragmentation and Degradation of Native Habitat and Species

Human settlement, agricultural development, and development of the Central Valley's flood management and water delivery infrastructure have reduced the original habitats in the Central Valley to a small percentage of their original extents (CVHJV, 1990; Hickey et al., 2003; Kelly et al., 2005; TNC, 1987). Loss of habitat has contributed to the listing of threatened and endangered species and rare plants within the CVFPP planning area. Factors that have contributed to the loss and degradation of native habitat and species include: (1) Loss and fragmentation of habitat and lack of connectivity between floodplain and river systems (2) introduction and establishment of invasive species, (3) limited environmental regulation coordination, (4) conflicts between maintenance practices and ecological processes, and (5) obstacles to successful mitigation.

Loss and Fragmentation of Habitat and Lack of Connectivity between Floodplains and River Systems

While habitat degradation has been caused by a wide variety of factors, the construction and O&M of the flood management system have contributed, in part, to a loss of habitat and fragmentation of remaining habitat within the Central Valley. Some assert that it has been difficult to reconcile O&M with the preservation of habitat and necessary connectivity because the system was not designed with ecosystem sustainability as a goal.

The quantity, quality, diversity, and connectivity of riparian floodplain, wetland floodplain, and shaded riverine aquatic (SRA) habitat along the Sacramento and San Joaquin rivers is limited due to reservoir flow regulation, confinement of the river system by levees, bank protection, channel stabilization, and clearing of land for agricultural and urban uses. Levees isolate portions of the historic floodplain, greatly reducing its exposure to periodic flooding, which is required for sustainable riparian and wetland habitat ecosystems.

In reaches with levees, the riparian floodplain, wetland floodplain, and SRA cover habitats are confined to a narrow, intermittent fringe, separated by large reaches with limited or only low-quality habitats. Lack of linear continuity of riparian habitats, or wildlife corridors, impacts the movement of wildlife species among habitat patches and results in a lack of diversity, and population complexity, and viability. Fish species are particularly vulnerable to a lack of habitat connectivity; stranding occurs in bypasses due to channels and weirs that were not designed to allow fish passage. Connectivity among remnant patches of native habitat, as well as interaction with the related fluvial processes that shaped these habitats, has

been reduced or altered to the point that many species are presently considered to be rare, threatened, or endangered by the USFWS, DFG, or California Native Plant Society (CNPS).

The relative lack of seasonal floodplains within the lower Sacramento River Basin (with the exceptions of the Yolo and Sutter bypasses and lower Cosumnes River) and their complete absence in the San Joaquin River Basin is likely one reason for the observed decline of Chinook salmon, Sacramento splittail, and similar special-status species that are adapted to exploit the dynamic nature of seasonal floodplain habitats. Another reason for the observed decline in salmonid populations throughout the region is the decline of SRA habitat throughout the study area.

There are a number of current and future challenges related to the loss and fragmentation of habitat, including the following: (1) urban development in floodplains encroaches on existing habitat, eliminates opportunities for habitat restoration, setback levees and agricultural uses, (2) challenges in managing agricultural lands for wildlife benefits while maintaining a profitable agribusiness, (3) difficulties in managing the flood system for ecosystem benefits while effectively protecting public safety, (4) high risk of future levee failures in the Delta, reducing the probability of long-term success for restoring terrestrial habitat and tidal marsh on Delta lands below sea level, (5) changes in seasonality, quantity and temperature of water, as well as sea level rise, that may affect the quality, quantity, and connectivity of terrestrial and aquatic habitat due to the effects of climate change, and (6) lack of an ecosystem-wide approach to managing the remaining habitat in the Central Valley.

The integration of ecosystem stewardship and flood risk reduction through reconnecting riparian habitat fragments could create opportunities for long-term environmental sustainability, transitory storage and improved water quality.

Introduction and Establishment of Invasive Species

While a wide variety of factors (i.e., ballast water, recreational boating, pets) contribute to the establishment of invasive and nonnative species, flood management facility construction and operation have also played a role in disturbing natural processes and biological communities. For example, flood management operations and upstream water flow management influence hydrodynamic conditions in the Delta by reducing the historical salinity gradients under which native species evolved. This, in turn, creates conditions favorable for invasive species and disrupts aquatic food webs, reduces habitat suitability for native species, and increases predation and competitive pressures on native species. The past and continuing introduction of aquatic, riparian, and upland invasive species

can reduce the effectiveness of flood management facilities, as well, by decreasing the capacity of floodways.

Introductions of nonnative and invasive species have contributed to a decline in the number and function of native wildlife and plant communities (Cohen and Carlton, 1998). The Central Valley and Delta now contain an unknown number of nonnative species, and a new species (many of which are aquatic invertebrates) is estimated to be introduced at least every 14 weeks (Cohen and Carlton, 1998). These species have dramatically altered the structure of the Delta's aquatic food web to the detriment of native pelagic fish and aquatic organisms (Sommer et al., 2007). Nonnative, invasive plant species that are similarly detrimental to native ecosystems are widespread within the study area where they often out-compete native plants for light, space, and nutrients, further degrading habitat quality for native fish and wildlife (CALFED, 2000b). Currently, there is limited public support for invasive species control.

