7.5 Preliminary Approach Enhance Flood System Capacity

The Enhance Flood System Capacity Approach seeks opportunities to achieve multiple benefits through enhancing flood system storage and conveyance capacity. In contrast to the other preliminary approaches, which focus on improvements that can be implemented primarily within the existing footprint of the flood management system, this approach would include modifications to the existing footprint and function of the flood management system.

7.5.1 Description

This approach supports the primary goal of improving flood risk management by enhancing the capacity of the flood management system through widening floodways, reconnecting floodplains, and increasing floodwater storage. Floodwater storage would be increased through a combination of operational changes to existing reservoirs, new reservoir storage, and modified or new floodplain storage.

This approach supports the secondary goals of promoting ecosystem functions and promoting multi-benefit projects. Enhancing flood system capacity would provide opportunities to achieve multiple benefits in addition to flood risk reduction, such as environmental restoration and related water resources benefits. For example, widening floodways could contribute to the restoration of ecosystem functions while also improving floodwater conveyance; similarly, the reconnection of floodplains could restore natural floodplain processes while also providing floodwater storage.

This approach would generally increase the level of flood protection provided by the system; however, levels of protection would vary widely from location to location. Compared with previous approaches, this approach would provide the greatest opportunities for restoring native habitats (including aquatic, riparian, and floodplain habitats) and also provide opportunities to improve connectivity and ecosystem functions. In addition, it would provide opportunities to improve water supply reliability through multipurpose reservoir storage projects, conjunctively managed groundwater and surface water resources, and groundwater recharge within floodplain storage areas.

7.5.2 Approach Formulation

To formulate the Enhance Flood System Capacity Approach, a series of steps were taken to assess the effectiveness of various modifications to the system in achieving the desired goals of increasing storage and conveyance, and providing opportunities for multi-benefit integration. Table 7-13 lists the approach formulation for the Sacramento and San Joaquin river basins. Thorough an iterative process, several capacity enhancement needs were identified, and recommendations for how they should be addressed were compiled. Assessment of capacity enhancement needs and recommendations for the Sacramento and San Joaquin river reaches is summarized in Tables 7-13 and 7-14.

Table 7-13. Summary of Needs and Recommendations for Sacramento River Basin

River Reach	Capacity Enhancement Needs	Enhancement Options
Sacramento River – Redding to Colusa	Out-of-system floodwaters were observed during all analyzed flood events (0.2 to 10 percent chance event). Improve connectivity and establish riparian habitat through creation of new lands by natural deposition process while reducing O&M responsibilities.	In-place levee improvements. Setback levees in this reach are not applicable because of topography constraints. New storage and/or reservoir operation modifications are not applicable. Remove unnecessary rock sites (Chico landing area/Sacramento River split area) from the SPFC while preventing removal from negatively impacting downstream project levees or local roads and infrastructure.
Sacramento River – Colusa to Fremont	Out-of-system floodwaters were observed during less frequent flood events (0.2 to 1 percent chance event). Reduction in flood peaks through this reach is needed. Continue system O&M as is. Continue to recognize the importance of the Sutter Bypass fish passage function, and support existing habitat areas within the bypass. Some opportunities for enhancing these features may exist. There is some potential for strategic levee setbacks to reduce O&M requirements related to erosion.	Floodplain storage to reduce flood stages. Bypass expansion of Colusa, Tisdale, and/or Sutter bypasses to reduce flood stages. Weir modification to widen Fremont Weir to improve conveyance from the Sutter Bypass to Yolo Bypass. Setback levees in this reach are not effective in reducing flood stages. New storage and/or reservoir operation modifications are not applicable. New bypass in lower system to take pressure off Tisdale Weir, and continue to provide fish passage to Butte Creek with shaded riverine habitat.

Table 7-13. Summary of Needs and Recommendations for Sacramento River Basin (contd.)

River Reach	Capacity Enhancement Needs	Enhancement Options
Sutter Bypass	Out-of-system floodwaters were observed in most analyzed flood events (0.2 to 4 percent chance event). Improved conveyance is needed	Bypass expansion through levee improvements/raise, or, alternatively, in locations where physically possible, through levee setbacks.
Feather River – Oroville to Yuba City	Out-of-system floodwaters were observed in more infrequent flood events. Reduction in flood peaks through this reach is needed.	Reservoir operation changes in Lake Oroville to reduce flood stages. New bypass downstream from Lake Oroville to Butte Basin through Cherokee Canal. New storage is not applicable. Setback levee is not effective.
Feather River – Yuba City to Nicolaus	Out-of-system floodwaters were observed in all analyzed flood events (0.2 to 4 percent chance event). Some flooding in this reach is caused by backwater effects. Improved conveyance is needed.	Levee improvement/raise or, alternatively, in locations where physically possible, levee setbacks to improve reach conveyance capacity. Transitory storage to divert floodwaters of the Feather River or Sutter Bypass to reduce backwater effects on the Feather/Sacramento river junction. Construct a setback levee at the confluence of the Feather River and the Sutter Bypass to connect the river system and floodplains. However, this modification may result in unintended hydraulic effects.
Sacramento River – Fremont Weir to Rio Vista	Out-of-system floodwaters were observed during high flood events (0.2 to 2 percent chance event). Improved levee reliability and/or reduction in flood peaks through this reach are needed.	Bypass expansion of Sutter and/or Yolo bypasses to reduce flood stages in this reach. Weir modification to widen Fremont Weir to improve conveyance from the Sutter Bypass to Yolo Bypass. Setbacks not effective in this reach in achieving stage reductions. Transitory storage not effective.

Table 7-13. Summary of Needs and Recommendations for Sacramento River Basin (contd.)

River Reach	Capacity Enhancement Needs	Enhancement Options
Yolo Bypass	Out-of-system floodwaters were observed in all analyzed flood events. Improved conveyance is needed to pass peak flows through the system and reduce water surface elevations in the Sacramento River.	Bypass expansion (setting back west levee of Yolo Bypass) to increase storage/conveyance. Widen Fremont Weir.

Key:
O&M = operations and maintenance
SPFC = State Plan of Flood Control

Table 7-14. Summary of Needs and Recommendations San Joaquin River Basin

River Reach	Capacity Enhancement Needs	Enhancement Options
Fresno Slough	Out-of-system floodwaters were observed in all analyzed flood events (0.2 to 10 percent chance event). Flooding is caused by flood operations on Kings River. (Increased storage is needed.)	Floodplain transitory storage to manage floodwaters, without affecting downstream reaches of the San Joaquin River. Other actions upstream on Kings River to reduce flood release through James Bypass and Fresno Slough. Reservoir storage is not applicable. Setbacks are not effective in creating large storage.
Chowchilla, Eastside, and Mariposa Bypasses	Out-of-system floodwaters were observed in all analyzed flood events (0.2 to 10 percent chance event). Channel capacity varied throughout the bypasses, which may be affected by subsidence. Improved conveyance is needed.	Bypass conveyance capacity expansion through levee raise or, alternatively, in locations where physically possible, through levee setbacks.
San Joaquin River – Mariposa Bypass to Merced River	Improved conveyance in the bypasses would increase the volume of floodwater conveyed through this reach. Improved conveyance is needed.	Levee raises or, alternatively, in locations where physically possible, levee setbacks to increase reach conveyance capacity.

Table 7-14. Summary of Needs and Recommendations for San Joaquin River Basin (contd.)

River Reach	Capacity Enhancement Needs	Enhancement Options
San Joaquin River – Merced River to Tuolumne River	Out-of-system floodwaters were observed in all analyzed flood events (0.2 to 10 percent chance event). SPFC levees are intermittent in this reach. Floodwaters from the bypasses and the Merced River dominated the flows in this reach. Lake McClure exceeds its release objectives during a 1 percent chance flood event, with a simulated 99 TAF of inflow that is in excess of available flood storage, indicating a need for increased storage.	Floodplain transitory storage to manage floodwaters from main-stem San Joaquin and tributaries. Storage and/or reservoir operation changes on the Merced River through modifications to Lake McClure operations. Setbacks are not effective in addressing the need for large storage.
San Joaquin River – Tuolumne River to Stanislaus River	Out-of-system floodwaters were observed in all analyzed flood events (0.2 to 10 percent chance event). SPFC levees are intermittent in this reach. Floodwaters from the Tuolumne River dominate the flows in this reach. New Don Pedro Reservoir exceeded its release objectives during 2 and 1 percent chance flood events (has a simulated 86 and 224 TAF of inflow that is in excess of available flood storage, respectively), indicating a need for increased storage.	Floodplain transitory storage to manage floodwaters from main-stem San Joaquin River and tributaries. Storage and/or reservoir operational criteria changes on the Tuolumne River through modifications to New Don Pedro Reservoir. Levee setbacks, while not effective in addressing the need for large storage, may be applicable at the confluence with the Tuolumne River to address erosion problems.
San Joaquin River – Stanislaus to Stockton	Out-of-system floodwaters were observed in all analyzed flood events (0.2 to 10 percent chance event). Floodwaters from the Tuolumne River dominate flows in this reach. New Melones Reservoir is appropriately sized to accommodate up to 1 percent chance event.	Floodplain transitory storage to manage floodwaters from mainstem San Joaquin River and tributaries. Storage and/or reservoir operations modifications to New Melones Reservoir were not effective because New Melones Reservoir is already appropriately sized. Levee setbacks, while not effective in addressing the need for large storage, may be applicable at the confluence with the Stanislaus River to address erosion problems.

Key:
SPFC = State Plan of Flood Control
TAF = thousand acre-feet

7.5.3 Approach Elements

Based on the findings summarized in Tables 7-13 and 7-14, a number of storage and conveyance concepts were formulated. This approach includes modifying the existing footprint and function of the flood management system primarily to increase the overall conveyance capacity and floodwater storage, and to provide opportunities for ecosystem restoration and water resources benefits. This approach also protects high risk communities and repairs levees in place in rural-agricultural areas to achieve design flow capacity from flooding from major rivers and tributaries with SPFC facilities. This approach does not include improvements that may be needed to address interior drainage or other local sources of flooding. Also, this approach does not include improvements to non-SPFC levees that protect some urban areas.

In general, flood system capacity can be increased through widening floodways and bypasses, setting back levees away from the active river channel, and increasing floodwater storage. Floodwater storage can be increased through a combination of operational changes to existing reservoirs, new reservoir storage, and modified or new floodplain storage. Widening floodways and setting back levees along some reaches of major rivers and tributaries also provides significant opportunities to restore native habitat quantity, quality, and connectivity, and to restore natural processes necessary to support healthy ecosystems.

