CHAPTER 5.0

FLOOD CONTROL ALTERNATIVES

This chapter describes the plan components, real estate requirements, operation, and accomplishments and residual risk of the eight flood control alternatives. A breakdown of the estimated costs and benefits associated with each alternative also is provided. A description of the five ecosystem restoration alternatives is provided in Chapter 6.0, "Ecosystem Restoration for Flood Plain Restoration and Fisheries Resources."

5.1 Alternative 1: No Action

5.1.1 Description

The No-Action Alternative is the same as the without-project condition and serves as the baseline against which the costs, benefits, and effects of the action plans are evaluated. Under this alternative, the Federal government would take no action to implement a specific plan to increase flood protection along the American River beyond what is already authorized. Already authorized flood control projects on the American River include the Common Features Project, Folsom Dam Modification Project, Folsom Dam Reoperation, and Folsom Dam Flood Management Plan update. Additional information on these projects as well as the No-Action Alternative is contained in Chapter 2.0, "Affected Environment."

With outlet modifications and surcharge storage in place, Folsom Dam would be able to pass only about 70 percent of the PMF. Folsom dam safety would continue to be a problem for the near term. Because Folsom is a major dam upstream of a heavily-populated area, dam safety is unacceptable for the long term. Even if there were no additional flood control modification done to Folsom Dam, the Bureau would develop, fund, and implement dam safety improvements for Folsom Dam. There is currently no dam safety plan and no funding; therefore, work to correct Folsom Dam's PMF deficiency is part of the without-project condition but is unscheduled.

5.1.2 Operation

Under the existing operating criteria, 400,000 acre-feet of the total storage capacity of 975,000 acre-feet are allocated to flood control. However, the Bureau and the SAFCA have an interim reoperation agreement that allows for operation of the dam to include a variable storage space ranging from 400,000 to 670,000 acre-feet.

Under no action, the variable flood control space reoperation would continue. After Folsom Dam outlet modifications are completed, the variable space would be revised from 400,000–670,000 acre-feet to 400,000–600,000 acre-feet.

The Folsom Dam Flood Management Plan mandates that the rate at which discharges from Folsom Dam are increased during flood operations be raised from 15,000 cfs in a 2-hour period to 15,000 cfs in a 1-hour period. The mandated change in discharge guidelines will be implemented as part of the no action alternative. In order to facilitate this change, the plan also

includes installation of upstream reporting gages, modifications to improve gate operations and development of a downstream warning system. However, the Corps and the Bureau have not formally adopted this change. The risk and uncertainty analysis for the current study was performed using a rate of 15,000 cfs per 2 hours for both the with- and without-project conditions. Sensitivity analysis has shown that use of this slower rate of change has not measurably affected the risk or on the economic calculations presented in this study.

The No-Action Alternative also assumes that the flood management plan for Folsom Dam will be updated to include guidelines for an advance release operation aimed at gaining additional flood space at little or no cost and no significant environmental effect. The advance release operation has not been fully developed. The Folsom Modification Project must be completed, and the advance release plan needs to be formulated and reviewed. As described in Chapter 2.0, the long-term study developed three alternative advance release scenarios:

- No advance release
- Moderate advance release:

  Lower bound: 0 acre-feet
  Most likely: 100,000 acre-feet
  Upper limit: 190,000 acre-feet

- Upper bound advance release:

  Lower bound: 100,000 acre-feet
  Most likely: 140,000 acre-feet
  Upper limit: 250,000 acre-feet

For alternative analysis purposes, this study has adopted the moderate advance release scenario. This is currently the greatest advance release that appears implementable without additional cost or environmental effect. The upper limit advance release appears to be not implementable, and is displayed as a check for economic feasibility in the event that existing flood constraints are overcome.

Potential economic damage related to flooding would increase as development occurs in the flood plain. Most of this development would be in Natomas and South Sacramento.

5.1.3 Accomplishments and Residual Risk

With all of the physical and operational improvements anticipated under the No-Action Alternative in place, the risk of flooding in Sacramento would be reduced to 1-in-164 (0.0061) in any year (Table 5-1). Exceedance of this risk would result in catastrophic flooding due to levee failure. The flood plain area subject to inundation in the event of a levee failure covers 86 square miles and includes 111,000 damageable structures. The conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 47.8 percent.

TABLE 5-1. Accomplishments and Residual Risk of Alternative 1

Without-Project Advance Release Scenarios	Expected Annual Probability of Alternative 1 Being Exceeded (1-in-X Chance per Year)		Existing Average Annual Economic Damages with Advance Release ($ millions)	Future Average Annual Economic Damages with Advance Release ($ millions)
	Before Advance Release	After Advance Release		
No advance release	0.0071 (140)	0.0071 (140)	81.4	86.0
Moderate advance release (0-100,000-190,000 acre-feet)	0.0071 (140)	0.0061 (164)	68.8	72.8
Upper bound advance release (100,000-140,000-250,000 acre-feet)	0.0071 (140)	0.0056 (179)	63.0	66.6

5.2 Alternative 2: 3.5-Foot Dam Raise/478-Foot Flood Pool Elevation

5.2.1 Description

Implementation of Alternative 2 would increase the flood control capacity of Folsom Dam by raising the height of the dam and enlarging the flood space available in the reservoir. The physical height of the dam would be increased from 480.5 feet to 484 feet. The maximum design flood pool elevation would be increased from 474 feet to 478 feet adding 47,000 acre-feet of flood space under this alternative. The top of the enlarged flood pool would be set high enough to protect the dam from wind and wave runup and to account for some backwater that may occur when the top of flood pool encroaches onto the spillway bridge.

Alternative 2 would also lower the main spillway crest of the dam by 6 feet and enlarge the spillway gates so as to increase the dam's spillway capacity. This increased capacity would help to contain the PMF that would produce a maximum water surface elevation of 479.0 feet. Additional work for dam safety consists of lowering the Folsom Dam auxiliary spillway 6 feet and improving L. L. Anderson Dam (French Meadows Reservoir) so that 100 percent of the PMF would pass safely through the Folsom Dam. This alternative is judged to be the least costly PMF fix. The plan components, real estate requirements, operation, and accomplishments and residual risk associated with Alternative 2 are described below.

5.2.2 Plan Components

Plate 5-1 shows the locations of the major structural modifications. Plate 5-2 shows spillway, gate, and top of dam elevations compare with other alternatives.

Raise Concrete Dam

The concrete portions of Folsom Dam outside of the spillway area would not need to be raised to accommodate the higher flood pool, since the top of the without-project bridge and dam parapet walls are at elevation 484 feet. However, the vertical joints in these existing walls would

be sealed to prevent leakage during extreme floods. The new bridge deck and roadway would remain at the without-project elevation of 480.5 feet. (See Plate 5-2.)

Lower Spillway

Both the main spillway and the auxiliary spillway crest would be lowered 6 feet, from 418 to 412 feet in elevation. The increased spillway capacity would be available for extremely unusual events when additional water must be released to avoid dam overtopping and failing. The spillway lowering would be accomplished by overexcavation of the existing concrete portion of the dam.

Replace Spillway Gates

All eight spillway radial gates would require replacement under this plan. The new gates would be approximately 69 feet high, 19 feet taller than the without-project condition gates. The top-of-gate elevation in the closed position would be 481 feet on a design flood pool elevation of 479 feet.

To accommodate the additional height and loading, the existing spillway piers need to be extended and strengthened. New radial gate trunnions (pivot points) would be located on the top of the new pier extensions. New high-strength, post-tensioned steel tendons would be cored and grouted into the pier/dam section to provide for trunnion anchorage. New hoisting motors and chains and new catwalks also would be required. Plate 5-3 shows a typical section view of the spillway structure.