Limited Environmental Regulation Coordination

Multiple regulatory agencies are responsible for ensuring the protection or mitigation of environmental resources impacted by flood management activities. Some believe that this fragmented regulatory structure can lead to a lack of shared understanding and vision among and within the regulatory agencies. Regulatory requirements can sometimes be subject to dissimilar interpretation by different individuals, agencies, and regions, which can result in inconsistent implementation, enforcement, and regulatory actions. Poor coordination among regulatory agencies can greatly increase the challenges of regulatory compliance.

For example, onsite vegetation restoration may be required by a permitting agency to replace loss of wetland habitat from a flood maintenance activity. But the proposed onsite restoration activities may not be counted as mitigation because another permitting agency requires mitigation in advance of construction through payment of in-lieu mitigation fees. The LMA would then be required to pay the costs of in-lieu mitigation fees in addition to the cost of the onsite vegetation restoration to comply with both permits. This predicament can be difficult to navigate out of and can result in delays and added costs.

Conflicts Between Maintenance Practices and Ecological Processes

Flood maintenance activities can sometimes conflict with the attainment of ecosystem goals. Levee and floodway maintenance practices and policies reduce or eliminate habitat complexity within river corridors that many native aquatic and terrestrial species are dependent on. For example, mandatory flood system maintenance activities, such as the USACE's levee vegetation policy, are often in direct conflict with ecosystem needs. There

is also concern that possible future levee strengthening and construction activities may lead to larger levee footprints and, if not coordinated properly, could result in further habitat loss and degradation. There is an opportunity to develop long-term, sustainable practices that benefit both the O&M needs of the flood management system and promote sustainable ecosystems.

Obstacles to Successful Mitigation (Coordination, Funding, Monitoring, and Adaptation)

Historically, flood damage reduction projects have focused on offsetting adverse impacts to environmental resources through implementing mitigation actions as part of a potential project. Obstacles to successful mitigation include: limited understanding of biological restoration needs for some habitats, poor locations and small size of mitigation projects (which may lead to high management costs per acre and limit long-term feasibility and functioning), unclear goals and adaptive management planning, lack of monitoring and abandonment before full completion, insufficient estimates of funding needs, inadequate long-term funding, opposition from neighboring landowners, and difficulties in finding suitable sites due to conflicting land uses. Creation of mitigation habitat in some areas is also complicated by local government concerns about new public lands that do not contribute to county tax revenues.

Mitigation planning has dramatically improved in recent years, providing better understanding of what it takes to achieve successful mitigation. More recent approaches have included incorporating ecosystem restoration actions into the construction and maintenance activities themselves, which can reduce overall mitigation requirements.

3.3.2 Flood System Development and Regulated Dams and Reservoirs Have Negatively Impacted Natural Hydrologic, Geomorphic and Biologic Processes

The construction of dams, levees, bank revetments, engineered channels and related flood management facilities has altered natural flow regimes, resulting in changes to the natural hydrologic, geomorphic, and biologic processes in the Sacramento and San Joaquin river basins.

Engineered/Constrained Channels and Related Facilities

Throughout the Sacramento and San Joaquin river basins, channels have been engineered to move water quickly and increase conveyance capacity. Construction of levees immediately adjacent to streams, continual bank protection and channel stabilization not only reduces floodplain storage capacity resulting in larger downstream flooding, but can also severely modify natural geomorphic processes such as erosion, deposition, and channel meandering. These processes are all important for the long-term physical and biological sustainability of the river ecosystem. For example, steep eroding banks are vital to wildlife in that they provide nesting habitat for many species, including the bank swallow, a State-listed threatened species. Reducing deposition processes can inhibit the establishment of riparian vegetation. Under normal conditions, newly deposited materials are quickly colonized and stabilized by willows and other opportunistic species and are further colonized by other riparian species. Channel dredging activities also restrict natural fluvial processes and greatly impact benthic organisms and habitat.

Channelization has also led to levee and channel incisions in some areas, which can disconnect floodplains from their rivers. This disrupts or eliminates ecological processes such as floodwater detention, groundwater recharge, riparian vegetation recruitment, nutrient exchange, sediment deposition, and fish rearing that are supported or enhanced by seasonal floodplain inundation.

Other facilities such as dams and weirs have created physical barriers to fish passage throughout the river systems. Increased sediment deposition from water diversions have also created physical barriers to fish passage.