In addition to the elements included in the prior two approaches, major elements of the Enhance Flood System Capacity Approach are shown in Figure 7-25 and include the following:

- The existing bypass system in the Sacramento River Basin, including the Sutter and Yolo bypasses and associated inflow weirs, forms the central backbone of the Sacramento River Flood Control Project, forming a corridor for conveying floodflows to the Delta. This approach would increase the capacity of the existing bypass system to enhance its efficiency and ability to convey large flood events. Initial analyses indicate that the following combination of features could effectively enhance the performance of the existing bypass system:
  - Widening the Sutter Bypass by up to 1,000 feet to increase its capacity by 50,000 cfs
  - Widening the Colusa Weir and Bypass and the Tisdale Weir and Bypass by up to 1,000 feet
  - Widening the Fremont Weir by about 1 mile, and widening portions of the Yolo Bypass to increase its capacity by 40,000 cfs

  - Widening the Sacramento Weir and Bypass by about 1,000 feet

- This approach also includes a potential new bypass to divert flows from the Feather River downstream from Oroville Dam along the alignment of Cherokee Canal into Butte Basin. Initial analyses indicate that a bypass with a capacity of 32,000 cfs could reduce peak flood elevations along the Feather River and help convey floodflows into the existing bypass system.

- In the lower portion of the San Joaquin River Basin, this approach includes a new bypass to divert flows from the San Joaquin River into the south Delta. Preliminary analyses indicate that a new bypass at Paradise Cut, or in its vicinity, with a capacity of about 4,000 cfs could effectively reduce peak flood stage along the San Joaquin River in the Stockton Metropolitan Area.

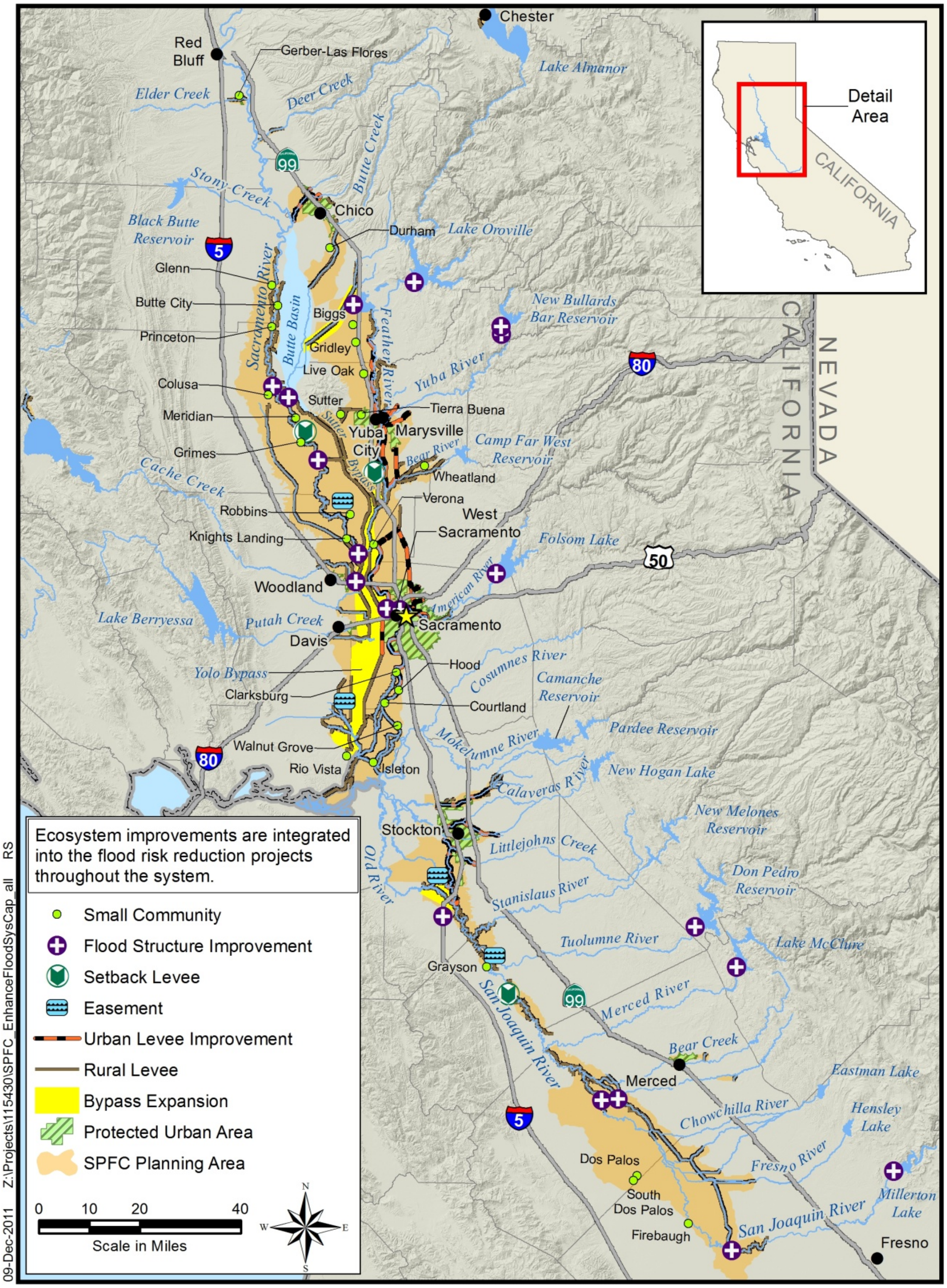
- This approach includes floodway widening along smaller sections of the river by setting back SPFC levees as follows:

  - Along the right bank of the Feather River (below the Bear River confluence) to allow opportunities for ecosystem restoration and to provide continuity with Sutter Bypass

  - Along intermittent sections of the Sacramento River upstream from the Tisdale Weir to provide a more continuous corridor for environmental restoration and to address levee conditions

  - Along the San Joaquin River between the Merced and Stanislaus rivers

- This approach includes modification to the reservoir release schedule and flood storage allocation at Oroville Dam and Reservoir (equivalent to an additional 200,000 acre-feet of flood storage), and coordinated operation with Bullards Bar Reservoir, to reduce flood stages on the Feather River during a 200-year (0.5 percent annual chance) flood event. Also, in the San Joaquin River Basin, the State would partner with interested reservoir operators to increase the flood storage allocation at New Don Pedro, Friant, and New Exchequer dams by about 400,000 acre-feet to effectively manage the 100-year (1 percent annual chance) flood event at these reservoirs. These features help manage the timing and magnitude of peak floodflows before they enter the Sacramento and San Joaquin rivers.



Key: SPFC = State Plan of Flood Control

Figure 7-25. Improvements Included in Enhance Flood System Capacity Approach

- This approach includes approximately 200,000 acre-feet of transitory storage in the floodplains of the Sacramento River Basin and approximately 100,000 acre-feet of transitory storage in the floodplains of the San Joaquin River Basin. Floodplain storage effectively works with bypass and floodway expansion to attenuate flood peaks and provide opportunities for conservation of agricultural lands and native floodplain habitats.

7.5.4 Approach Assessment

Based on an initial assessment, the Enhance Flood System Capacity Approach is estimated to cost between approximately $32 billion to $41 billion and would take 35 to 40 years to implement. This approach would provide an approximate 80 percent reduction in annual flood damages compared to current conditions.

This investment would expand system storage and conveyance capacity, resulting in reduced peak flood stages throughout the system. This would, in turn, result in increased levels of flood protection throughout the system, although levels would continue to vary from location to location. Some urban areas would achieve an urban level of flood protection, or higher, through the combination of conveyance and storage improvements, while others would not.

Flood Stage Assessment

This approach would provide opportunities to address chronic erosion, geomorphic conditions, and levee foundation conditions that make O&M of the current system costly and unsustainable. Hence, the approach would significantly address the supporting goal of improving O&M.

This investment would expand the system storage and conveyance capacity resulting in reduced peak flood stages throughout the system (see Figure 7-26). In the Sacramento River Basin, reduction in stage would result from expansion of the Sutter and Yolo bypasses as well as from widening the Fremont and Sacramento weirs. By improving the levees, diverting flows to bypasses, and widening the channel in key locations, more water would be allowed to flow through the system at reduced stage.

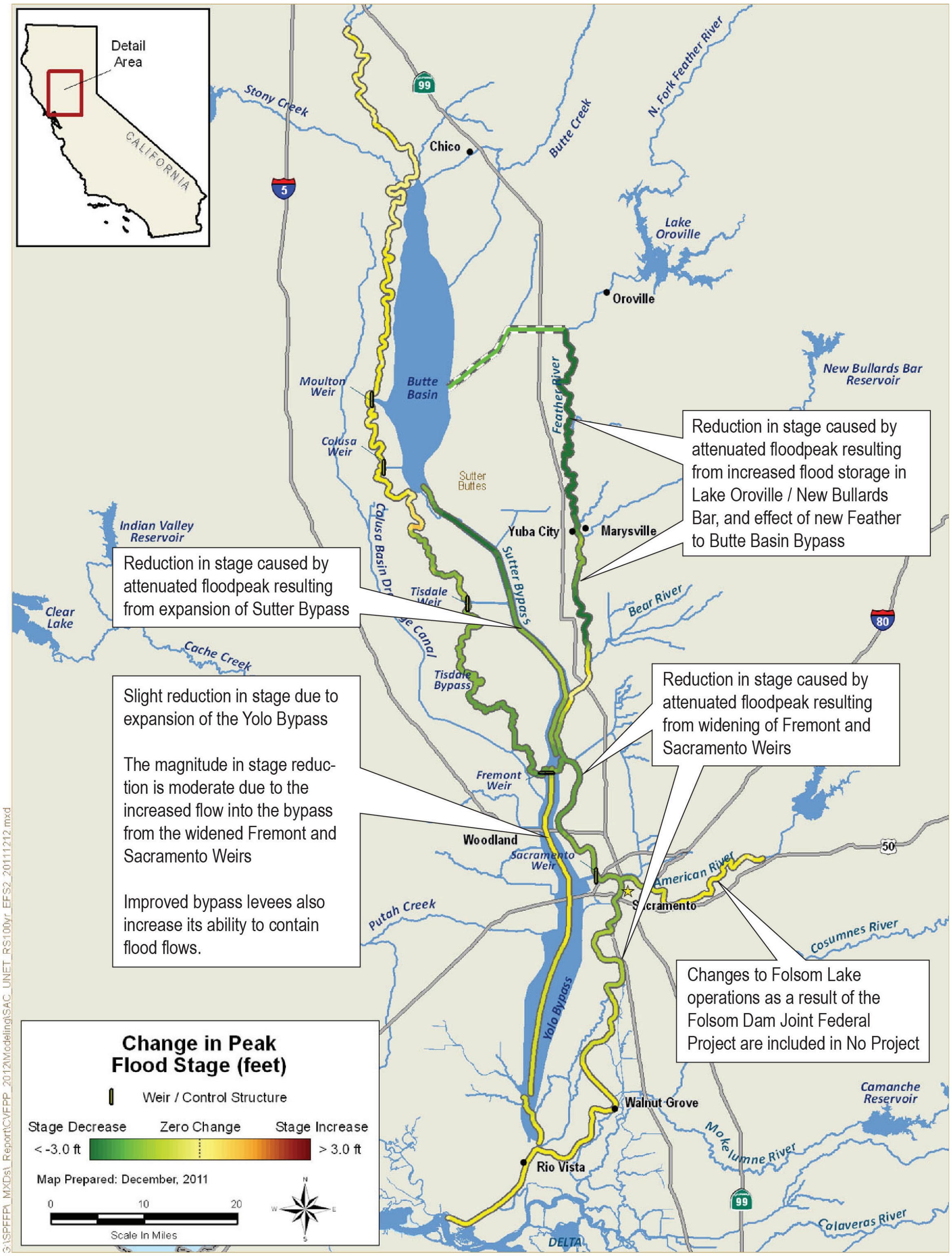


Figure 7-26. Change in Peak Flood Stage for Enhance Flood System Capacity Approach Compared to No Project in Sacramento River Basin (100-year Event)