Modify Spillway Bridge Piers

The spillway bridge piers would require modification under this plan. The piers would be raised and extended on the downstream face of the dam to anchor the new larger radial gates. Installation of post-tensioned tendons to anchor the piers to the mass concrete of the overflow section also would strengthen the piers.

Preliminary engineering analysis has been performed for both the existing and raised conditions of the dam. This analysis concludes that severe concrete cracking and weakening of the reinforcing steel in the concrete section of the dam can be expected during large earthquake ground motions in the cross-canyon direction. However, if the piers are sufficiently constrained by the new spillway bridge superstructure, the cracking would be less severe and the load could be redistributed without weakening the reinforcing steel.

Replace Spillway Bridge

The existing eight-span spillway bridge consists of two riveted steel plate girders with a composite concrete deck, each approximately 34 feet wide by 50 feet long. The existing bridge would require removal and replacement due to the higher flood control pool and spillway gates. The new bridge would be a prestressed concrete multiple box girder bridge of approximately the same dimensions as the existing bridge, with one through traffic lane in each direction.

Extend Stilling Basin

Extension of the spillway stilling basin and side walls approximately 60 feet is required to ensure proper stilling basin function and adequate energy dissipation of the larger flows and higher heads of the new design flood and PMF. This component also would include rock excavation, shaping, and stabilization to improve flow patterns in the vicinity of the stilling basin.

3.5-Foot Concrete Wall

The flood space would be enlarged by the construction of a 3.5-foot-high reinforced concrete crest wall. The wall would be designed to absorb wind and wave runup on the waterside of the wall, protect the dike from erosion, allow for inspection of the wall, and allow space for a 20-foot-wide road across the dikes and 25-foot-wide road across the dam. Asphalt pavement would be placed on the crest of the dam to protect the landside top of the dam. Wind and wave runup may be lessened by placing rock revetment on the waterside of the wall, or by forming the wall in a curved concave shape. Mormon Island Dam and Dikes 5 and 7 have an existing impervious core that would be raised. A slurry wall would be constructed on top of the impervious core that would extend 13 feet to the top of the existing dike at elevation 484 feet and connect to the crest wall foundation. Design details will be decided in the Preconstruction, Engineering, and Design (PED) phase.

Borrow Areas and Haul Routes

A borrow site that provides suitable embankment material has been identified. A maximum of 90 acres of land would be excavated at the Peninsula site, located in the FLSRA between the North and South Forks of the American River. Approximately 8,000 cubic yards of material would be taken from this site. The haul distance and route to the Peninsula are 2–3 miles and embankment would be barged across Folsom Lake to the dikes and dams. All material for this alternative would come from the Peninsula site. (See Plates 5-5a and 5-5b.)

Location of Construction Staging Areas

The construction staging areas would be located on the waterside, or immediately adjacent to the landside of the existing embankment dams and dikes. The locations were selected based on existing topography and environmental conditions to minimize environmental effects.

Temporary Construction Bridge

During construction of the dam raise, the top of the dam would be closed to traffic and a temporary construction bridge and approach roads would be constructed. This bridge would be intended to mitigate short-term traffic effects during construction of the dam modifications. The temporary construction bridge is shown in plan view (Plate 5-6a) and in profile view (Plate 5-6b). This bridge, located immediately downstream of the dam, would act as a detour for public traffic and reduce conflicts with construction activities. The southeast approach would merge with the existing Folsom Dam road near the left wing dam abutment. The northwest

approach would be aligned along the southern perimeter of the Bureau's Folsom Dam operations and maintenance area, near the American River Water Education Center (a multi-agency facility). The western end of the detour would parallel the American River Bike Trail and intersect with Folsom Auburn Road about 300 feet south of the existing intersection. To negotiate the new alignment, a bike path underpass would be built.

The temporary construction bridge alignment would be designed to minimally affect the Bureau's facilities and operations, the Water Education Center, the bike path, and other neighboring uses. The alignment would require that the south spillway access road be relocated. Construction of a bicycle underpass to allow users of the existing bike path to cross the road safely would also be required.

An alternative alignment that would tie into the existing intersection of Folsom Auburn Road and Folsom Dam Road was explored, but would have required relocating some of the Bureau's facilities and the Water Education Center. Also explored was an alignment to the south that would have tied into Folsom Auburn Road about ¼ mile from the existing intersection. This would have avoided the Bureau's facilities and the Water Education Center, but would be very costly and have substantial effects on vegetation, wildlife habitat, and recreation.

After completion of the dam raise, traffic would be routed back onto the top of the dam. At the Bureau's discretion, the bridge could be left in place if a local sponsor is identified to assume the operation and maintenance responsibilities for the bridge. Alternatively, the bridge would be removed upon completion of construction.

Mooney Ridge

The 478-foot maximum flood pool elevation related to this dam raise would inundate the lower edge of up to 7 lots in the Mooney Ridge subdivision. The expected annual probability that the properties would be inundated is 0.0059 (1 chance in 170 per year). The duration of flooding would be less than one day. The Corps' land acquisition criteria would require acquisition of adequate interests in the affected private lands to accommodate project features and operations. Perpetual intermittent flowage easements would constitute the minimal real estate interest that would meet this requirement. In addition, it may be necessary to deepen and strengthen the foundations of residential structures on the land to prevent sloughing during saturated soil conditions.

Acceptable alternatives to flowage easements are construction of a new dike on existing Federal project lands to protect the backyards, or construction of a retaining wall with backfill on the properties, thereby giving the affected homeowners a flat yard. If a structural alternative to easements were preferred after consultation with property owners, this would be funded 100 percent by local interests to the extent that the structural work exceeds the cost of the easements.

Enlarge L. L. Anderson Dam Spillway

L. L. Anderson Dam is owned by the Placer County Water Agency (PCWA) and is located on the Middle Fork of the American River above Folsom Dam. The embankment dam has inadequate spillway capacity and would overtop and fail during a PMF event. This failure

would add approximately 250,000 cfs to the PMF at Folsom Dam. Providing for passage of that additional flow at Folsom Dam would cost considerably more than modifying L. L. Anderson Dam and spillway for safe passage of the PMF.

The dam is fitted with parapet walls ranging in height from 1 to 3 feet along the left and right sides of the dam crest. The wind setup and wave runup for the project is 3.6 feet. The spillway consists of an ogee crest at elevation 5,244.5 feet discharging to a rock-lined exit channel. The spillway crest is gated with two tainter gates 20 feet wide by 18.5 feet high. The spillway discharges to a trapezoidal exit channel 50 feet wide. At approximately 300 feet downstream of the spillway, the exit channel drops 44 feet into an escape channel at a right angle to the exit channel. The escape channel is approximately 1,000 feet long and varies in bottom width from 25 feet at the upstream end to 50 feet at the downstream end. Downstream of the escape channel, there is an additional 800 feet of channel work before the spillway flows return to the Middle Fork of the American River. Through a combination of a small increase in the dam height (to approximately elevation 5,276.4 feet) and doubling of the present spillway capacity, passage of the PMF would be attained.

The following modifications are proposed for L. L. Anderson Dam:

- The existing two-tainter-gate (20 feet wide by 18.5 feet high) ogee crest control structure would be removed.
- A new three-tainter-gate (27 feet wide by 18.5 feet high) ogee crest control structure would be constructed at the entrance to the spillway channel.
- The existing rock excavated spillway channel would be deepened (approximately 23 feet) and extended (approximately 100 feet) to connect to the new control structure as a side-channel spillway.
- The existing downstream spillway escape channel would be widened at two constriction points.
- The existing parapet crest wall would be raised and extended (3.6-foot maximum height, 1,200-foot raise, 1,400-foot extension) to provide adequate freeboard during the PMF event. The material excavated would most likely be stored at the staging area used during construction of L. L. Anderson Dam or at the downstream end of the spillway.