Changes in Flow Regime (Duration and Timing)

The hydrologic regime has been altered by the construction and operation of flood management facilities. In most river systems in California today, the current pattern of flows does not match or approximate the pattern that occurred naturally and to which native biological species were adapted. Although the peak flood flows occur at the same time with and without dams, the magnitude of the flood peaks is reduced. These changes in flows,

along with the construction of levees, dampens the frequency of seasonal flooding patterns and reduces the width of the floodplain. Managed releases from the reservoirs, both during and outside of flood season, have resulted in changes in sediment deposition and erosion patterns, gravel/substrate movement, and seasonal floodplain habitat availability, thus affecting the quantity and quality of habitat. Seasonal flooding has many benefits to fish and wildlife, such as transporting nutrients, sediments, and woody materials; providing cover, foraging, and breeding habitats for fish and wildlife; and regenerating riparian habitat. Dam and flood operation rules at reservoirs thus alter the in-stream flow regimes necessary to sustain floodplain and riparian habitat, reduce habitat complexity, and limit habitat access for many aquatic and terrestrial species. For example, in the Lower Sacramento River Region, spring releases can be especially damaging to germinating plants and grasses in the Yolo Bypass, which provide the seeds that feed wintering waterfowl.

In many areas, changes in the patterns of flows have caused poor regeneration of native vegetation, which has in turn increased the opportunity for nonnative species to invade areas and become established. The majority of seasonal flooding that now occurs is typically conducted to support agricultural operations, and provides secondary benefits to wildlife species, and is managed on small parcels that are often disconnected from similar habitats. Alterations to the already modified hydrologic regime may occur in the future due to the effects of climate change. Potential changes to the hydrologic regime from climate change, such as altered precipitation and runoff patterns, earlier snowmelt occurrence, and increased flood peak flows and flood volumes, were described in Section 3.1.5.

3.4 Policy and Institutional

Responsibilities and roles for flood management in the Sacramento and San Joaquin river basins are dispersed among many agencies with varying functions and priorities. Development of the CVFPP provides an opportunity to improve the common understanding and coordination of flood management agency roles, responsibilities, and policies; promote more informed consideration of flood risk in land-use planning; and address expected needs for funding.

The development, maintenance, and improvement of the State's flood management system, as well as land-use planning, are all related. Dispersal of these responsibilities across many local, regional, State, and federal agencies can lead to policies, funding practices and mechanisms, and institutional arrangements that don't support effective flood management and land-use planning. Table 3-4 lists contributing factors related to policy and institutional problems and their relevance to each of the five planning regions. The following discussion reflects the views and perspectives of all participants and input received, recognizing that there are differing opinions on the magnitude, relative importance, or underlying causes of the identified problem and its contributing factors.

Table 3-4. Policy and Institutional Problem Statement Contributing Factors Summary

Contributing Factors	Regional Differences*					
	Upper Sacramento	Lower Sacramento	Delta		Upper San Joaquin	Lower San Joaquin
			Tidal	Riverine		
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
Flood management is often made difficult by the large number of agencies and entities involved because of the following:						
a) Complex jurisdictional roles and responsibilities	●	●	●	●	●	●
b) Conflicting policies, missions and priorities	●	●	●	●	●	●
c) Conflicting regulations and legislation	●	●	●	●	●	●
d) Lack of coordination (planning and implementation)	●	●	●	●	●	●
Land-use decisions at the local level may not adequately consider flood risk because of the following:						
a) Poor or outdated flood risk information and maps	●	●	●	●	●	●
b) Strong desire for economic development	◖	◖	◖	◖	◖	◖
Land-use practices can affect flood management because of the following:						
a) Rapid urbanization	◖	◖	◖	◖	◖	◖
b) Agricultural land practices	◖	◖	◖	◖	◖	◖
Trend toward strict liability for damages due to flood control facility failure deters construction and effective management of flood management projects.	●	●	●	●	●	●
Current federal, State, and local funding mechanisms are not adequate to sustain effective flood management because of the following:						
a) Inability to assess and generate funding at a local level	●	●	●	●	●	●
b) Limitations on State funding	●	●	●	●	●	●
c) Declining federal cost share	●	●	●	●	●	●
d) Federal benefit/cost requirements	●	●	●	●	●	●

Notes:
* Table is intended to graphically capture the regional differences. The identified problems and opportunities contained in this table include the views, perspectives, and input of all participants. At this point in the planning process, there are differing opinions on whether all of the items included as problems and opportunities are in fact problems that should be evaluated further. There are also differing opinions about the magnitude, relative importance or underlying causes of the identified problems and opportunities. This table is subjective, not meant to be scientifically precise and not meant to imply that technical or scientific documentation about the condition is necessarily available.
** "Relevant" indicates that a region is currently experiencing the problem or previously experienced problems associated with a particular contributing factor. In those instances where the problem was previously experienced, the region may have resolved the problem, but concerns remain over the problem potentially recurring in the future.