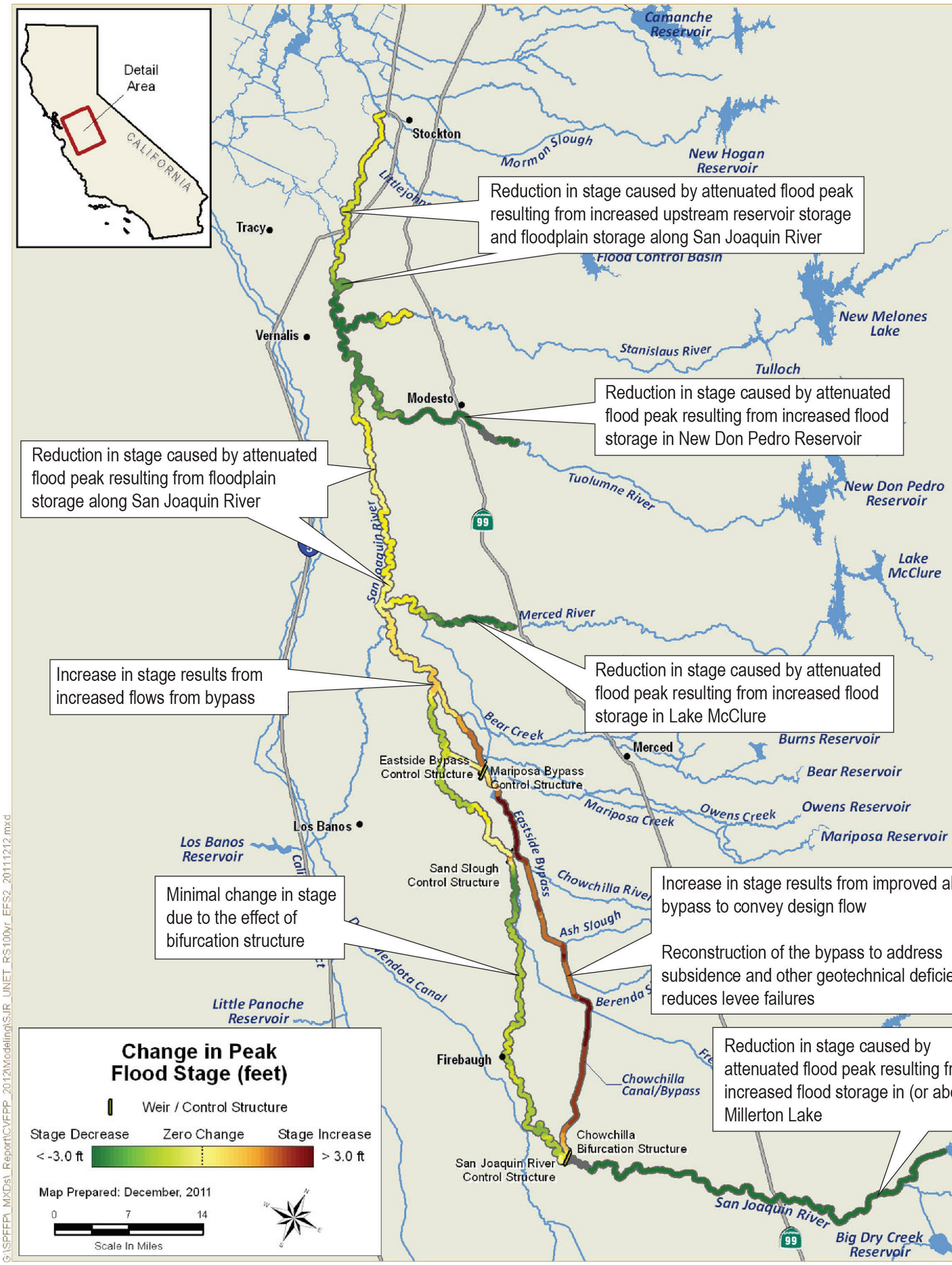


Figure 7-27. Change in Peak Flood Stage for Enhance Flood System Capacity Approach Compared to No Project in San Joaquin River Basin (100-year Event)

In the San Joaquin River Basin, stage reductions due to increase flood storage in reservoirs and floodplain easements would be partly offset by an increase in stage as a result of repairing and strengthening the Chowchilla/Eastside/Mariposa bypasses levee system (see Figure 7-27).

Overall, the Enhance Flood System Capacity Approach would result in increased levels of flood protection throughout the system, although levels would continue to vary from location to location.

Environmental Assessment

This approach would provide opportunities to restore native habitats (including aquatic, riparian, and floodplain habitats) and improve the quality and connectivity of environmental resources within the flood management system. It would also provide opportunities to improve (1) water supply reliability through multipurpose reservoir storage projects, (2) conjunctive management of groundwater and surface water resources, and (3) groundwater recharge within floodplain storage areas. Accordingly, it would fully address the supporting goals of promoting ecosystem functions and multi-benefit projects.

Economics Assessment

Economic damages would be reduced to various degrees throughout the system. Accordingly, this approach would address the primary goal of improving flood risk management, although at a high cost.

Figures 7-28 and 7-29 show the EAD for structure and contents, crop and business losses for the Enhance Flood System Capacity Approach compared with No Project for the Sacramento and San Joaquin river basins, respectively. Figures 7-30 and 7-31 provide geographic representations of the changes between the Enhance Flood System Capacity Approach and No Project for the Sacramento and San Joaquin river basins respectively. For both basins, expected annual damages to structures and businesses will be reduced considerably from those incurred under No Project.

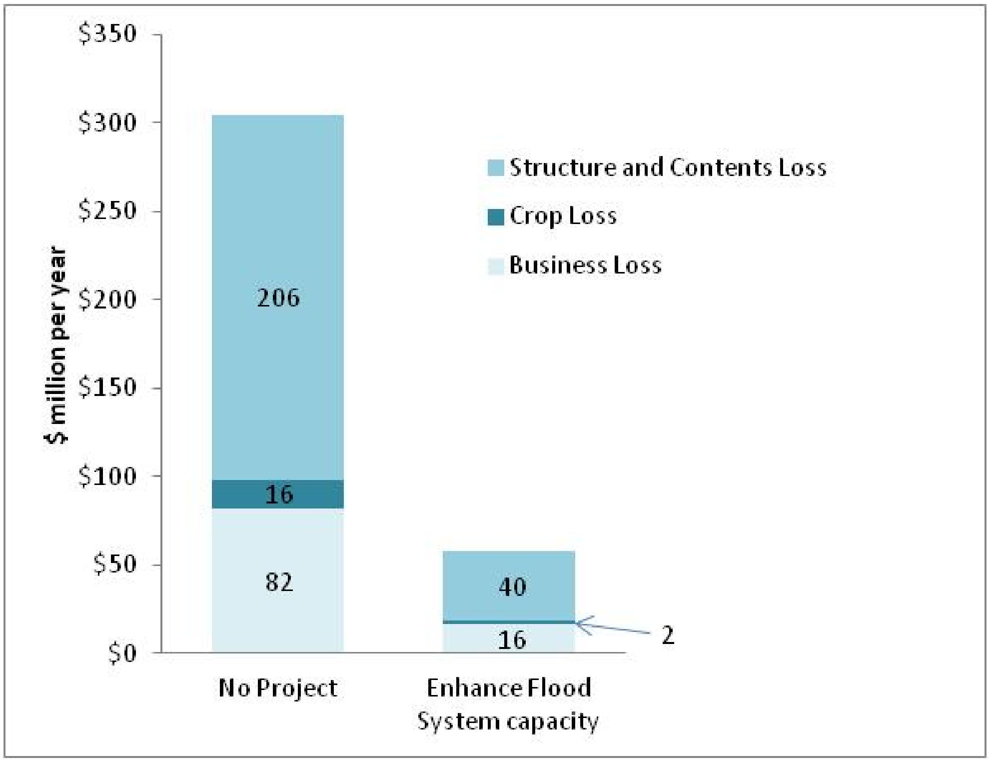


Figure 7-28. Expected Annual Damages from Flooding: Enhance Flood System Capacity Approach Compared to No Project for Sacramento River Basin

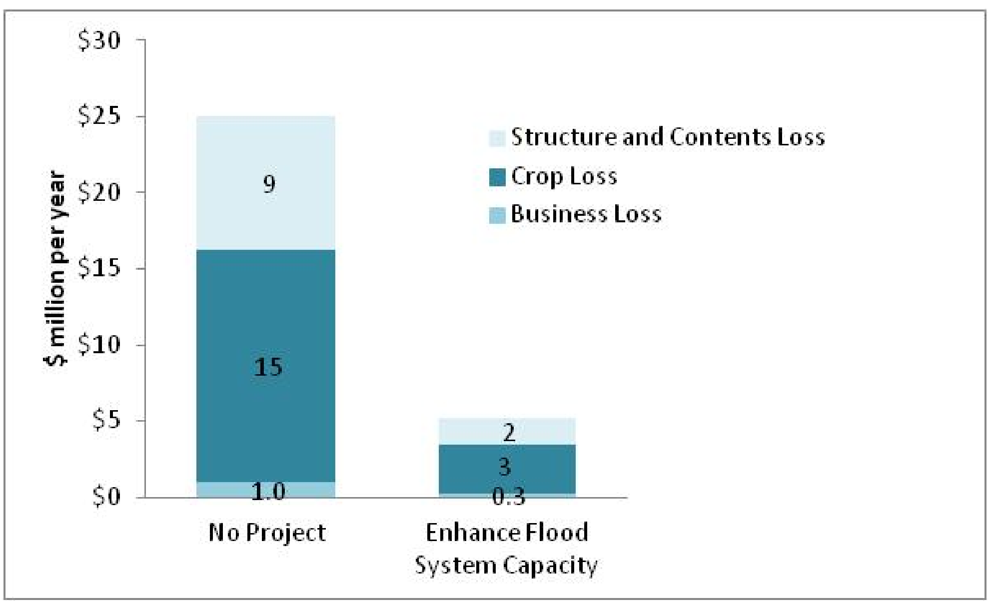


Figure 7-29. Expected Annual Damages from Flooding: Enhance Flood System Capacity Approach Compared to No Project for San Joaquin River Basin