Additional Structural Work

The gantry crane would be temporarily relocated from the top of the dam while the spillway bridge is raised. The reach of the upper crane on the gantry would need to be enlarged to handle spillway gate stop logs. Alternatively, the gantry crane could be removed and replaced with a portable crane.

The penstock wheel gates would require that the hydraulic power units and controls be relocated above the flood pool. The penstock inlet temperature shutters would be extended upward commensurate with the physical dam raise.

Environmental Commitments and Best Management Practices

The Corps has incorporated the following Environmental Commitments and Best Management Practices (BMPs) into Alternative 2. These measures would avoid or reduce adverse effects during construction:

Environmental Commitments

- Folsom Reservoir Inundation Zone Monitoring and Adaptive Management Program. The Corps and local sponsor will implement a vegetation monitoring and adaptive management program for the expanded inundation zone at Folsom Reservoir. This would include designing and implementing a program to monitor the condition of vegetation and other resources at representative sites around the inundation zone for the life of the project. Based on USFWS recommendations, the baseline conditions would be updated every 10 years. After a major flood event in which floodwater is stored at elevations higher than 474 feet, changes in the condition of vegetation and other resources attributable to operation of the project would be determined. Damages attributable to inundation would be mitigated by replanting vegetation onsite. Off-site mitigation would be used in the event effects could not be mitigated onsite.

The Corps would be responsible for developing the monitoring program. Once the flood control project is constructed, the local sponsor will be responsible for implementing the monitoring and adaptive management program.

- Seasonal Wetland/Riparian Vegetation Construction Buffers. During project construction, the Corps will avoid disturbing seasonal wetlands and riparian vegetation to the maximum extent feasible. This would include installing temporary fencing around wetlands and riparian vegetation. Fencing would be placed at an adequate distance from seasonal wetlands and riparian vegetation to avoid disturbance during construction. The location of fencing and width of buffers would be determined in consultation with the SVRWQCB and DFG.

Best Management Practices

- Litter and construction debris would be removed from the floodway and disposed of at an appropriate upland site.

- Any temporary access roads constructed in the floodway or near any body of water would have adequate provisions (e.g., sediment barriers, drainage settling basins) to prevent entry of sediment into the water.

- After project construction, temporary access roads and the temporary construction bridge would be removed, regraded to original contours where feasible, and reseeded with grasses.

- Refueling of equipment and vehicles would occur only in a designated part of the staging areas where potential spills can be readily contained.

- Equipment and vehicles operated in the staging areas in the floodway or near any water bodies would be checked and maintained to prevent leaks of fuels, lubricants, or other fluids.

- Any spills of hazardous material would be cleaned up immediately. Spills would be reported in construction compliance reports.

- Appropriate erosion control measures would be incorporated into the storm water pollution prevention program.

- All construction material placed in water should be nontoxic. Any combination of wood, plastic, concrete, or steel is acceptable provided there are no toxic coatings, chemical antifouling products, or other toxic treatments that may leach into the surrounding environment.

5.2.3 Real Estate Requirement

Under Alternative 2, private property would be affected at the Mooney Ridge site, and at some sites around the reservoir, drainages, and feeder streams would be affected. Based on Headquarters' guidance in the application of the Corps' acquisition criteria for cost shared projects, the Government would pursue the acquisition of perpetual intermittent flowage easements at Mooney Ridge and at those places where the full pool will exceed the project boundaries. Structural alternatives to the acquisition of flowage easements for the Mooney Ridge area, if selected, would be funded by the local interests to the extent the alternatives' costs exceed the cost of easement acquisition.

Modifications to utilities, facilities, or roadways within the existing and proposed full pool or on current project lands would be analyzed on a cost-benefit basis to determine whether they qualify as a project mitigation modification should they not qualify as a real estate utility/facility relocation requirement.

Sites on the peninsula of Folsom Lake and at Mississippi Bar adjacent to Lake Natoma, owned by the Federal government, would be used for borrow material. Use of existing project resources for borrow material would result in significant savings. Should State-owned lands be required for use as borrow, as a cost share partner, the State would be credited the fair market value of the borrow material contributed from State-owned lands.

Lands for environmental mitigation would be another real estate requirement that can be met by using existing project lands.

5.2.4 Operation

The operations plan for Folsom Dam regulates the reservoir storage space available for flood control and water releases from the dam. Implementation of Alternative 2 would provide an additional 47,000 acre-feet of surcharge storage space totaling 139,000 acre-feet. The dam re-operation variable flood space would remain at 400,000 to 600,000 acre-feet.

Water releases from the dam are made through eight gated outlets at the lower level of the dam, five main spillway gates, and three auxiliary spillway gates (under this alternative, the auxiliary gates would continue to be used only in emergencies). Releases are restricted by the capacity of discharge structures and by the existing operation criteria that limits the increases in release rates. The lower level outlet capacity would be 115,000 cfs (with Folsom Modifications project); after inflows exceed this outflow capacity, the reservoir begins to fill. The outflow rate remains at 115,000 cfs until the water level reaches the spillway crest, at which time spillway releases from the main gates can begin. The current operations plan restricts the maximum rate of increase to 15,000 cfs per hour until outflow reaches the 115,000-cfs objective release limit. Increased releases are limited to 15,000 cfs per hour to minimize erosion damage to levees and banks due to sudden large increases while the objective release limit is set to prevent flows that exceed the safe carrying capacity of the downstream river channel. The maximum emergency release rate is 160,000 cfs with a maximum duration of 48 hours. The reservoir water surface raise from 474 feet to 478 feet would occur at infrequent intervals; the duration of a water surface above 474 would be at most 1 day.

Plate 5-7 shows inflow and outflow hydrographs for without-project and this and other dam raise alternatives for the 200-year event American River at Fair Oaks. Plate 5-8 shows the floodflow release frequencies for this and the other dam raise alternatives.

5.2.5 Accomplishments and Residual Risk

Implementation of Alternative 2 would solve the existing dam safety problem because the dam would be able to pass the PMF. Plates 5-9a and 5-9b chart the exceedance values for different frequency events with and without the project alternative. Table 5-2 shows the residual damages and percent of the without-project damages and the reduction in the probability of flooding Sacramento due to levee failure. The conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 56.5 percent.

TABLE 5-2. Accomplishments and Residual Risk of Alternative 2

Without-Project Advance Release Scenarios	Without-Project Expected Annual Damage ($ million)	With Alternative 2 Expected Annual Residual Damage ($ million)	Percent	Percent Chance Exceedance (1-in-X Chance per Year)	
				Without Project	With Alternative 2
No advance release	86.0	76.8	89	0.0071 (140)	0.0065 (154)
Moderate advance release (0–100,000–190,000 acre-feet)[1]	72.8	63.8	88	0.0061 (164)	0.0053 (189)
Upper bound advance release (100,000–140,000–250,000 acre-feet)	66.6	59.3	89	0.0056 (179)	.0049(204)

[1] Advance release scenario adopted for alternative analysis

5.3 Alternative 3: Seven-Foot Dam Raise/482-Foot Flood Pool Elevation

5.3.1 Description

The plan components under Alternative 3 would be essentially the same as under Alternative 2 with the exception of lowering the spillway. The height of the dam would be raised by 7 feet, from a dam crest elevation of 480.5 feet to a top of wall elevation of 487.5 feet. The maximum design flood pool elevation would be raised to elevation 482 feet, an 8-foot increase from the without-project condition that would create 96,000 acre-feet in additional flood control space. No further raising of the flood space could be made without major stabilization work to the dam (see Alternative 4 below). Alternative 3 would increase flood control and correct the dam safety problem so that the PMF would be passed without dam failure. The Alternative 3 dam raise would have a PMF water surface of 484.5 feet. The top of dam would be set to allow for wind and wave and possible backwater from spillway flow encroachment on the spillway bridge. Additionally, the L. L. Anderson Dam (French Meadows Reservoir) spillway would be widened to reduce the PMF inflow to Folsom Dam. The plan components, real estate requirement, operation, accomplishments, and residual risks associated with Alternative 3 are described below.