3.4.1 Flood Management is Often Made Difficult by the Large Number of Agencies and Entities Involved

Flood management is often complicated by the large number of agencies and entities involved, and their complex jurisdictional roles and responsibilities. Overlapping jurisdictions across various federal and State agencies involved in flood management can lead to inconsistent policies and regulations. Coordinating activities within this fragmented jurisdictional landscape can be challenging, particularly for local entities.

Complex Jurisdictional Roles and Responsibilities

Levee certification, maintenance, inspections, insurance, planning, land use, funding, and enforcement – all occur across multiple agencies and jurisdictions. In many cases, multiple agencies carry responsibilities for routine flood management activities. A good example relates to maintenance of State-federal levees:

- The USACE establishes vegetation management and other maintenance requirements for State-federal levees
- LMAs are responsible for carrying out physical maintenance on the levees
- DWR is responsible for maintaining the channels that can affect levee erosion
- DWR is responsible for inspecting levees to determine whether they meet the relevant standards
- The Board is responsible for taking action to enforce the established maintenance standards
- Various regulatory agencies are responsible for ensuring the protection or mitigation of environmental resources impacted by maintenance activities

Some LMAs assert that designated responsibility has not been clearly defined for some areas such as channel maintenance, bank protection, and beaver management. This can lead to deferred maintenance and conflicts among agencies. For example, some LMAs contend that inadequate channel maintenance, such as a lack of dredging, sedimentation or debris build-up, causes some levees to fail inspections.

While coordination among State, federal, and local agencies itself presents a significant challenge, overlapping jurisdictions and responsibilities

among local agencies can also further complicate flood management efforts. Flood management functions within a single geographic area may be carried out by a combination of city and county planning and public works departments, drainage districts, water supply districts, joint powers authorities, and others. Furthermore, floodplains and flood flows are not always confined to the geographic boundaries of the local agencies responsible for managing them.

Conflicting Policies, Missions and Priorities

Conflicting and/or overlapping jurisdictional missions across agencies involved in flood management also make coordination difficult. The wide range of missions related to flood management includes:

- Flood control planning and implementation
- Floodplain management
- Land use
- Water supply
- Emergency response and recovery
- Resource conservation (terrestrial, aquatic)
- Pest and vector control
- Economic development
- Insurance
- Transportation
- Homeland security

Conflicts arise when one mission or responsibility can only be achieved at the expense of another mission or responsibility. For example, a multipurpose reservoir must be operated during the flood season according to the water control manual, but doing so may impact the ability to store adequate water supplies to meet urban, agricultural, and environmental needs later in the year. Similarly, reservoir releases may prevent flood damages in one area, while exacerbating water levels in another.

Conflicting Regulations and Legislation

Conflicting missions and priorities can lead to inconsistent policies and regulations from various federal and State agencies involved in flood management, as described in Section 3.2.1. These inconsistent regulations cause inconsistent practices at a local level and problems related to enforcement.

Lack of Coordination (Planning and Implementation)

Flood risk in the Central Valley is continually changing over time. Flood management planning, policies, and standards are only effective if they can account for the interdependencies of the flood management system with other State resources and needs (the various functions of levees in the

Delta, for example), and adapt to changes in land use, population, climate, and infrastructure.

Planning for flood management occurs at multiple levels and by multiple agencies. For example, USACE is most often associated with federal feasibility studies for flood risk reduction and watershed management, but the U.S. Forest Service also addresses drainage and flooding at a federal level as part of forest management plans. The State conducts specific flood damage reduction studies, while also addressing flood management as part of integrated regional water management planning efforts. Flood management planning also occurs at the local level, led by LMAs, cities and counties, and joint powers authorities. Furthermore, constructing and/or maintaining flood system improvements or risk reduction projects often falls within the jurisdiction of entities different from those responsible for the relevant planning functions. Coordination across multiple agencies at all levels – State, federal, and local – is necessary to accomplish efficient and effective flood management in the Central Valley that provides public safety while remaining consistent with the economic, social, and environmental values of the State.

Efforts to improve flood management in the Central Valley provide opportunities to coordinate policies and guidance at the State, federal, and local levels. Recent initiatives, such as the California Levees Roundtable, have highlighted the benefits of such efforts. The California Levees Roundtable is composed of senior-level officials representing the USACE, the Board, DWR, NMFS, USFWS, the DFG, FEMA, RD 2068, and Sacramento Area Flood Control Agency (SAFCA). The California Levees Roundtable agencies worked together to draft the Central Valley Flood System Improvement Framework, which presents a short-term framework for flood system improvements, and includes an interim criterion for vegetation management.

3.4.2 Land Use Decisions at the Local Level May Not Adequately Consider Flood Risk

Urban development in the Central Valley has rapidly expanded into existing floodplains. Much of this development has encroached into agricultural lands that were protected by flood infrastructure constructed a half-century ago without any consideration of modern design standards. In the past, local land-use decision makers have overlooked flood risks associated with expanding development into these floodplains for the following reasons: (1) poor or outdated flood risk information and maps, and (2) a strong desire for economic development.