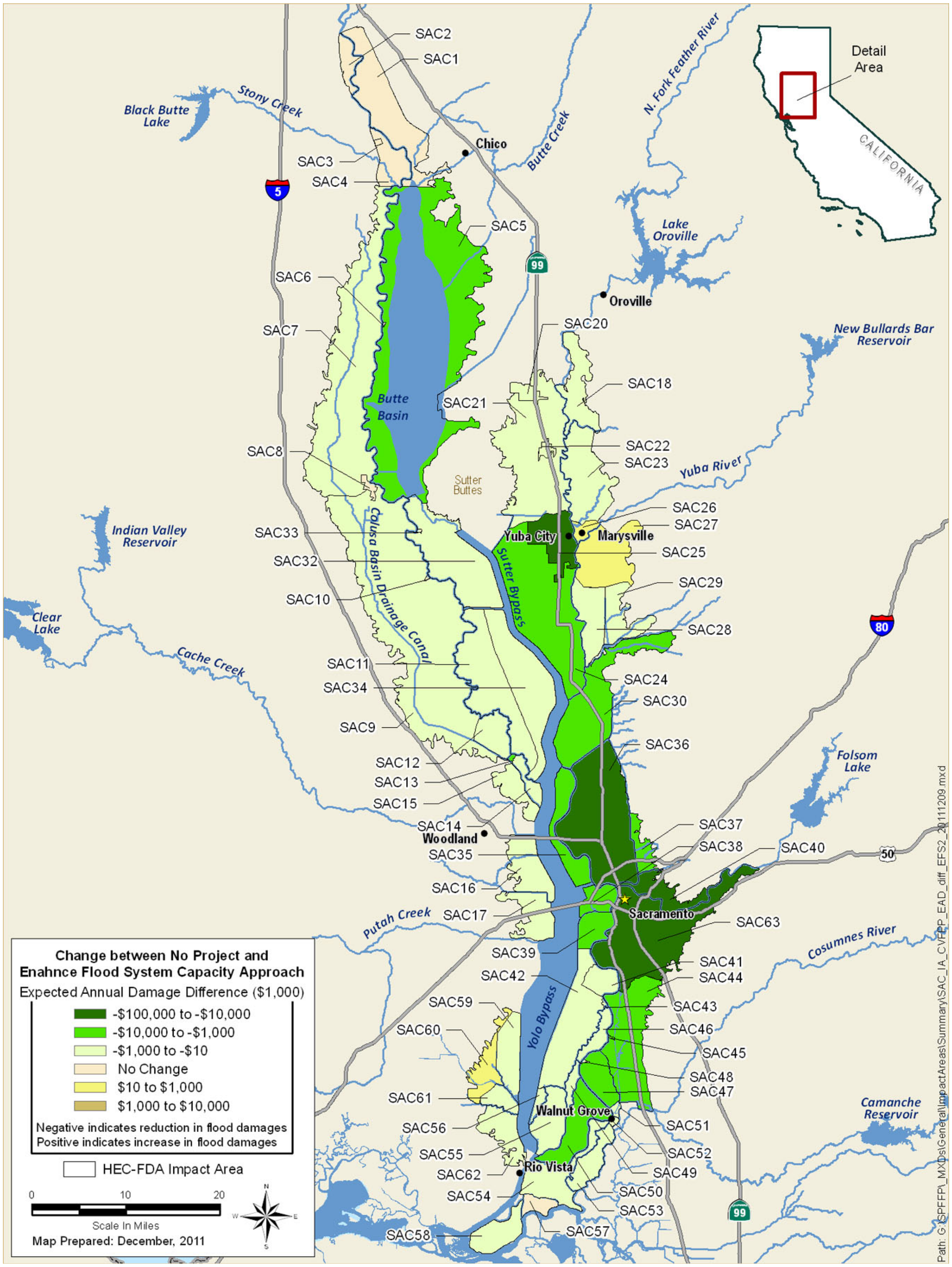


Figure 7-30. Change in Expected Annual Damages for the Sacramento River Basin Under the Enhance Flood System Capacity Approach Compared to No Project

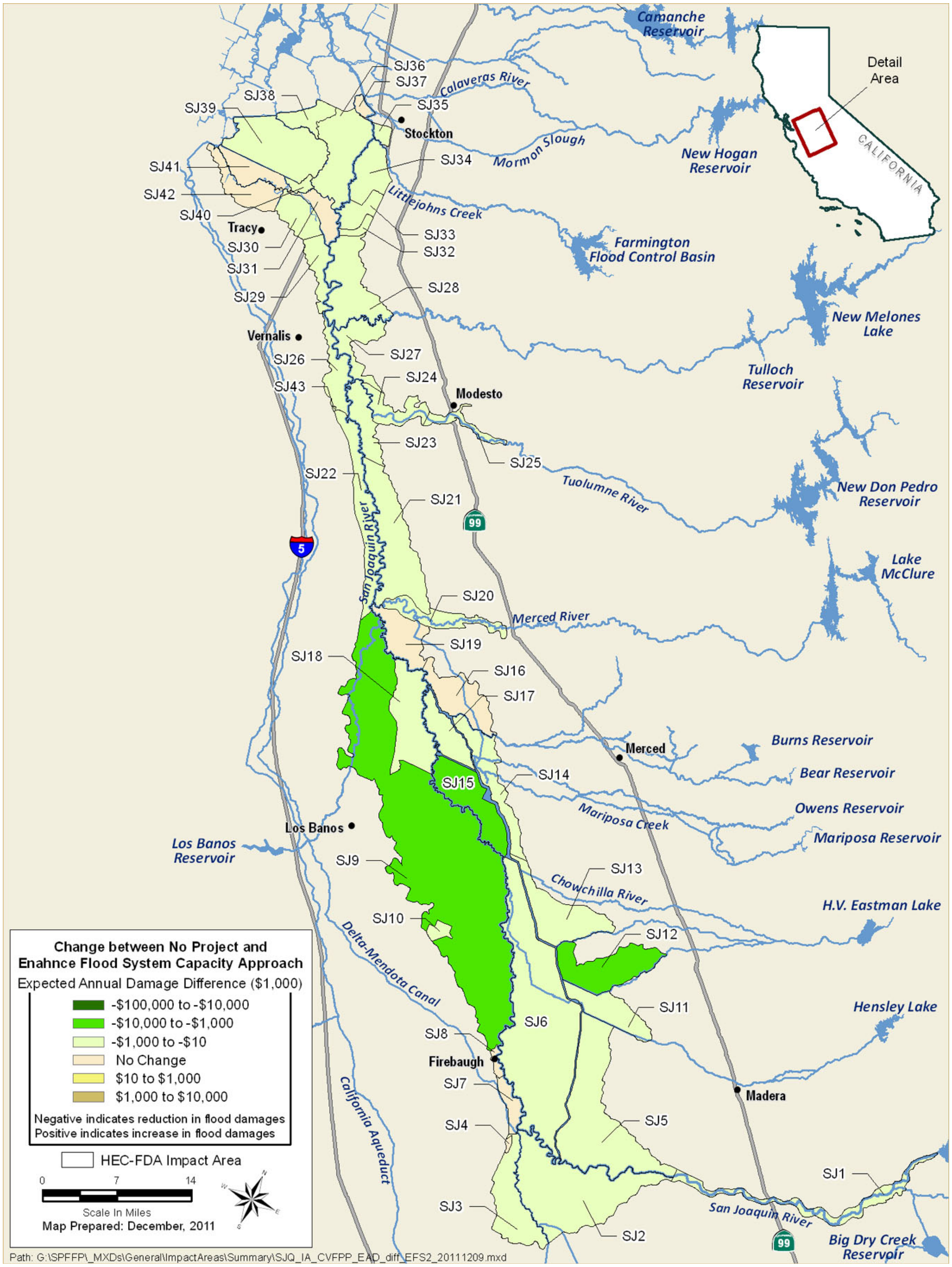


Figure 7-31. Change in Expected Annual Damages for the San Joaquin River Basin Under the Enhance Flood System Capacity Approach Compared to No Project

Cost Assessment

The Draft 2012 CVFPP – Cost Estimating Methodology Memorandum (GEI Consultants, 2011) provides cost estimates for the Enhance Flood System Capacity Approach. The costs for this approach were categorized into four flood management elements:

1. **System Improvements** – This is a significant element of the Enhance Flood System Capacity Approach. In addition to costs associated with F-CO/F-BO, this approach also includes costs for bypass expansion and improvements, fish passage improvements, and increased flood storage in foothill reservoirs and on floodplains.

2. **Urban Improvements** – Includes 200-year LOP urban SPFC levee projects.

3. **Rural Agricultural Improvements** – Includes improvements to non-urban SPFC levees through the NULE Program, and new levees for small communities located within the SPFC.

4. **Residual Risk Management** – This is a minor part of the Enhance Flood System Capacity Approach since the need is expected to be less than other approaches because of the significant investment in physical flood system improvements.

Table 7-15 summarizes the improvement costs for the Enhance Flood System Capacity Approach for the Sacramento and San Joaquin river basins.

Table 7-15. Improvement Costs for the Protect High Risk Communities Approach for the Sacramento and San Joaquin Basins ($ Millions)

	Sacramento River Basin			San Joaquin River Basin		
	Low		High	Low		High
System Improvements	$ 5,394	to	$6,846	$ 2,216	to	$ 4,043
Urban Improvements	$ 4,704	to	$ 5,091	$ 792	to	$ 434
Rural Improvements	$ 14,425	to	$ 18,366	$ 3,663	to	$ 4,709
Residual Risk Management	$ 442	to	$ 536	$ 211	to	$ 232
Total Costs	$ 24,965	to	$ 30,839	$ 6,882	to	$ 9,446

7.5.5 Residual Risk Management

Even with the realization of major physical improvements to the flood management system, the risk of flooding can never be completely eliminated. Unanticipated facility failures or extreme flood events may cause flooding. This remaining flood threat is called “residual risk.”

DWR manages residual risk through programs governed by DWR’s existing organization for FloodSAFE implementation. These programs are responsible for specialized work in the following areas:

- Flood emergency response
- Flood O&M
- Floodplain risk management

Areas protected by levees that undergo major improvements will generally require lower levels of residual risk management compared with levees that are not improved.

In addition to the major physical elements shown above, each approach would require different levels of ongoing annual management of residual risk. Emergency response, flood system O&M, and floodplain risk management depend on the configuration and reliability of the physical features included in the system. Table 7-16 shows residual risk management for the three preliminary approaches. The columns on the right show the residual risk management actions included for each preliminary approach. In some cases, the actions would be implemented with a small, medium, or large level of effort. Additional discussion of residual risk is included in Section 8.11.

7.6 Evaluation and Comparison of Accomplishments

To illustrate the potential trade-offs among benefits, costs, and other factors relevant to formulation of the SSIA, the three preliminary approaches were compared according to their effectiveness in contributing to the 2012 CVFPP goals and other performance measures.