5.3.2 Plan Components

The plan components under Alternative 3 would be essentially the same as those under Alternative 2, apportioned up to the 482-foot maximum design flood pool elevation. These components work together to effectively raise the physical height of the dam from 480.5 feet to 487.5 feet, which includes the parapet wall. The spillway would not be lowered under this plan. Additionally, L. L. Anderson Dam (French Meadows Reservoir) would be modified to accommodate the PMF. Plate 5-1 shows the locations of the major structural modifications. Plate 5-2 shows spillway, gate, and top of dam elevations compared with other alternatives.

Replace Spillway Gates

All eight spillway radial gates would require replacement under this plan. The new gates would be approximately 66 feet high, 16 feet taller than the gates under the without-project condition. The top-of-gate elevation would be 484.0 feet on a design flood control pool elevation of 482.0 feet.

To accommodate the additional height and loading, the existing piers would require extension and strengthening, and new trunnions (pivot points) would be located on the top of the new pier extensions. New high-strength, post-tensioned steel cables would be cored and grouted into the pier/dam section to provide for trunnion anchorage. New hoisting motors and chains, and new catwalks would also be required.

Modify Spillway Bridge Piers

The spillway bridge piers would require modification under this plan. The piers would be raised and extended downstream to anchor the new larger radial gates. Additionally, the piers would be strengthened by installing post-tensioned tendons to anchor the piers to the mass concrete of the overflow section.

Replace Spillway Bridge

This alternative would include essentially the same replacement bridge as for Alternative 2. The existing eight-span spillway bridge would require replacement commensurate with the higher dam elevation. The new bridge would be approximately 400 feet long and 35 feet wide with one through traffic lane in each direction.

Raise Concrete Dam

The concrete portions of Folsom Dam including the spillway area would be raised to accommodate the higher flood control pool. This raise would be accomplished through a combination of raising the dam crest and spillway bridge deck, and constructing a short crest/parapet wall. The new top-of-dam elevation in the concrete section would be 487.5 feet (top of crest/parapet wall), and the top of the roadway and bridge deck would be 487.0 feet elevation.

Extend Stilling Basin

Work to extend the stilling basin would be identical to that described for Alternative 2.

3.5-Foot Concrete Wall

As with the concrete dam section, the left and right embankment wing dams beyond the center concrete section would need to be raised. Plate 5-4 shows the section of embankment dams and dikes around the perimeter of the reservoir that would be raised in direct relationship to the dam raise to accommodate higher water storage elevations. The embankments would be raised and expanded with a combination of earthfill and 3 1/2-foot-high reinforced concrete crest

wall. The wall would be designed to absorb wind and wave runup on the waterside of the wall, protect the dike from erosion, allow for inspection of the wall, and allow space for a 20–foot-wide road across the dikes and 25-foot-wide road across the dam. Asphalt pavement would be placed on the crest of the dam to protect the landside top of the dam. Wind and wave runup may be lessened by placing rock revetment on the waterside of the wall, or by forming the wall in a curved concave shape. Mormon Island Dam and Dikes 5 and 7 have an existing impervious core that would be raised. The slurry wall would be constructed on top of the impervious core. It would extend 18 feet to the top of the raised dike at elevation 484 feet and connect to the crest wall foundation. Design details will be decided in the PED phase.

Modify Elevator Tower

The dam elevator tower would require modification under this plan. Tower modifications would include raising the elevator roadway lobby, adding a floor to the top of the tower, relocating the elevator machinery up one floor, and modifying the elevator controls.

Borrow Areas and Haul Distances

Two borrow sites have been identified to supply suitable embankment material. A maximum of 90 acres of land would be excavated at the Peninsula site, located between the North and South Forks of the American River. Approximately 75,000 cubic yards of material would be taken from this site. A maximum of 140 acres of land would be excavated at the Mississippi Bar site, located just upstream and northeast of Nimbus Dam. Approximately 675,000 cubic yards of material would be taken from this site. Material would be excavated and barged across Folsom Lake to the dikes and dams. The haul distance and route to the Mississippi Bar borrow site covers five miles. From the Mississippi Bar site, material would be trucked using existing roads to Lake Natoma. The material would then be barged across the lake to a staging area in the vicinity of Willow Creek. Depending on the location of the staging area, the parking area and boat launch site at Willow Creek might have to be closed to recreation during the construction phase. From Willow Creek, material would be trucked to Dikes 1–6 and the right wing dam via Folsom Boulevard and Folsom Auburn Road. Material taken to Mormon Island Dam, Dikes 7 and 8, and the left wing dam would be trucked via Blue Ravine Road and Green Valley Road. The borrow sites are shown on Plates 5-5a and 5-5b.

Location of Construction Staging Area

All construction staging areas would be located on the waterside, or immediately adjacent to the landside of existing earthen dams and dikes to minimize disturbance of outlying environmental resource areas.

Temporary Construction Bridge

During construction of the dam raise, the top of the dam would be closed to daily traffic and a temporary construction bridge and approach roads would be constructed southeast of the dam. The bridge would, for the east approach, merge with the existing Folsom Dam Road near the left wing dam abutment. The west approach would connect with Folsom Auburn Road about 300 feet south of the existing intersection. The bridge would be aligned to provide an alternate

route of transportation across the American River and to ensure that no conflicts occur with existing Folsom Dam operations. Construction of the bridge is intended to mitigate short-term traffic effects during construction of the dam modifications. The alignment would require that the south spillway access road be relocated as well as construction of a bicycle underpass to allow users of the existing bike path to cross the road safely. After completion of the dam raise, traffic would be routed back onto the top of the dam. At the discretion of the Bureau, the bridge could be left in place if a local sponsor is identified to assume the operation and maintenance responsibilities for the bridge. Alternatively, the bridge could be removed upon completion of construction of the project.

Raise Folsom Dam Road East of Dam

Approximately one-third of a mile of Folsom Dam Road southeast of the left wing dam is at an elevation below 480.5 feet. This section of road would be inundated before the reservoir surface reached the operating flood control pool of 482 feet. To keep the road passable while Folsom Dam is under a flood operation, approximately one-third of a mile of road would be raised in place. The alignment would be within project lands, so no new rights-of-way would be required.

Mooney Ridge

This alternative would result in a full flood pool that would inundate the lower portion of 16 lots in the Mooney Ridge subdivision. No habitable structures would be affected. The inundation would be very infrequent and of short duration. Since the dam raise would increase the size of the normal operation reservoir, one of the Corps' acquisition criteria is to acquire adequate interests in lands to accommodate project features and operations. Perpetual intermittent flowage easement is the minimal acquisition that would meet this requirement. In addition to the easement, residential foundations may be deepened and strengthened to prevent sloughing during saturated soil conditions.

As with Alternative 2, acceptable alternatives to flowage easements are construction of a new dike on existing Federal project lands to protect the backyards, or construct a retaining wall with backfill on the properties, thereby giving the homeowners a flat yard. If, through consultation with property owners, a structural alternative to easements is preferred, this would be funded 100 percent by local interests to the extent that the structural work exceeds the cost of the easements.