Poor or Outdated Flood Risk Information and Maps

As discussed in Section 3.1.5 and 3.1.10, changes in floodplain maps can be caused by limited historical hydrological data, climate change, hydraulic changes in the watersheds, or inconsistencies among the floodplain boundaries of multiple agencies. Another challenge associated with floodplain maps used by land-use planners is that they often contain poor or outdated information that can lead to inadequate consideration of flood risk.

Mapping of the 100-year flood zones in the Central Valley is incomplete, and many flood maps were made under the tenuous assumption that the State-federal project levees provided protection from 100-year flood events. Where maps do exist, many are more than a decade old and do not account for current or future build-out. As future development occurs, runoff from that new development can increase flows in flood-prone areas downstream.

In addition, many floodplain maps are prepared based on political boundaries (e.g., city, county, or agency), not on watershed boundaries. Different jurisdictions frequently use different floodplain mapping data and methods. These different standards lead to inconsistencies in floodplain mapping and limit the ability to do comprehensive floodplain management.

Strong Desire for Economic Development

A strong desire for economic development at the local level can outweigh concerns regarding flood risk during the land-use planning process. Often, local officials who make land-use decisions promote development and encourage business to generate tax revenue and create employment. Current development in the Central Valley's deep floodplains is in progress because these areas are close to population centers and offer easy-to-build-on land. Developers building in floodplains assume or have been led to believe that adequate flood protection will be provided by the government. New development in deep floodplains will continue until it is clear

(to communities, developers, and citizens) that the long-term costs of building in these areas, to the public at large and to the floodplain residents in particular, outweigh any short-term economic benefits.

3.4.3 Land-Use Practices Can Affect Flood Management

Land-use practices that can affect flood management include rapid urbanization and agricultural land practices.

Rapid Urbanization

Rapid population growth in California has led to increasing urbanization of the Central Valley, with attendant conversion of agricultural land. Much of the new development in the Central Valley is occurring in areas that are susceptible to flooding. Urbanization in floodplains increases the potential for flood damage to homes, businesses, and communities. While levees and other facilities may decrease the frequency of flooding, they do not offer complete protection from flooding.

Aerial Photograph of Sacramento's Pocket Area Showing Urbanization in a Floodplain Protected by Levees

Furthermore, many of the SPFC facilities were built a hundred years ago to protect agricultural land and were not designed to protect the large urban populations that are now growing behind them. Many of the agricultural levees were only designed to provide protection from a 100-year flood event or less. Flood legislation passed in 2007 establishes the 200-year flood event (flood with a 1-in-200 chance of occurring in any year) as the minimum level of flood protection to be provided in urban and urbanizing areas.

Agricultural Land Practices

Agricultural land practices can have both positive and negative impacts on flood management. The Central Valley was historically used for rangeland, and when it is converted to cropland, the consequent leveling alters flow paths. The planting of certain crops on floodplains increases surface roughness, which slows water runoff and increases flood stage. Flooding rice fields, as opposed to burning rice stubble, can also take up potential floodplain flood space and reduce the ability of floodplains to attenuate

flood peaks. Some agricultural land practices, such as tilling or ripping the soil for future crops, for example orchards, can increase erosion. In addition, the replacement of low-value crops, such as alfalfa, in the floodplain with high-value crops, such as vineyards, increases the potential economic losses if the fields are flooded.

Agricultural land practices can also have many positive impacts on flood management. Croplands can sometimes serve as a hydraulic buffer by providing temporary storage of flood waters for downstream urban areas. Conservation or riparian buffers consisting of grasses and trees planted along streams and croplands prevent soil erosion and nutrient runoff into waterways. Many crops, such as alfalfa, also capture sediment and mitigate for soil erosion. Some agricultural lands with appropriate soil and groundwater conditions can also provide groundwater recharge benefits and may help mitigate land subsidence.

3.4.4 Trend Toward Strict Liability for Damages Due to Flood Control Facility Failure Deters Construction and Effective Management of Flood Management Projects

Liability for loss of life or property resulting from natural disasters has typically been assigned to those agencies or entities that acted unreasonably in carrying out their duties or responsibilities. However, recent court decisions and legal actions in California, and elsewhere in the United States, indicate that courts are increasingly assigning liability to flood control agencies, such as the State of California, based on a standard of strict liability (Basye et.al., 2004). Strict liability is the legal responsibility for damages, or injury, even if the entity found strictly liable was not at fault or negligent.