Table 7-16. Residual Risk Management

Flood Management Element	Project Location or Required Components	Achieve SPFC Design Flow Capacity	Protect High Risk Communities	Enhance Flood System Capacity
Enhanced Flood Emergency Response	All-Weather Roads on Levee Crowns	(included in rural levee repairs)	(No rural levee repairs)	(included in rural levee repairs)
	Flood Information Collection and Sharing	YES (small)	YES (large)	YES (small)
	Local Flood Emergency Response Planning	YES	YES	YES
	Forecasting and Notification		YES	
	Rural Post-Flood Recovery Assistance Program		YES (large)	
Enhanced Operations and Maintenance	Identify and Repair After Event Erosion	YES (small)	YES (large)	YES (small)
	Develop and Implement Enhanced O&M Programs and Regional O&M Organizations	YES	YES	YES
	Sacramento Channel and Levee Management, and Bank Protection	YES	YES	YES
Floodplain Management	Raising and Waterproofing Structures and Building Berms	YES*	YES*	YES*
	Purchasing and Relocating Homes in Floodplains	YES*	YES*	YES*
	Land-Use and Floodplain Management	YES	YES	YES

* Ongoing FEMA programs, implementation based on available funding and conformance with federal criteria

Key:
O&M = operations and maintenance
SPFC = State Plan of Flood Control

7.6.1 System Performance Indicators

Several system performance indicators can demonstrate how well each of the approaches meets the primary goal of the 2012 CVFPP, improving flood risk management. These system performance indicators include the following:

- **Life Risk** – Life risk is described as the long-term annual number of lives potentially lost in an identified area, considering a given climate and land-use condition, with a specified plan of flood protection in place.

- Expected Annual Damages –The key output of HEC-FDA is the EAD, which is defined as the average or mean of all possible values of damages determined by Monte Carlo sampling.

- **Level of** Protection – LOP is defined as the amount of flood protection able to withstand flooding for AEP.

- **Changes in Peak Flow** – The effectiveness of the flood management system can be measured by how much the peak flood flow is reduced.

Other system performance indicators measure how each of the approaches meet the supporting goals of the CVFPP. These secondary performance indicators include the following:

- **Changes in** O&M – Improvements in O&M can be measured by the cost or frequency to complete routine O&M.

- Ecosystem Function – Promotion of ecosystem functions can be measured by the restoration of key physical processes, restoration of habitats, and number of native species.

- Institutional Support – Improvement of institutional support can be measured by the amount of funding available for flood management projects or the number of projects that are completed.

- Multi-Benefit Projects – Promotion of multi-benefit projects can also be measured by the amount of funding available or the number of projects completed.

7.6.2 Primary Goal Indicators

This section summarizes the results for each of the primary goal indicators.

Life Risk

The consequence of flood inundation may be measured in terms of direct and/or indirect economic costs, loss of life, environmental impacts, or other specified measure of flood effects. In the analysis described herein, the consequence of flood risk is represented in terms of potential loss of life. Life risk, as described in the 2012 CVFPP, is the long-term average annual number of lives potentially lost in an identified area, considering a given climate and land-use condition, with a specified plan of flood protection in place.

A life risk calculation, as an indicator or representation of flood risk, was developed based on the following:

- Population exposed to inundation before a warning is given

- Types and efficiencies of warning systems

- Exposed population after a warning is given
- Potential loss of life due to inundation

Table 7-17 summarizes the estimated life risk values for the Sacramento and San Joaquin river basins, for No Project and the three 2012 CVFPP preliminary approaches. These values are the expected annual statistics computed by HEC-FDA. Details on how life risk values were calculated can be found in Attachment 8G: Life Risk Analysis.

Table 7-17. Percent Reduction in Life Risk Values: Sacramento and San Joaquin River Basins

Study Approaches	Sacramento River Basin (Percent Reduction)	San Joaquin River Basin (Percent Reduction)	Stockton Area (Percent Reduction)	Total (Percent Reduction)
No Project	58.6	4.1	1.4	64.1
Achieve SPFC Design Flow Capacity	56.0	4.0	0.2	60.2
Protect High Risk Communities	31.6	3.9	0.2	35.6
Enhance Flood System Capacity	23.2	2.0	0.2	25.4

Key: SPFC = State Plan of Flood Control

The general trend shows that all three approaches would reduce potential lives lost relative to No Project, with the highest potential reduction realized through the Enhance Flood System Capacity Approach.

Economic Damages

Economic damages from a flood event indicate the performance of the flood management system. Figures 7-32 and 7-33 present the annual structure, crop and business losses for the Sacramento and San Joaquin river basins for No Project and each of the three preliminary approaches. Economic damages are shown in millions of dollars per year.

In the Sacramento River Basin, the general trend shows that all three approaches reduce annual damages and business losses relative to No Project, with the highest potential economic benefits realized through the Enhance Flood System Capacity Approach (Figure 7-32).

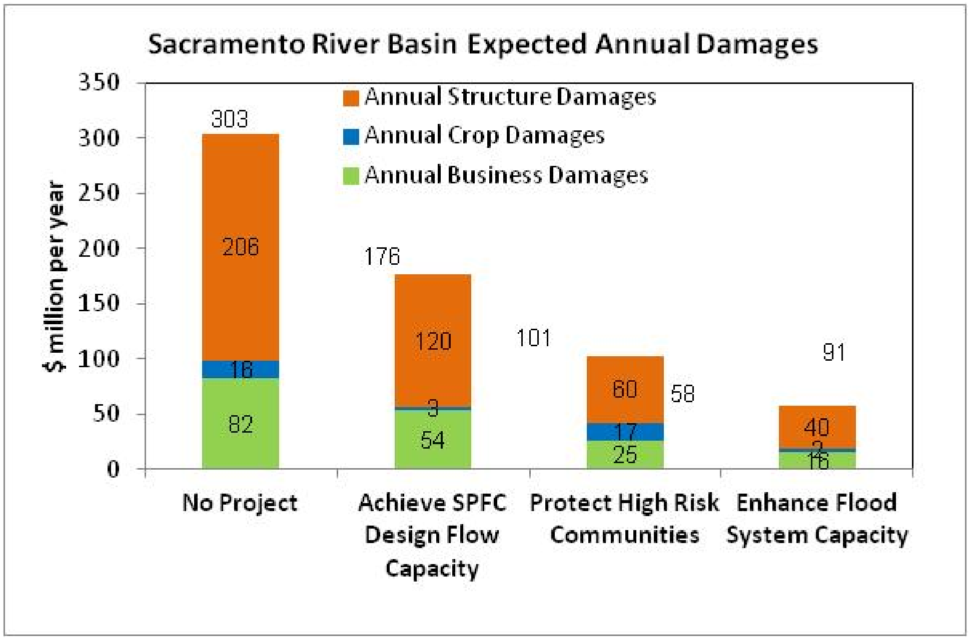


Figure 7-32. Summary of Potential Annual Direct Impacts of Flooding in the Sacramento River Basin

In the San Joaquin River Basin, the general trend shows that all three approaches reduce annual structure damages relative to No Project (Figure 7-33). Annual business losses remain unchanged from No Project by any of the preliminary approaches. Annual crop damages are reduced by the Achieve SPFC Design Flow capacity and the Enhance Flood System Capacity approaches; however, the Protect High Risk Communities Approach does not show a reduction in annual crop damages. This is because although cities and towns are protected under this approach, agricultural lands do not receive an increased LOP.

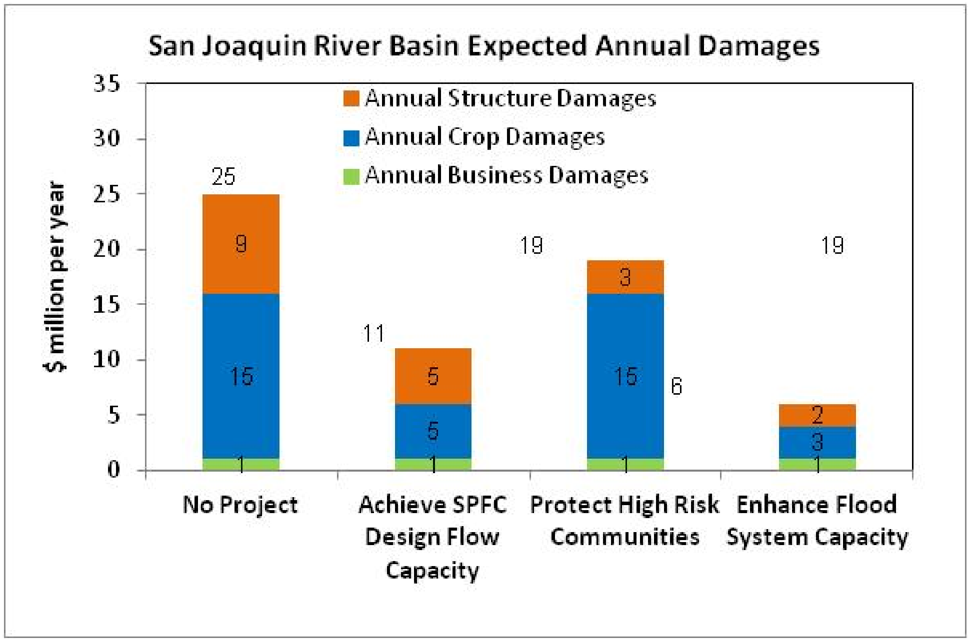


Figure 7-33. Summary of Potential Annual Direct Impacts of Flooding in the San Joaquin River Basin

Level of Protection

The 2012 CVFPP has a goal for urban areas to achieve an LOP against a 0.5 percent AEP flood event (200-year LOP). The goal for rural areas is to achieve an LOP against a 1 percent AEP flood event (100-year LOP). Figures 7-34 and 7-35 show the populations in the Sacramento and San Joaquin river basins and the LOP afforded to them under each approach. All of the preliminary approaches showed an increase in the percentage of populations that are protected from the 0.5 or 1 percent AEP flood versus No Project with the greatest LOP for the greatest population occurring under the Protect High Risk Communities Approach.

Change in Peak Flow

The three preliminary approaches result in different peak flows and stages. Hydrologic and hydraulic modeling for the three preliminary approaches provided estimates of peak flow and stage compared to No Project at key SPFC locations[1]. Figure 7-36 shows peak 100-year floodflows at several of these locations within the Sacramento River Basin for No Project and the three preliminary approaches. The figure also shows the corresponding peak stage change for each preliminary approach compared to current conditions.

[1] A separate hydraulic analysis would be required to assess hydraulic impacts.