Enlarge L. L. Anderson Dam Spillway

Work on the L. L. Anderson Dam spillway would be identical to that described for Alternative 2.

Additional Structural Work

The gantry crane would be temporarily relocated from the top of the dam while the spillway bridge is raised. The reach of the upper crane on the gantry would need to be enlarged

to handle spillway gate stop logs. Alternatively, the gantry crane could be removed and replaced with a portable crane.

The penstock wheel gates would require that the hydraulic power units and controls be relocated above the flood pool. The penstock inlet temperature shutters would be extended upward commensurate with the physical dam raise.

Environmental Commitments and Best Management Practices

The Corps has incorporated Environmental Commitments and BMPs into Alternative 3 to avoid adverse effects during construction. These BMPs are the same as discussed for Alternative 2.

5.3.3 Real Estate Requirement

Under Alternative 3, as with the prior alternative, private property would be affected at the Mooney Ridge site, and at some sites around the reservoir, drainages and feeder streams would be affected. Based on Headquarters' guidance in the application of the Corps' acquisition criteria for cost shared projects the Federal government would pursue the acquisition of perpetual intermittent flowage easements at Mooney Ridge and at those places where the full pool will exceed the project boundaries. One habitable structure would require structural modifications to protect it from the maximum flood pool. Structural alternatives to the acquisition of flowage easements for the Mooney Ridge area, if selected, would be funded by the local interests to the extent the alternatives' costs exceed the cost of easement acquisition.

Modifications to utilities, facilities, or roadways within the existing and proposed full pool or on current project lands would be analyzed on a cost-benefit basis to determine whether they qualify as a project mitigation modification should they not qualify as a real estate utility/facility relocation requirement.

Sites on the peninsula of Folsom Lake and at Mississippi Bar adjacent to Lake Natoma, owned by the Government, would be used for borrow material. Use of existing project resources for borrow material would result in significant savings. Should State-owned lands be required for use as borrow, as a cost share partner, the State would be credited the fair market value of the borrow material contributed from State-owned lands above the 486-foot elevation project take line.

Another real estate requirement would be lands for environmental mitigation. This requirement can be met by using existing project lands.

5.3.4 Operation

The operations plan for Folsom Dam regulates the reservoir storage space available for flood control and water releases from the dam. Under the existing operating criteria, 400,000 acre-feet of the total storage capacity of 975,000 acre-feet are allocated to flood control. However, the Bureau and SAFCA have an interim reoperation agreement that allows for operation of the dam to include a variable storage space ranging from 400,000 to 600,000 acre-

feet. The dam re-operation variable flood space would remain 400,000 to 600,000 acre-feet. Implementation of Alternative 3 would provide an additional 95,000 acre-feet of surcharge storage space totaling 187,000 acre-feet.

Water releases from the dam are made through eight gated outlets at the lower level of the dam, five main spillway gates, and three auxiliary spillway gates (under this alternative, the auxiliary gates would continue to be used only in emergencies). Releases are restricted by the capacity of discharge structures and by the existing operation criteria that limits the increases in release rates. The lower level outlet capacity is 115,000 cfs; after inflows exceed this outflow capacity, the reservoir begins to fill. The outflow rate remains at 115,000 cfs until the water level reaches the spillway crest, at which time spillway releases from the main gates can begin. The operations plan restricts the maximum rate of increase to 15,000 cfs per hour until outflow reaches the 115,000-cfs objective release limit. Increased releases are limited to 15,000 cfs per hour to minimize erosion damage to levees and banks due to sudden large increased outflows while the objective release limit is set to prevent flows that exceed the safe carry capacity of the downstream river channel.

The emergency release operation plan under Alternative 3 and the physical features of the dam would allow for surcharge storage to 482 feet in elevation. Once the water surface reaches the existing surcharge storage space, the dam is operated with the objective of preventing the dam from being overtopped. Emergency release operations include opening the spillways and maintaining a release of 160,000 cfs (the maximum amount the downstream levees can handle) before the reservoir reaches 482 feet in elevation. The maximum duration of the emergency release of 160,000 cfs would be 24 hours.

5.3.5 Accomplishments and Residual Risk

Plates 5-9a and 5-9b chart the exceedance values for different frequency events with and without Alternative 3. Table 5-3 shows the residual damages and percent of the without-project damages and the reduction in the probability of flooding Sacramento due to levee failure. Under this alternative, the conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 63.5 percent. Implementation of Alternative 3 would solve the existing dam safety problem because the dam would be able to pass the PMF.

TABLE 5-3. Accomplishments and Residual Risk of Alternative 3

Without-Project Advance Release Scenarios	Without-Project Damage ($ million)	With Alternative 3 Residual Damage ($ million)	Percent	Percent Chance Exceedance (1-in-X chance per year)	
				Without Project	With Project
No advance release	86.0	68.5	80	0.0071 (140)	0.0065 (154)
Moderate advance release (0-100,000-190,000 acre-feet)[1]	72.8	56.9	78	0.0061 (164)	0.0053 (189)
Upper bound advance release (100,000–140,000–250,000 acre-feet)	66.6	53.4	80	0.0056 (179)	0.0044 (227)

[1] Advance release scenario adopted for alternative analysis

5.4 Alternative 4: Twelve-Foot Dam Raise/487-Foot Flood Pool Elevation

5.4.1 Description

This alternative is judged to be the highest dam raise possible without encountering severe technical problems necessitating removal of the embankment wrap sections, dewatering of the reservoir, foundation work, and extension of the concrete nonoverflow sections. As with the other dam enlargement alternatives, flood damages would be reduced by physically enlarging the flood control space behind Folsom Dam. This plan would incorporate most of the project features described under the previous dam raise alternatives with some exceptions. In addition, once the flood pool elevation reaches above approximately elevation 482 feet, preliminary stability analyses indicate that conventional overturning stability criteria would not be satisfied. To satisfy this criterion, additional structural improvement is needed both on the downstream face and within the concrete dam monoliths.

This plan would raise the dam and surrounding dikes by 12 feet, from the existing top of dam crest elevation of 480.5 feet to 492.5 feet. The top of the flood space would be increased from 474 feet to 487 feet. This would provide an increase in the dam's water storage capacity of 157,000 acre-feet. The physical raise provides for wind and wave runup and possible backwater from spillway flows encroaching on the spillway bridge. Improvements to L. L. Anderson Dam (French Meadows Reservoir) to pass the PMF would be implemented to ensure that Folsom Dam could safely pass the. The plan components, real estate requirements, operation, and accomplishments and residual risk associated with Alternative 4 are described below. Plate 5-10 shows a graphic depiction of the dam raise.

5.4.2 Plan Components

Plate 5-1 shows the locations of the major structural modifications. Plate 5-2 shows spillway, gate, and top-of-dam elevations compared with other alternatives.

Raise Concrete Dam

The concrete portions of Folsom Dam outside of the spillway area would be raised to contain the higher flood pool elevation by removing the top of the concrete nonoverflow sections down the bond break joint at elevation 478 feet. This raise could be accomplished through a combination of raising the dam crest with roller-compacted concrete, and constructing a 3.5-foot parapet wall, with sealed vertical joints to prevent leakage during extreme floods. The new top-of-dam elevation would be 492.5 feet, and the top-of-the-roadway elevation would be 489 feet. Preliminary stability analyses indicate that after the flood pool elevation rises above 484 feet, the dam is no longer stable and could overturn if no additional modifications are made. Measures to satisfy the stability criteria include both a concrete buttress on the downstream side of the spillway and post-tension anchors installed in the dam.