In 2003, the Third District Court of Appeals ruled in Paterno v. State of California that the State was liable in inverse condemnation on the basis that a levee, constructed by others years earlier but accepted by the State of California into the SRFCP, had been constructed improperly. The court found that the LMA was not jointly liable with the State because it had no part in the construction of the levee or the decision by the State to accept the levee into the State-federal system, and no authority to modify or improve the levee independent of the State. The ruling further indicated that although the State cannot be held liable for failing to upgrade a system to provide an increased level of protection, it could be held liable for not taking corrective action to ensure that the planned level of protection of the original project was realized. The ruling established that when a public entity operates a flood control system built by someone else, it accepts liability as if it had planned and constructed the system itself.

This legal standard creates challenges for the State and other flood protection agencies, which are increasingly hesitant to implement even those projects that are publicly supported and widely recognized as needed to improve public safety. Many of the levees adopted into the SPFC were constructed decades ago without formal engineering or design standards in place. Further, the strict liability standard may not fully address the fact that levees and other flood control facilities reduce the potential for flooding but do not eliminate the risk; the threat to lives and property remains, with or without the project in place. The potential legal ramifications are further complicated by the unique interdependence of private and State-federal levees in areas such as the Delta (Basye et.al, 2004).

The application of strict liability does not consider that decisions related to the use of hazardous floodplains lies at the local level, rather than with the State or federal project owners and operators (Kusler and Thomas, 2007).

Land-use and development decisions are made at a local level, an aspect which flood legislation passed in 2007 seeks to address by requiring cities and counties in the Central Valley to consider flood risk in their general planning activities and provide minimum levels of protection to urban populations. For a more detailed description of this legislation see Section 3.1.6.

Ultimately, all taxpayers carry the financial burden of catastrophic flood damages through State and federal subsidized disaster assistance and recovery programs, such as FEMA's NFIP. The cost to the State for levee breaks continues to escalate in terms of repair, liability, and preventative maintenance and enforcement – and threatens the economic wellbeing of the State.

3.4.5 Current Federal, State, and Local Funding Mechanisms are Not Adequate to Sustain Effective Flood Management

Funding for flood management is derived from a number of State, federal, and local sources, primarily through tax revenues and assessments or emergency declarations. At the local level, there are a large number of LMAs with a wide variety of funding levels and sophistication, but all with similar responsibilities. Lack of funding can often lead to staff shortages, which slows down the ability of LMAs and other flood management agencies to serve the public. Several constraints and challenges associated with current State, federal, and local funding mechanisms are limiting the ability to sustain effective flood management. These include: (1) inability to assess and generate funding at a local level, (2) limitations on State funding, (3) declining federal cost share, and (4) federal benefit-cost requirements.

Inability to Assess and Generate Funding at a Local Level

As previously described in Section 3.2.1, local governments are restricted by two constitutional amendments governing the use of property taxes or benefit assessments: Propositions 13 and 218. Originally intended to prevent government agencies from raising taxes without sufficient input from the public, the amendments require a two-thirds majority vote to approve special taxes and can restrict the ability of local agencies to use taxes and assessments to increase flood control funding.

While the original Proposition 218 legislation was intended to reduce discretionary spending that lacked broad public approval, flood management differs from other government functions in that failure to properly maintain levees and other facilities can result in significant threats to public safety, as well as catastrophic damages that subject the entire State to financial liability. Public safety and security – a key function of flood management – are typically viewed by the public as essential government functions, rather than discretionary services.

A lack of stable, long-term funding and multiple-agency funding streams still constrain many aspects of integrated flood management, including the development of a comprehensive, sustainable, ecological corridor-based approach; implementation of projects that achieve multiple objectives and provide multiobjective long-term habitat management; and reducing the long periods between levee maintenance activities, which would reduce the environmental impact and cost of maintenance.

Limitations on State Funding

Public funds available through various State grant, loan, and bond programs have helped bridge funding gaps for many local improvement projects. However, funding for these State programs has varied over time and is limited by budget constraints and political subjectivity. Currently, economic decline and the recent fiscal crisis have decreased funding available for maintenance, improvements, and management activities. Passage of Assembly Bill (AB) 1147 shifted the nonfederal share of USACE projects between the State and the local sponsor from 70 percent and 30 percent to 50 percent and 50 percent, respectively, for single-objective projects. State budgeting is based on short time periods (1 to 3 years), making it difficult to accommodate opportunities for phased and adaptive development of long-term flood management and environmental planning.

Declining Federal Cost Share

Federal cost sharing for flood management projects dropped from 75 percent to 65 percent in recent years. The financial resources of many cities, counties, and LMAs are too limited to carry out many recognized actions to address levee problems, even if they qualify for federal funding assistance. The current economic challenges facing the State further diminish the ability to provide the local cost share needed for major flood management improvement projects.

Current federal funding mechanisms may actually encourage LMAs to defer needed maintenance or repairs. For example, an LMA can receive federal funds to repair flood-damaged facilities under Public Law 84-99 if an emergency is declared, whereas they may be unable to receive federal

funding assistance to proactively address problems before a flood occurs due to an unfavorable benefit-cost ratio or the inability to meet local cost-sharing requirements.