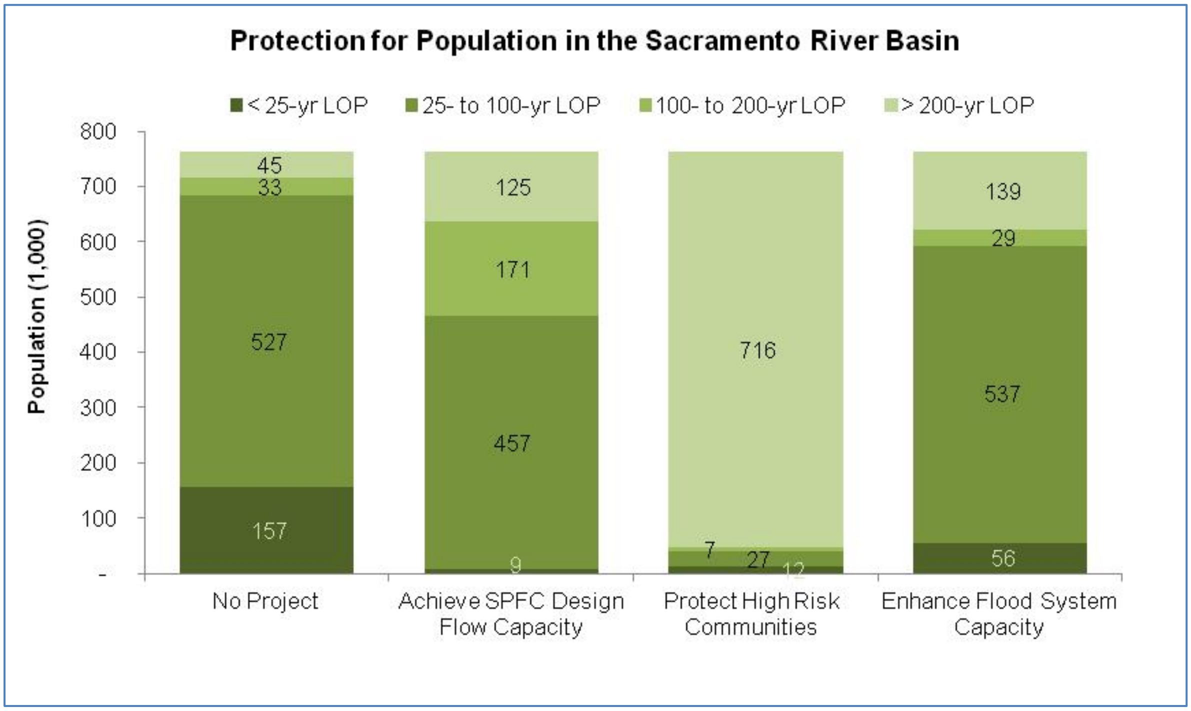


Figure 7-34. Protection for Population in Sacramento River Basin

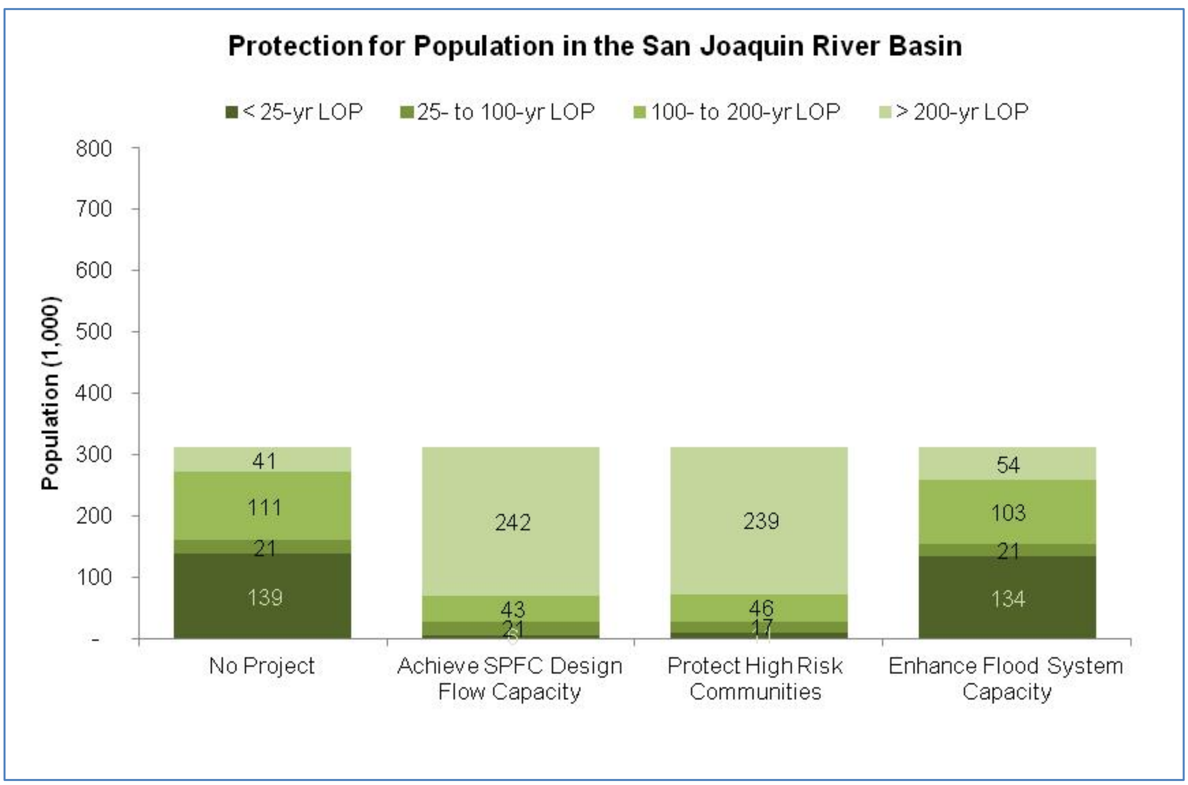


Figure 7-35. Protection for Population in San Joaquin River Basin

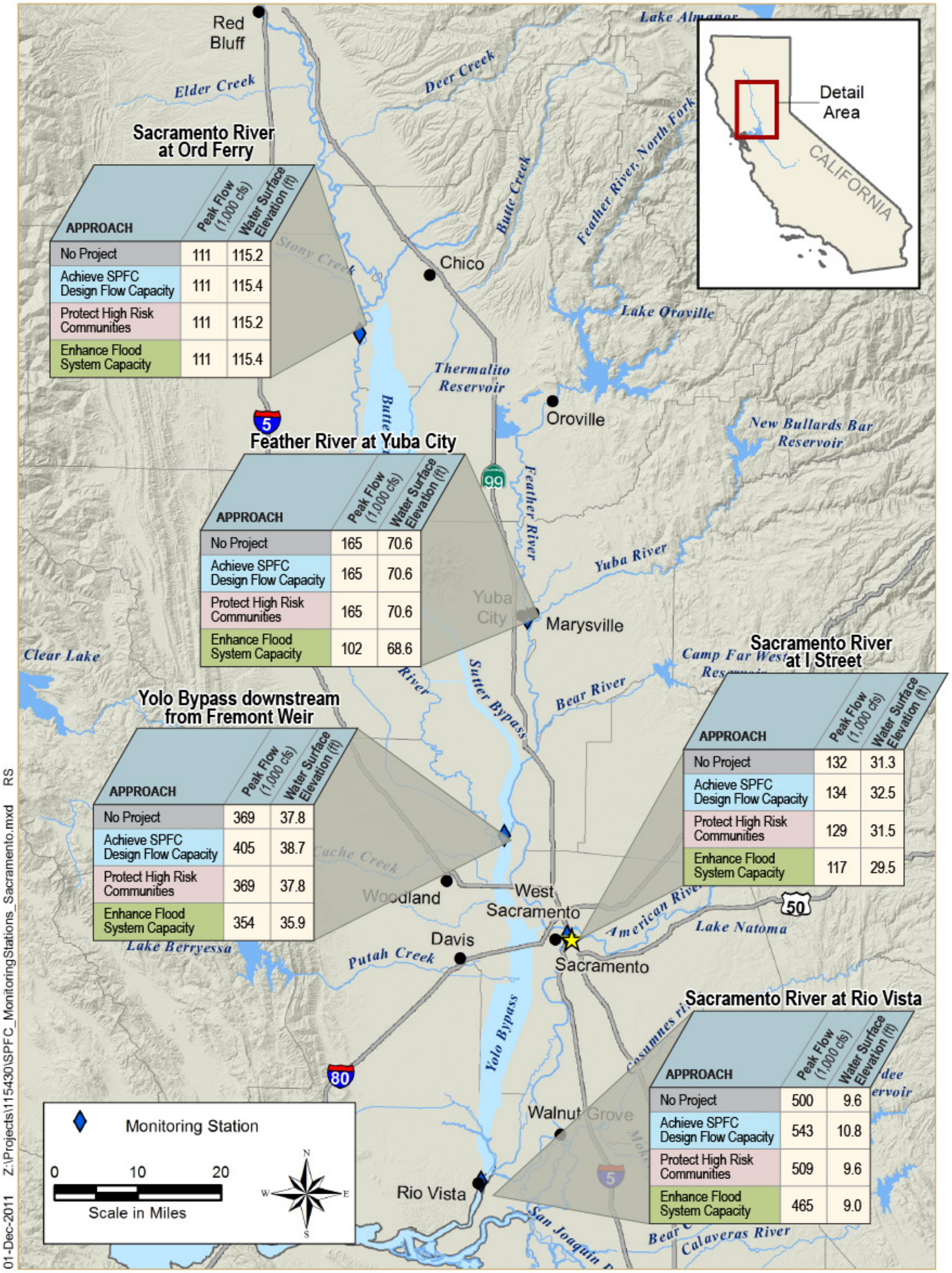
Figure 7-37 shows peak 100-year floodflows at several of these locations within the San Joaquin River Basin for current conditions and the three preliminary approaches. The figure also shows the corresponding peak stage for each preliminary approach compared to current conditions.

In general, the Achieve SPFC Design Flow Capacity Approach would result in higher river stages than for No Project because levee rehabilitation would result in more water being passed. The Protect High Risk Communities Approach would result in relatively little stage change compared with existing conditions because levee improvements would be focused in small areas and much of the levee system would remain in its current condition. The Enhance Flood System Capacity Approach generally would provide for lower flood stages, except in the upper San Joaquin River Basin bypass, since flood peaks would be lowered by storage, and bypasses would provide wider flow areas that reduce stages.

7.6.3 Supporting Goal Indicators

As stated above, four other system performance indicators were used to measure how each of the approaches would meet the secondary goals of the 2012 CVFPP. These secondary goal indicators include improvements in O&M, promotion of ecosystem functions, improvement of institutional support, and promotion of multi-benefit projects. Improvements in O&M can be measured by the cost to complete or frequency of completing routine O&M. In addition to routine O&M, the need and cost to complete nonroutine O&M can be an indicator of how well the flood management system is performing. Promotion of ecosystem functions can be measured by the restoration of key physical processes, restoration of habitats, and number of native species. The number of fish passage opportunities can also be an indicator of ecosystem functions in the flood management system. Improvement of institutional support can be measured by the amount of funding available for flood management projects or the number of projects that are completed. Promotion of multi-benefit projects can also be measured by the amount of funding available or the number of projects completed. To complete multi-benefit projects, a qualitative assessment of opportunities to integrate water quality, groundwater recharge, recreation, power, and other benefits should be completed for flood management planning projects.

> ***Multi-Benefit Projects***
>
> To complete multi-benefit projects, a qualitative assessment of opportunities to integrate water quality, groundwater recharge, recreation, power, and other benefits should be completed for flood management planning projects.