Concrete Dam Stability Measures

To satisfy stability criteria for flood pool elevations in excess of approximately 482 feet, additional measures are required, as follows:

- **Buttress**. The downstream face of accessible dam monoliths would be excavated and resurfaced with additional structural concrete to provide the base width needed for each monolith. This would include the main spillway monoliths, as well as the nonoverflow monoliths between the spillway and the right wing dam wrap fill retaining wall.

- **Foundation anchors**. High-capacity rock anchors, consisting of multiple strands of high-strength, prestressed steel tendons, would be drilled and grouted into holes located near the axis of the dam. Location of the anchorage zones and stressing blocks would be staggered vertically to avoid coincidence of the stressed zones. Top anchorage blocks would be located on the spillway crest. Anchorage would extend to galleries or adits in the nonoverflow monoliths. Anchorage would be provided for all monoliths except the last four at each end of the concrete dam section.

Replace Spillway Gates

All eight spillway radial gates would require replacement under this plan. The new gates would be approximately 72 feet high (22 feet taller than the existing gates), with a radius of approximately 65 feet. The top-of-gate elevation in the closed position would be 489.5 feet, on a design flood control pool elevation of 487 feet.

Modify Spillway Bridge Piers

To accommodate the additional height and loading, the existing piers would require extension and strengthening, and new trunnions (pivot points) would be located on the top of the new pier extensions. New high-strength, post-tensioned steel cables would be cored and grouted into the pier/dam section to provide for trunnion anchorage. New hoisting motors and chains, and new catwalks would also be required.

Replace Spillway Bridge

This alternative would include the same replacement bridge as Alternatives 2 and 3. The existing eight-span spillway bridge would require replacement commensurate with the higher dam elevation. The new bridge would be approximately 400 feet long and 35 feet wide with one through traffic lane in each direction.

Extend Stilling Basin

Work to extend the stilling basin would be identical to that described for Alternatives 2 and 3.

3.5-Foot Concrete Wall

As with the concrete dam section, the left and right embankment wing dams beyond the center concrete section would need to be raised and expanded. Plate 5-4 shows the sections of embankment dams and dikes around the perimeter of the reservoir that must be raised in direct relationship to the dam raise to accommodate higher water storage elevations. These embankments and dikes would be raised and extended with a combination of earthfill and a reinforced concrete crest wall, faced with rock revetment matching the existing embankment slope. The existing impervious cores in Mormon Island Dam and Dikes 5 and 7 would have a slurry wall constructed down to elevation 466 feet after the dam has been raised; therefore, the cores of these dam and dike features would be raised to elevation 487 feet and connected to the crest wall foundation. A 3.5-foot-high concrete parapet wall would be constructed at the top of embankment dams and dikes to prevent wave wash from spilling out of the reservoir. No permanent water storage elevations are planned to reach the parapet wall.

Modify Elevator Tower

The dam elevator tower would require extensive modification under this plan. Elevator modifications would consist of raising the elevator roadway lobby, adding a floor to the top of the tower, relocating the elevator machinery up one floor, and modifying the elevator controls.

Borrow Areas and Haul Distances

Two borrow sites have been identified that would provide suitable embankment material. A maximum of 90 acres of land would be excavated at the Peninsula site, located between the North and South Forks of the American River. Approximately 150,000 cubic yards of material would be taken from this site. A maximum of 140 acres of land would be excavated at the Mississippi Bar site, located just upstream and northeast of Nimbus Dam. Approximately 1,350,000 cubic yards of material would be taken from this site for this alternative. The haul distance and route to the Peninsula and Mississippi Bar borrow sites would be the same as those described for Alternatives 2 and 3.

Location of Construction Staging Area

All construction staging areas would be located on the waterside, or immediately adjacent to the landside of existing earthen dams and dikes to minimize disturbance of outlying environmental resource areas.

Temporary Construction Bridge

During construction of a dam raise, the top of the dam would be closed to daily vehicular traffic, and a temporary construction bridge would be constructed southeast of the dam and merge with the existing Folsom Dam road near the left wing dam abutment. The bridge would be identical to that described for Alternative 2.

Raise Folsom Dam Road East of Dam

Approximately one-third of a mile of Folsom Dam Road southeast of the left wing dam is at an elevation below 480.5 feet. This section of road would be inundated before the reservoir surface reached the operating flood control pool of 487 feet. To keep the road passable while Folsom Dam is under a flood operation, about one-third of a mile of road would be raised in place. The alignment would be within project lands, so no new rights-of-way would be required.

Mooney Ridge

This alternative would result in a full flood pool that would inundate the lower portion of 17 lots in the Mooney Ridge subdivision and flood the ground floor of one home. The inundation would be very infrequent and of short duration. Since the dam raise would increase the size of the normal operation reservoir, one of the Corps' acquisition criteria is to acquire adequate interests in lands to accommodate project features and operations. Perpetual intermittent flowage easement is the minimal acquisition that would meet this requirement. In addition to the easement, residential foundations may be deepened and strengthened to prevent sloughing during saturated soil conditions.

As with previous alternatives, acceptable alternatives to flowage easements are construction of a new dike on existing Federal project lands to protect the backyards, or construct a retaining wall with backfill on the properties, thereby giving the homeowners a flat yard. If, through consultation with property owners, a structural alternative to easements is preferred, this would be funded 100 percent by local interests to the extent that the structural work exceeds the cost of the easements.

Enlarge L. L. Anderson Dam Spillway

Work on the L. L. Anderson Dam spillway would be identical to that described for Alternatives 2 and 3.

Additional Structural Work

The gantry crane would be temporarily relocated from the top of the dam while the spillway bridge is raised. The reach of the upper crane on the gantry would need to be enlarged to handle spillway gate stop logs. Alternatively, the gantry crane could be removed and replaced with a portable crane.

The penstock wheel gates would require that the hydraulic power units and controls be relocated to above the flood pool. The penstock inlet temperature shutters would be extended upward commensurate with the physical dam raise.

Environmental Commitments and Best Management Practices

The Corps has incorporated Environmental Commitments and BMPs into Alternative 4 to avoid adverse effects during construction. These BMPs are the same as discussed for Alternative 2.

5.4.3 Real Estate Requirement

Under Alternative 4, private property would be affected to a greater extent at the Mooney Ridge site with 17 lots experiencing extremely infrequent intermittent flooding, and at an additional 36 sites around the reservoir, drainages and feeder streams would be affected. Again, based on Headquarters' guidance in the application of the Corps' acquisition criteria for cost shared projects the Government would pursue the acquisition of perpetual intermittent flowage easements at Mooney Ridge and at those places where the full pool will exceed the project boundaries. Structural alternatives to the acquisition of flowage easements for the Mooney Ridge area, if selected, would be funded by the local interests to the extent the alternatives' costs exceed the cost of easement acquisition.

Modifications to utilities, facilities, or roadways within the existing and proposed full pool or on current project lands would be analyzed on a cost-benefit basis to determine whether they qualify as a project mitigation modification should they not qualify as a real estate utility/facility relocation requirement.

Sites on the peninsula of Folsom Lake and at Mississippi Bar adjacent to Lake Natoma, owned by the Government, would be used for borrow material. Use of existing project resources for borrow material would result in significant savings. Should State-owned lands be required for use as borrow, as a cost share partner, the State would be credited the fair market value of the borrow material contributed from State-owned lands above the 486-foot-elevation project take line.

Another real estate requirement would be lands for environmental mitigation. This requirement can be met by using existing project lands.