Many local agencies need assistance in pursuing federal grants to mitigate flood risk. FEMA's Flood Mitigation Assistance (FMA) Program was created with the goal of reducing or eliminating claims under the NFIP. FEMA provides FMA planning, project, and technical assistance grants to assist states and communities implement measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. In Fiscal Year 2009, $35,700,000 of funding were available for the FMA programs. California received $842,400 compared to the highest grant award of $5,193,300. FEMA also provides grants under the Pre-Disaster Mitigation (PDM) Program, which provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects before a disaster event. In Fiscal Year 2008, $54,000,000 was made available for the PDM programs. Grant recipients in California received $624,210 compared to the highest grant award of nearly $3,000,000.

Federal Benefit-Cost Requirements

Historically, federal decisions for investing in flood management have been based on contributions to national economic development, as reflected in the benefit-cost ratio. Benefits are estimated based on the value of flood damages with no direct benefit associated with reducing flood risk.

While environmental benefits are included in the overall project benefit-cost ratio of federal projects through Water Resources Development Act (WRDA) Section 1135[23], there are other impacts that are not fully accounted for. The benefit-cost ratio may not fully account for residual risk (depth or rapidity of flooding), the magnitude of the threat to public safety (number of people at risk within the floodplain), long-term economic impacts (permanent loss of an industry or work sector), or social/cultural impacts. These factors can be considered in other benefit accounts, but these accounts generally fall outside the economic criteria used for federal decision making.

Flood improvements within a region can provide significant benefits outside of the region that may not be reflected in traditional benefit-cost

[23] WRDA Section 1135 provides the authority to modify existing USACE projects to restore the environment and construct new projects to restore areas degraded by USACE projects. For example, environmental benefits accounted for more than 60 percent of the total project cost in the Hamilton City Flood Damage Reduction and Ecosystem Restoration project under Section 1135.

analyses. Although the responsibility for funding levee maintenance and repairs lies with those receiving direct protection (LMAs, for example), flood management systems often provide broad regional and societal benefits beyond the boundaries of the assessment area. For example, people living in areas just outside a 100-year floodplain may reap the economic benefits of development in the adjacent floodplain. Similarly, a major flood event in the State's capital of Sacramento could disrupt the operation of State government and provision of services throughout all of California. Although the water used by two-thirds of Californians passes through Delta waterways created by levees, LMAs struggle to adequately maintain levees with their limited, local tax base.

Many rural and agricultural areas have historically experienced difficulty securing federal funding because the value of local infrastructure and rural land uses do not outweigh the increasing cost of implementing flood-damage-reduction projects. Some assert that traditional economic methods for analyzing benefit-cost ratios of agricultural-related projects often undervalue the overall benefits associated with agricultural production. Agricultural lands often provide broad public benefit by serving as a buffer for more densely populated areas. Agricultural practices can also promote biodiversity through integrated pest management, active control of nonnative plant and pest species, creation of vegetative buffer zones, provision of feed and habitat for wildlife, and protection of habitat areas, such as managed wetlands, National Wildlife Refuges, State Wildlife Areas and mitigation lands. Also, although farm receipts represent just one percent of California's $1.8 trillion economy, its raw products are converted to billions of dollars in finished products and provide thousands of tax-paying jobs.

3.5 Integrated Water Management

The flood management systems within the Sacramento and San Joaquin river basins rely on physical hydrologic features, infrastructure, and institutional arrangements that affect other components of water resources management. Flood management requirements often make it difficult to meet other water resources needs. Many management actions that could be taken to improve flood risk management and O&M can also provide significant opportunities for improvements to water supply, water quality, ecosystem functions and attributes, and recreation.

DWR is currently promoting the concept of integrated regional water management (IRWM). IRWM planning is the way in which DWR hopes to achieve sustainable water uses, reliable water supplies, better water quality, environmental stewardship, efficient urban development, protection of agriculture, a strong economy, and improved flood management. Table 3-5 lists the contributing factors related to IRWM, and their relevance to each of the five planning regions. The following discussion reflects the views and perspectives of all participants and input received, recognizing that there are differing opinions on the magnitude, relative importance, or underlying causes of the identified problem.