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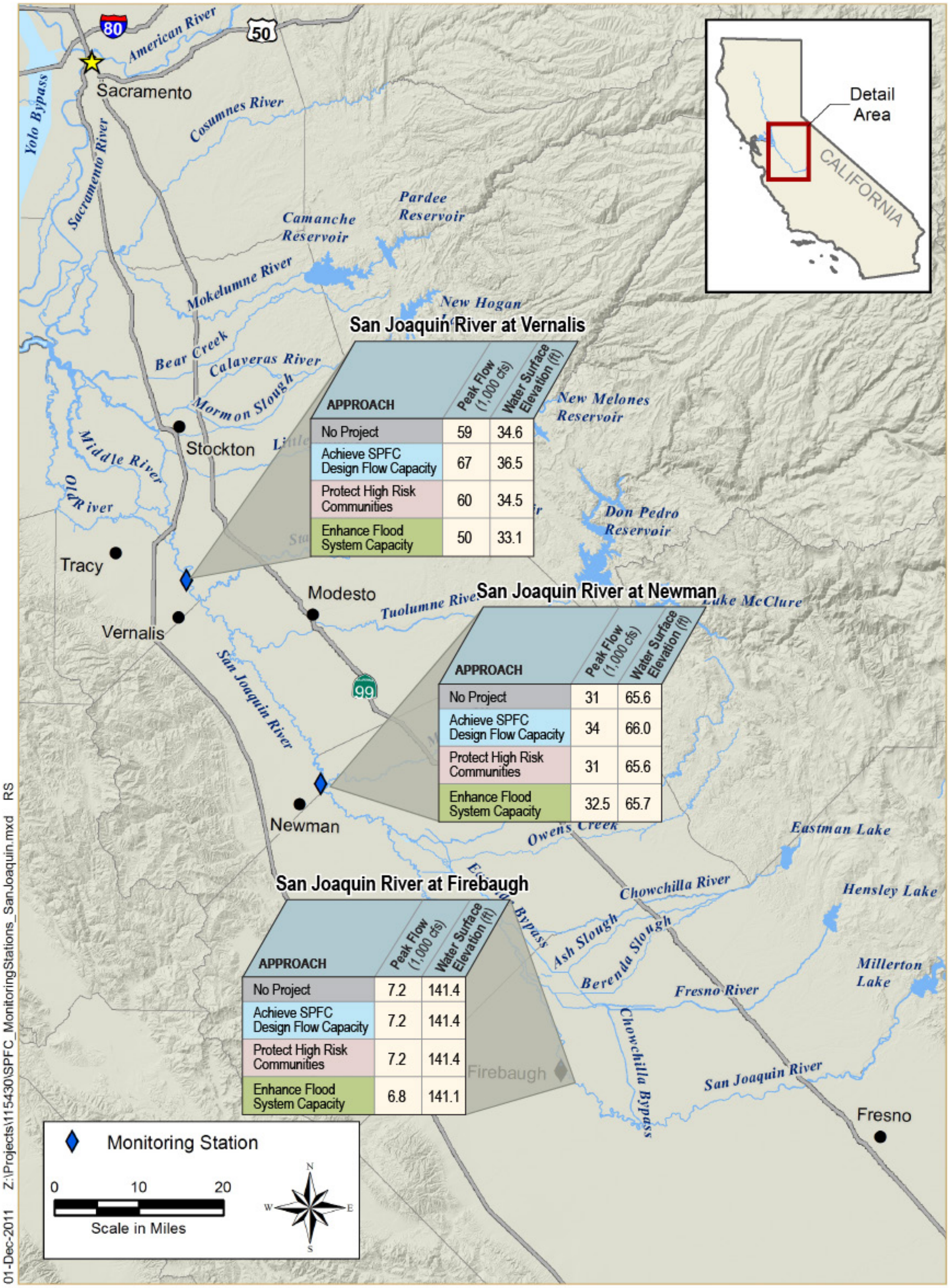
Location of Peak Flow and Water Surface Elevation Estimates for 100-Year Storm Event at selected monitoring locations in the Sacramento River Basin.
Key: cfs = cubic feet per second ft = feet SPFC = State Plan of Flood Control

Figure 7-36. Simulated Peak Flow and Stage Changes for Sacramento River Basin for 100-Year Storm Events



San Joaquin River at Vernalis

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	59	34.6
Achieve SPFC Design Flow Capacity	67	36.5
Protect High Risk Communities	60	34.5
Enhance Flood System Capacity	50	33.1

San Joaquin River at Newman

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	31	65.6
Achieve SPFC Design Flow Capacity	34	66.0
Protect High Risk Communities	31	65.6
Enhance Flood System Capacity	32.5	65.7

San Joaquin River at Firebaugh

APPROACH	Peak Flow (1,000 cfs)	Water Surface Elevation (ft)
No Project	7.2	141.4
Achieve SPFC Design Flow Capacity	7.2	141.4
Protect High Risk Communities	7.2	141.4
Enhance Flood System Capacity	6.8	141.1

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Location of Peak Flow and Water Surface Elevation Estimates for 100-Year Storm Event at selected monitoring locations in the San Joaquin River Basin.
Key: cfs = cubic feet per second ft = feet SPFC = State Plan of Flood Control

Figure 7-37. Simulated Peak Flow and Stage Changes for San Joaquin River Basin for 100-Year Storm Events

7.6.4 Other Indicators

Other considerations for the different approaches include downstream effects. Improvements to the flood management system would cause fewer system failures, which could increase downstream Delta inflows.

The flood management system in the Delta manages flows from the Sacramento and San Joaquin watersheds, tributaries, and tides from the San Francisco and San Pablo bays. Water management facilities in the Delta include levees around the developed islands, pumping plants, control gates, port facilities, gages used in flood and water quality forecasting, and diversion and inlet structures. Summary findings for the Delta Model results for No Project are as described in Section 3 of Attachment 8D: Estuary Channel Evaluations. Results are shown in two formats:

1. Stage-frequency curves for 15 locations in the Delta to show the peak water stage of each of six storm events.

2. Peak volume of water inside inundated Delta islands.

Comparing these No Project results to results for each of the three preliminary approaches can be used to compare the downstream effects for each approach. Flows to the Delta can affect levee stress and levee failures.

7.6.5 Contributions to the 2012 CVFPP Goals

Table 7-18 compares the relative contributions of the preliminary approaches to the 2012 CVFPP primary goal of improving flood risk management. Contributions to the primary goal are described in terms of level of flood protection, public safety, and economic damages.

Table 7-19 compares the relative contributions of the preliminary approaches to the 2012 CVFPP supporting goals of Improve Operations and Maintenance, Promote Ecosystem Functions, and Promote Multi-Benefit Projects. Table 7-19 also assesses the relative completeness of the preliminary approaches described as the ability to meet the various objectives described in the authorizing legislation.

Sustainability

Table 7-20 compares the sustainability aspects of the three preliminary approaches. Sustainability relates to the overall financial, environmental, social, and climate change adaptability aspects of the flood management system under a given approach.

Table 7-18. Relative Comparison of Preliminary Approach Contributions to Central Valley Flood Protection Plan Primary Goal

Metric	Existing System (No Project)	Preliminary Approaches		
		Achieve SPFC Design Flow Capacity	Protect High Risk Communities	Enhance Flood System Capacity
Contributions to Primary Goal – Improve Flood Risk Management				
Level of Flood Protection	**Varies throughout system** • Most urban areas do not have urban level of flood protection • Protection to rural-agricultural areas and small communities varies widely	**Varies throughout system** • Substantial improvement in rural-agricultural areas and partial improvement in urban areas • SPFC facilities reliably pass design flow capacities • Levels of flood protection associated with SPFC design flow capacities vary throughout the system	**High in urban areas and small communities, varies elsewhere** • Urban areas achieve 200-year flood protection • Small communities achieve 100-year flood protection	**Overall higher protection, but varies throughout system** • Urban areas achieve 200-year flood protection • Small communities achieve 100-year flood protection • Overall increased levels of flood protection throughout system
Public Safety (focused on population at risk)	**Varies throughout system** • Public safety threat is high for many communities, particularly those in deep floodplains • **79% of population with less than 100-year protection**	**Some improvement** • Improvement in urban areas • Improvement in some small communities protected by SPFC facilities • **46% of population with less than 100-year protection**	**Highest improvement** • Substantial improvement in urban areas • Improvement in small communities • **6% of population with less than 100-year protection**	**Improvement varies** • Improvement in urban areas • Improvement in small communities and rural-agricultural areas • **5% of population with less than 100-year protection**
Economic Damages[1]	**Very high potential for damages** • Economic damages, particularly in urban areas, are very high • $329 million /year in EAD	**Reduction in rural-agricultural area damages** • Substantial reduction throughout rural areas; some reduction in urban areas • 47% reduction in total EAD	**Reduction in urban and small community damages** • Substantial reduction due to focus on protecting urban areas and small communities • 63% reduction in total EAD	**Reduction in urban and rural-agricultural area damages** • Substantial reduction due to increased storage and conveyance • 66% reduction in total EAD

Note:

[1] Structure and content values used parcel data from the 2010 June ParcelQuest with an October 2010 price index. Parcel data were updated based on information (including depreciation, construction quality, construction class, occupancy type) in reconnaissance-level field surveys collected from summer 2010 to summer 2011.

Crop data acreages were from the May 2010 DWR GIS land-use datasheet. Crop damage unit costs were originated from the USACE Comprehensive Study (2002) and were adjusted to an October 2010 price index. EAD include, structure and content, crop, and business income loss.

Key:
CVFPP = Central Valley Flood Protection Plan
DWR = California Department of Water Resources
EAD = expected annual damages
GIS = Geographic Information System
SPFC = State Plan of Flood Control

Table 7-19. Comparison of Preliminary Approach Contributions to Central Valley Flood Protection Plan Supporting Goals and Completeness

Goal/Metric	Existing System (No Project)	Preliminary Approaches		
		Achieve SPFC Design Flow Capacity	Protect High Risk Communities	Enhance Flood System Capacity
Contributions to Supporting Goals				
Improve Operations and Maintenance	**Ongoing and long-term O&M requirements remain very high**	**Initial decrease in O&M costs, but remain high long term** • SPFC reconstruction will initially decrease O&M requirements • Long-term O&M costs would remain high because of potential conflicts with natural geomorphic process	**Increase in long-term O&M requirements** • Potential cost increase due to the construction of approximately 120 miles of new levees to protect small communities	**Decrease in long-term O&M requirements** • Decrease in long-term costs due to modifications that make the system more compatible with natural geomorphic processes and facilitate vegetation management and removal of facilities
Promote Ecosystem Functions and Environmental Restoration	**Limited opportunities for ecosystem restoration** • Native habitat may be integrated into SPFC facility repair projects, primarily through mitigation	**Limited opportunities for ecosystem restoration** • Limited opportunities to integrate ecosystem restoration into in-place repairs to SPFC facilities	**Limited opportunities for ecosystem restoration** • Limited opportunities to integrate restoration into in-place repairs in urban areas, and new facilities protecting small communities	**Substantial opportunities for ecosystem restoration** • Floodplain expansion improves ecosystem functions, fish passage, and the quantity, quality, and diversity of habitats
Promote Multi-Benefit Projects	**Limited opportunities for multi-benefit project** • Limited opportunities to integrate other benefits into repairs to SPFC facilities	**Limited opportunities for multi-benefit project** • Limited opportunities to integrate other benefits into repairs to SPFC facilities	**Limited opportunities for multi-benefit project** • Limited opportunities to integrate other benefits into repairs, improvements, and new levees	**Enhanced opportunities for multi-benefit project** • Increased opportunities to integrate water quality, groundwater recharge, recreation, power, and other benefits
Completeness (ability to meet legislative objectives)				
Ability to Meet Objectives in Flood Legislation	**Do not meet** • Varied level of protection throughout the system and high potential for public safety and economic damages	**Partially meets** • Limited contributions to environmental and water supply objectives; does not achieve high level of urban flood protection	**Partially meets** • Limited contributions to environmental and water supply objectives	**Mostly meets** • Contributes to all objectives, but at highest cost and with substantial impacts to existing land uses (potentially low acceptability)