5.4.4 Operation

The operations plan for Folsom Dam regulates the reservoir storage space available for flood control and water releases from the dam. Under the existing operating criteria, 400,000 acre-feet of the total storage capacity of 975,000 acre-feet are allocated to flood control. However, the Bureau of Reclamation and SAFCA have an interim reoperation agreement that allows for operation of the dam to include a variable storage space ranging from 400,000 to 600,000 acre-feet. The dam re-operation variable flood space would remain 400,000 to 600,000 acre-feet. Implementation of Alternative 4 would provide an additional 157,000 acre-feet of surcharge storage space totaling 249,000 acre-feet.

The emergency release operation plan under Alternative 4 and the physical features of the dam would allow for surcharge storage to 487 feet in elevation. Once the water surface reaches the existing surcharge storage space, the dam is operated with the objective of preventing the dam from being overtopped. Emergency release operations include opening the spillways and maintaining a release of 160,000 cfs (the maximum amount the downstream levees can handle) before the reservoir reaches 487 feet in elevation. The maximum duration of the emergency release of 160,000 cfs would be 48 hours.

5.4.5 Accomplishments and Residual Risk

Plates 5-9a and 5-9b chart the exceedance values for different frequency events with and without the project alternative. Table 5-4 shows the residual damages and percent of the without-project damages and the reduction in the probability of flooding Sacramento due to levee failure. Under Alternative 4, the conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 68.5 percent. Implementation of Alternative 4 would solve the existing dam safety problem because the dam would be able to pass the PMF.

TABLE 5-4. Accomplishments and Residual Risk of Alternative 4

Without-Project Advance Release Scenarios	Without-Project Damage ($ million)	With Alternative 4 Residual Damage ($ million)	Percent	Percent Chance Exceedance (1-in-X Chance per Year)	
				Without Project	With Project
No advance release	86.0	61.3	71	0.0071 (140)	0.0051 (196)
Moderate advance release (0-100,000-190,000 acre-feet)[1]	71.8	52.7	72	0.0061 (164)	0.0043 (233)
Upper bound advance release (100,000-140,000-250,000 acre-feet)	66.6	48.0	72	0.0056 (179)	0.0040 (250)

[1] Advance release scenario adopted for alternative analysis

5.5 Alternative 5: Stepped Release to 160,000 cfs

5.5.1 Description

The Stepped Release Plan primarily consists of raising the objective release and "stepping" releases from Folsom Dam during infrequent floods, depending on the severity of the storm and its effect on storage in Folsom Reservoir. This plan is a stepped objective release from 115,000 to 145,000 cfs, and then stepped to 160,000-cfs emergency release. By limiting the controlled release to 160,000 cfs, only minimal work is needed to modify the levees and bridges in the Lower American River.

A major part of this plan is to mitigate for increased flows downstream of the American River in the Yolo Bypass, the Sacramento River below the bypass, and affected tributary sloughs and streams. Increased flows from this stepped release plan would increase water surfaces and increase the risk of levee failure in the Yolo Bypass and lower Sacramento River. Effects are limited to 145,000 cfs because flows are purposely held to this level until downstream flood conditions are such that increasing above 145,000 cfs would not result in an effect greater than the without-project condition. To mitigate for increased flows, the Sacramento Weir and Bypass would be widened, and levees in the Yolo Bypass and sloughs would be raised, and levees along the lower Sacramento River would be modified. The mitigation is designed so that all lands outside of the floodway would have the same overall risk of flooding as under without-project conditions (with Common Features and Folsom Dam Modifications in place).

This alternative does not include dam safety improvements to Folsom Dam. (Dam safety would be fixed as part of the without-project condition, although not scheduled.)

5.5.2 Plan Components

Plates 5-11, 5-12, 5-13, 5-14, 5-15, and 5-16 show the major components of this plan.

Lower American River

Raise and Strengthen Existing American River Levees. A slurry wall or other strengthening measures may be needed along the Lower American River from I-5 to 5,000 feet upstream of the Natomas East Main Drainage Canal (NEMDC) (Plate 5-16).

Levee strengthening by a stability berm and lengthening the levee slope would be constructed on right bank of the American River from the Sacramento River to about the NEMDC. The stability berm would be 7 feet high and extend the levee base about 15 feet on the land side. Some sections of the landside levee slope would be extended so that the slope would be 2 horizontal to 1 vertical. (See Plate 5-11.)

Erosion protection would be placed along 5.8 miles of the levees so the levees could withstand the higher flow velocities associated with this plan.

Increased flows resulting from this alternative may increase erosion of natural channel banks, leading to undercutting of levees and riparian vegetation. The Sacramento River Bank

Protection Project (SRBPP) provides for erosion control of banks along the Lower American River. Increased bank erosion from this alternative would be mitigated by the SRBPP.

New Levees and Floodwalls. No new levees or floodwalls would be needed under this alternative.

Modify Bridges. No bridges would require modification under this alternative.

Modify Local Drainage Facilities. The higher water surface elevations caused by the increased releases could adversely affect the operation of many pumping and drainage facilities in the City and County of Sacramento. These facilities collect rainfall runoff from the protected areas of Sacramento and convey it to the American River by pumping or gravity flow. Table 5-5 summarizes the drainage facilities along the American River and those requiring modifications. The facilities were evaluated to determine whether they are negatively affected by changes from the Stepped Release Plan. Modifications to drainage facilities are based on effects from the expected 145,000-cfs objective release profile. Effects from higher releases are lessened by the flood protection provided by the alternative for these less frequent events.

TABLE 5-5. Summary of Drainage Facilities

Type of Facility and Total	Facilities Requiring Modifications
Pumping plants-9	7
Gravity drains-17	2
Drainage channels-4	0[a]
Sumps-11	11

[a] Modifications to Mayhew drain may not be required, depending on modifications to this facility under the Common Features Project.

Four types of modifications to the above facilities were formulated: raise existing pump discharge invert, new pumps and motors, new pump discharge line, and new pump station.

Raise Existing Pump Discharge Invert. The existing pumping plants have pipes passing through the levees. The pipes would be raised so that the low invert elevation would be above the probable failure point (PFP) at that location. This would be done to ensure that the levees could safely pass the objective release without backflow to the land side. The raises vary from 2.2 to 10.5 feet. A minimum of 2 feet of cover would be required over the top of the raised discharge lines. This would require the levee crown to be ramped over the discharge lines. The raised pipes would be welded steel lines.

New Pumps and Motors. The increased head on the pumps due to the change in elevation would reduce the capacity of the pumps. The flow rate of the pumps would be reduced, which would cause overloading of the motors. These motors would be replaced with larger units; in addition, the pumps and electrical equipment would be modified to maintain capacity. In some cases, only motors may need to be modified.

New Pump Discharge Line. In some cases, the higher-capacity pumps would require construction of a new discharge line through the levee.

New Pump Station. The existing Del Dayo and Tiffany Lane gravity drains would require the addition of new pump stations, pumps, motors, and possibly new discharge lines. At Del Dayo drain, (river mile 11.9) new 36-inch pumps with a 26,900-gallons per minute (gpm) capacity would be required. Two 36-inch welded steel discharge lines would convey flows to the river channel. At Tiffany Lane drain (river mile 13.2), 2 new 8-inch pumps with a 900-gpm capacity would be required. Two 8-inch welded steel discharge lines would convey flows to the river channel. The new pumping plants would be fenced.

Table 5-6 lists appropriate modifications to drainage facilities to the American River.