Table 3-5. Integrated Water Management Problem Statement Contributing Factors Summary

Contributing Factors	Regional Differences*					
	Upper Sacramento	Lower Sacramento	Delta		Upper San Joaquin	Lower San Joaquin
			Tidal	Riverine		
	N/A = Problem not applicable to region ◖ = Problem is relevant to parts of the region** ● = Problem is relevant to the entire region**					
Integrated flood management is made difficult by competing needs including the following:						
a) Flood protection	●	●	●	●	●	●
b) Water supply	●	●	●	●	●	●
c) Ecosystem resources	●	●	●	●	●	●
d) Recreation	●	●	●	●	●	●
e) Water quality	●	●	●	●	●	●
f) Hydropower	●	●	●	●	●	●
g) Dam safety	●	●	●	●	●	●

Notes:
* Table is intended to graphically capture the regional differences. The identified problems and opportunities contained in this table include the views, perspectives, and input of all participants. At this point in the planning process, there are differing opinions on whether all of the items included as problems and opportunities are in fact problems that should be evaluated further. There are also differing opinions about the magnitude, relative importance or underlying causes of the identified problems and opportunities. This table is subjective, not meant to be scientifically precise and not meant to imply that technical or scientific documentation about the condition is necessarily available.
** "Relevant" indicates that a region is currently experiencing the problem or previously experienced problems associated with a particular contributing factor. In those instances where the problem was previously experienced, the region may have resolved the problem, but concerns remain over the problem potentially recurring in the future.

Integrated Flood Management is Made Difficult by Competing Needs

Reservoirs designed for flood control are increasingly being required to meet a wide variety of objectives for which they were not originally designed, including those listed below. These objectives can lead to increased competition over limited reservoir storage space and the quantity, timing, and duration of reservoir releases. Balancing these competing demands is difficult, and will likely become more challenging with potential changes in runoff patterns from climate change (California Natural Resources Agency, 2009b).

Flood Protection Maintaining the flood space is critical for flood protection, yet sometimes comes at the expense of other reservoir objectives (water supply, recreation, hydropower, timed instream releases, etc.).

Water Supply The need for flood releases and maintenance of flood space can conflict with the desire to maximize storage for water supply. When flood space is increased to meet rules for flood operations, available storage for water supply is decreased.

Ecosystem Resources At specific times of the year, reservoir releases are made to meet temperature, stage or flow objectives that support fish needs. Since these releases are designed to support specific fish life stages, such as spawning, rearing, and migration, they vary widely in timing, duration, and quantity based on the unique biological needs of each stream reach and species. During flood management operations there are typically no considerations (other than minimum releases) made for ecosystem resources. Flood releases are made on the schedule prescribed in the water control manual, which may not be conducive to ecosystem preservation or restoration.

Recreation Much like water supply, flood management operations can also impact lake recreation. Decreases in reservoir storage to create flood space decreases the water surface area available for marina operations and lake access and increases the "bathtub ring" shoreline that mars the views.

Water Quality Reservoir releases to achieve downstream water quality and temperature control objectives are dependent on reservoir storage after the end of the flood season. Reservoir releases that create flood space reduce available water storage to meet water quality and temperature requirements in the spring.

Hydropower Generating capacity is dependent on two factors in a reservoir, water surface elevation and available water for release. High water storage increases generating capacity but decreases flood space. Conversely, increased flood space decreases water surface elevation and available water for generation. Typically, operators can send initial releases for flood management through the power house, but surplus releases are made over the spillway. Water released over the spillway cannot be used for hydropower generation.

Dam Safety Dam safety concerns can also constrain the ability of a reservoir to meet competing objectives. Overtopping of a dam can lead to catastrophic failure. Flood detention dams (or multipurpose dams) are sized for the Probable Maximum Flood. Releases can be made for dam safety, consistent with the emergency spillway release diagram, that far exceed the objective release. The only constraint on emergency releases is the physical capacity of the spillway to pass the flows.

Although balancing the needs of multiple objectives can be difficult, not all objectives are conflicting. Implementing IRWM practices together with flood management provides opportunities to benefit multiple resources. For example, expanding use of floodplains to increase flood capacity could provide other benefits such as additional groundwater recharge, agricultural production, or environmental restoration.

An example of integrated water management is the Yolo Wildlife Area. The Yolo Wildlife Area is a 16,000-acre public/private restoration project managed by the DFG that achieves multiple objectives including: (1) flood control, (2) wildlife and habitat management, (3) recreation and education, and (4) agricultural production. Wetlands in the area are managed to reduce the establishment of large areas of emergent and riparian habitat that could restrict flood flows and compromise the flood carrying capacity of the Yolo Bypass. The area is also home to nearly 200 species of birds and supports agricultural rice production.

There is a need to create more multiobjective flood control projects that involve multiparty coordination. While single-purpose flood management projects were acceptable in the past, they no longer are considered the preferable approach to floodplain management. Increasingly, floodplains are seen as valuable resources that provide opportunities for flood protection, agricultural production, open space, valuable native habitat, ecosystem protection, recreation, economic development, and housing. Multiobjective projects serve to maximize the diverse benefits that floodplains can provide instead of adversely impacting one objective for another. Multiobjective projects that involve multiple parties can also pool and leverage project funding and benefits. Governmental agencies and the private sector typically do not have the resources or public support to fund projects that do not achieve multiple benefits. Greater financial incentives are now available for multiobjective projects, such as AB 1147, Proposition 13, Proposition 50, and Proposition 84.