Key:
CVFPP = Central Valley Flood Protection Plan
O&M = operations and maintenance
SPFC = State Plan of Flood Control

Table 7-20. Relative Comparison of Preliminary Approach Sustainability

Metric	Existing System (No Project)	Preliminary Approaches		
		Achieve SPFC Design Flow Capacity	**Protect High Risk Communities**	**Enhance Flood System Capacity**
Sustainability (financial, environmental, and social)				
Social	• Significant risk to public safety and economic consequences of flooding	• Chance for redirected growth outside floodplain from where currently planned due to extensive levee improvements in non-urban areas • Some land-use impacts due to acquisition/easements to accommodate SPFC reconstruction	• Some potential to encourage new development in floodplains within and adjacent to urban and small community improvements	• Considerable impacts to existing land uses due to floodway expansion • Some potential to encourage new development in floodplains due to improved level of flood protection
Climate Change Adaptability	• Low system resiliency (i.e., ability to adapt to climate change)	• Does not improve flood system resiliency	• Does not improve flood system resiliency	• Improves flood system resiliency by enhancing storage and conveyance

Key:
SPFC = State Plan of Flood Control

7.6.6 Costs and Time to Implement

The estimated costs and time to implement the three preliminary approaches are shown in Table 7-21.

Table 7-21. Estimated Cost of Approaches

Preliminary Approach	Low Cost ($ billion)		High Cost ($ billion)	Implementation (Years)
Achieve SPFC Design Flow Capacity	19	to	23	30 – 35
Protect High Risk Communities	9	to	11	15 – 20
Enhance Flood System Capacity	32	to	41	35 – 40

Key:
SPFC = State Plan of Flood Control

Cost estimates in the table are for initial costs to implement physical on-the-ground improvements over 25 years to manage the residual risk for each approach. These estimates are based on 2011 dollars and will differ in the future. Since the approaches are not complete alternatives, the cost estimates are likely low, but suitable for comparison of the approaches. In addition, actual implementation costs would likely be higher than the estimates because of inflation and the length of time needed to implement the work. The cost estimates allow for planning studies, design, permitting, and project mitigation. The estimates also include costs for ecosystem mitigation for the first two preliminary approaches. For the Enhance Flood System Capacity Approach, the goal is for ecosystem restoration and enhancements to provide for overall habitat improvement, thereby eliminating the need to mitigate for most ecosystem impacts. However, depending on the timing of improvements and implementation, some ecosystem mitigation may be required.

The estimates of time to implement are based on experience with past flood projects, but with assumptions of more efficient execution of planning and design, engaged federal and local partners, streamlined permitting, and timely funding. In the past, many flood protection projects have remained in the feasibility study phase for a decade or more. Large complicated projects have often taken several decades to progress from initial concept to completion. Maintaining focus to complete projects in a timely manner is often difficult, especially given changing commitments from State, federal, and local partners over long periods of time.

7.6.7 Preliminary Approach Performance

Considering evaluation information available for the preliminary approaches, including information shown in this section, DWR prepared a qualitative comparison to show the broad differences in potential performance of the approaches. Figure 7-38 shows estimated relative performance for each preliminary approach. For example, an open circle indicates the lowest performance and a full circle indicates the highest performance.

PERFORMANCE CATEGORY	ACHIEVE SPFC DESIGN FLOW CAPACITY	PROTECT HIGH RISK COMMUNITIES	ENHANCE FLOOD SYSTEM CAPACITY
Flood Risk Reduction Benefit	Moderate	Moderate-High	High
Level of Flood Protection	Low-Moderate	Moderate	High
Life Safety	Low-Moderate	Moderate-High	Moderate-High
Economic Damages	Moderate	Moderate-High	Moderate-High
Regional Economics	Moderate	Moderate-High	High
Cost	Moderate-High	Moderate	Moderate-High
Capital Costs	Moderate-High	Low-Moderate	High
Operations & Maintenance	Moderate	High	Low-Moderate
Integration & Sustainability	Low	Low-Moderate	High
Promote Ecosystem Functions	Low	Low	High
Promote Multi-Benefit Projects	Low	Low-Moderate	High
Sustainable Land Uses	Low	Low-Moderate	High

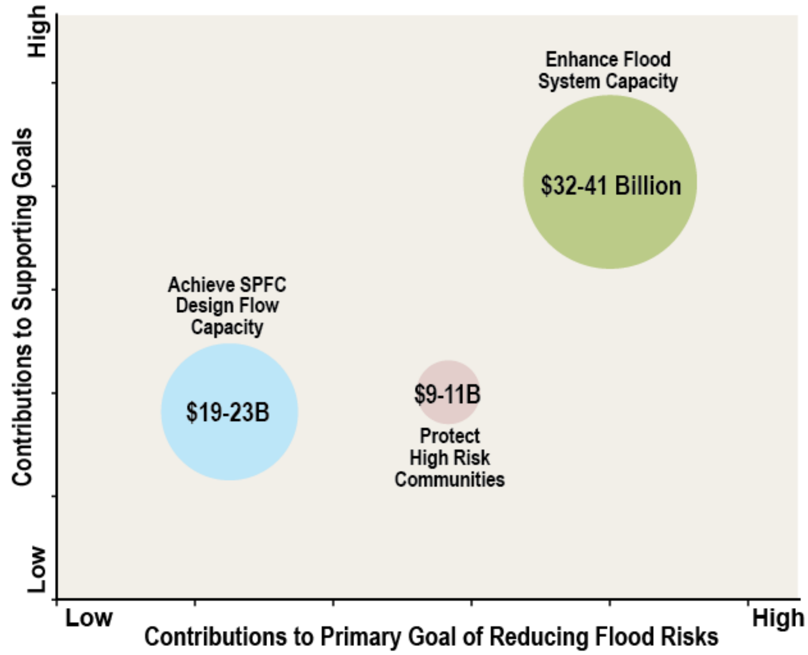
KEY
- Low
- Low-Moderate
- Moderate
- Moderate-High
- High

Key: SPFC = State Plan of Flood Control

Figure 7-38. Performance Comparison for Preliminary Approaches

Another view of the relative performance of the three preliminary approaches is shown in Figure 7-39. The figure shows estimated performance in terms of secondary benefits against performance for the primary goal of improving flood risk management. For example, the Achieve SPFC Design Flow Capacity Approach and the Protect High Risk Communities Approach perform similarly for secondary benefits, but the

Protect High Risk Communities Approach performs better for improving flood risk management. The figure also plots the size of the approaches (circles) relative to their estimated costs.



Key: B = billion SPFC = State Plan of Flood Control

Figure 7-39. Relative Cost and Performance of Three Preliminary Approaches

7.7 Summary of Findings

Based on relative comparisons of the three preliminary approaches, no single approach contributes substantially to the five 2012 CVFPP goals. However, each approach highlights opportunities to achieve the goals in different ways and to different degrees. The Enhance Flood System Capacity Approach meets most of the legislative objectives and scores highest on sustainability; however, it has a substantially higher capital cost, compared to the other approaches. The Protect High Risk Communities Approach is the least costly approach, and would result in substantial reduction in flood risks to urban areas and small communities.

Examining the performance of preliminary approaches highlights the need to develop a State flood management strategy that combines the strengths of each of the three preliminary approaches into a single approach – the SSIA. The three preliminary approaches presented above contributed to 2012 CVFPP goals to differing degrees. For example, the Achieve SPFC Design Flow Approach would provide protection for rural-agricultural areas, with less emphasis on an urban level of flood protection and ecosystem benefits. The Protect High Risk Communities Approach would achieve 200-year urban protection and associated life safety benefits, but does not contribute to improving rural-agricultural flood risk management. The Enhance Flood System Capacity Approach would provide multiple benefits, but at a high cost. Various elements from each of the three approaches have been chosen and combined to formulate the SSIA.

Following are additional observations on performance of the preliminary approaches that contributed to formulation of the SSIA.

Achieve SPFC Design Flow Capacity – Improving the existing flood management system to meet current engineering criteria within its existing footprint:

- Is very expensive considering that it primarily addresses the Improve Flood Risk Management goal and does little for supporting goals, especially for promoting multi-benefit projects
- Level of flood protection is significantly improved throughout the system, but is spatially highly variable
- Would increase the population receiving at least a 100-year (1% annual chance) level of flood protection from about 21 percent to about 54 percent compared with existing conditions
- May initially improve operations and maintenance conditions, but long-term benefits are questionable
- Does little to improve ecosystem functions
- May increase flood risks (residential development) in rural-agricultural areas
- Would create significant increases in downstream flood stages over existing conditions by reducing the chance of levee failures upstream
- Would reduce potential flood damages by about 47 percent compared to existing conditions
- Need for residual risk management would be reduced from existing conditions

Protect High Risk Communities – Improving levees in urban areas and small communities:

- Protects, with the least investment, the majority of the population
- Does little to address supporting goals of improving operations and maintenance and promoting ecosystem functions
- Would do little to contribute to adaptive flood management
- Urban areas would achieve 200-year (0.5% annual chance) level of flood protection
- Small communities within the area protected by facilities of the SPFC would achieve 100-year (1% annual chance) of flood protection
- Would increase the population receiving at least a 100-year (1% annual chance) level of flood protection from about 21 percent to about 94 percent compared with existing conditions
- Level of flood protection for rural-agricultural areas would remain unchanged
- Relatively few increases in downstream flood stages from upstream improvements
- Would reduce potential flood damages by about 63 percent compared to existing conditions
- Would increase the population receiving at least a 100-year (1% annual chance) level of flood protection from about 25 percent to over 90 percent compared with existing conditions
- Need for residual risk management would be the highest among the preliminary approaches

Enhance Flood System Capacity – Improving urban, small communities, and rural-agricultural levees along with expanded flow capacity:

- Is by far the most expensive approach
- Significantly meets all CVFPP Goals
- Urban areas would likely exceed 200-year (0.5% annual chance) level of flood protection

- Many small communities would likely exceed 100-year (1% annual chance) level of flood protection
- Most areas, including rural-agricultural areas, would benefit from lower flood stages, improved levee conditions, and improved levees constructed for bypass expansion
- Would reduce potential flood damages by about 80 percent compared to existing conditions
- Would increase the population receiving at least a 100-year (1% annual chance) level of flood protection from about 21 percent to about 95 percent compared with existing conditions
- Need for residual risk management would be the lowest among the preliminary approaches
- Includes significant ecosystem features and multipurpose projects