TABLE 5-6. Drainage Facilities Requiring Modifications

Facility	River Mile/Bank	Owner	Raise Existing Discharge Invert	Modify/ Replace Existing Pumps	New Pump(s), Motors	New Discharge Line	New Pump Station
Pumping Plant D-01	11.7 / Right	County of Sacramento	✓				
Pumping Plant D-02	9.0 / Right	County of Sacramento	✓				
Pumping Plant D-05	5.5 / Right	County of Sacramento	✓		✓	✓	
Pumping Plant D-06	10.9 / Left	County of Sacramento	✓	✓			
Pumping Plant D-10	10.0 / Left	County of Sacramento	✓	✓			
Pumping Plant D-11	13.2 / Left	County of Sacramento	✓				
Pumping Plant D-43	10.0 / Right	County of Sacramento	✓	✓			
Del Dayo Gravity Drain	11.9 / Left	County of Sacramento					✓
Tiffany Lane Gravity Drain	13.2 / Left	County of Sacramento					✓
Mayhew Drain Channel	10.9 / Left	County of Sacramento					
Sump 010	4.6 / Left	City of Sacramento	✓	✓			
Sump 058	1.3 / Right	City of Sacramento	✓				
Sump 091	7.4 / Left	City of Sacramento	✓		✓		
Sump 092	8.0 / Left	City of Sacramento	✓		✓		
Sump 095	6.4 / Right	City of Sacramento	✓	✓			
Sump 099	3.9 / Left	City of Sacramento	✓	✓			
Sump 101	6.1 / Left	City of Sacramento	✓	✓			
Sump 109	8.2 / Right	City of Sacramento	✓	✓	✓		
Sump 111	0.9 / Left	City of Sacramento	✓				
Sump 151	3.1 / Right	City of Sacramento	✓	✓			
Sump 152	4.8 / Right	City of Sacramento	✓	✓			

Modify Water Intake Facilities. Several water intake facilities and wells operated by local districts would be affected by higher flow. To mitigate potential damage due to scour, the

facilities would be strengthened or armored. Table 5-7 summarizes modifications to these facilities required for this alternative.

Table 5-7. Water Intake Facilities Modifications

Facility	Location	Owner	Modification
Fairbairn Water Treatment Plant	Downstream Howe Avenue, river mile 7.4	City of Sacramento	Strengthen intake structure footings and sewer line to resist increased flow
Rossmoor Bar collection wells	River mile 17.5	Carmichael Water District	Protect wells from scour
Infiltration wells	River mile 11.7	Arcade Water District	Protect electrical lines and water supply main from scour

Relocate Utilities. Besides the bridges, internal drainage facilities, and water intake facilities, there are many other items in the Lower American River under without-project conditions that are not flood control related, but that would require modifications or relocations for higher objective releases. These include recreation facilities, pipelines, roads, bike trails, utilities, fences, signs, and numerous other items.

A review of the levee logs identified many pipelines and other utilities passing through the levees. In general, these would be required to pass through the levee above the PFP profile. Therefore, some would require raising. Some existing pipes passing through the levees below the current design water surface are already not above the high-water mark. Whether to raise these will be examined in more detail during final design. Previous study has identified about 50 pipes passing under the levee crowns that would likely need to be raised.

Borrow Sites. Borrow for levee raising and other fill requirements would be taken from a site located just south of Old Placerville Road and west of Mather Field. Additional borrow would be from Port of Sacramento dredge tailings disposal sites.

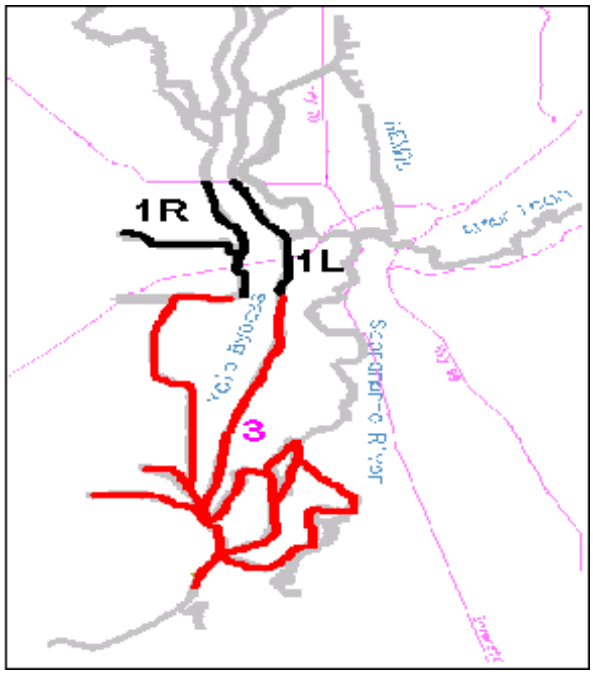
Construction Staging Areas. Six staging areas used for the Common Features construction would be available for use. Five of the areas are located southeast of Cal Expo: four on the north bank and one on the south bank. One is located just west of Cal Expo.

Downstream from American River

Hydraulic effects and mitigation were determined by examining risk and uncertainty (R&U). Downstream areas that would experience increased flood risk were identified (see "Increase Objective Release through Levee Modifications" section in Chapter 4.0). Levee reaches that are geotechnically weak relative to other levees in the R&U index area were identified. Levee strengthening and stability work appropriate to correcting the levees' geotechnical weaknesses were identified. The corrective work would in effect raise the probable non-failure point (PNP) for that index area so that the without-project flood risk (measured using expected annual probability of exceedance) would be restored throughout that index area. Table 5-8 shows index areas and the height of PNP raise required. Types of levee work and extent are described below for each index area. Table 5-9 lists the levee work.

TABLE 5-8. PNP Mitigation Areas and Amounts

Index Area/Reach	Description	PNP Increase (feet)
1R	Right bank Yolo Bypass and Willow Slough Bypass	0.6
1L	Left bank Yolo Bypass	1.0
3	Lower Yolo Bypass, Lower Sacramento River and sloughs	0.3



Listed below are components required for hydraulic mitigation. As explained earlier, work would be done to levees in the Sacramento Bypass, Yolo Bypass, Sacramento River, and tributary sloughs to reduce the overall flood risk to without-project conditions.

Modify the Sacramento Weir and Bypass. Under this alternative, there would be higher objective releases in the American River. After these higher flows reach the mouth of the American River, they must be able to safely pass downstream through the system. Increased flows could pass down the Sacramento River, down the Yolo Bypass, or a combination. Flows enter the Yolo Bypass from the Sacramento River via the Sacramento Weir and Bypass. The Sacramento Weir and Bypass are located on the west side of the Sacramento River (river mile 63) in Yolo County, approximately 3 miles northwest of the City of Sacramento. The Sacramento River south of the American River is at capacity during major storm runoff events. Hydraulic effects may be more easily mitigated in the Yolo Bypass than the Sacramento River, as the Yolo Bypass is associated with less damageable development. Accordingly, to ensure that

the higher flows from the American River flow into the Yolo Bypass instead of down the Sacramento River, the Sacramento Weir and Bypass would be modified (Plate 5-13).

The existing weir is a reinforced concrete structure that is 2,000 feet wide and has 48 bays. It consists of a concrete overflow weir with flashboards and a concrete stilling basin. The structure also supports a reinforced concrete deck for two lanes of vehicular traffic (Sacramento River Road) and a structural steel bridge for one railroad line (Yolo Shortline Railroad). The weir and the bridge piers are supported on pile foundations.

The Sacramento Bypass channel is approximately 9,000 feet long connecting the Sacramento River and the Yolo Bypass.

The Sacramento Weir and Bypass would have to be widened by 1,000 feet. The new 1,000 feet of weir would have the same section and configuration as the existing weir. The new weir would consist of twenty-five 40-foot-wide bays and would be located to the north of the existing weir along the alignment of the railroad line.

Relocation of the North Levee of the Sacramento Bypass. The Sacramento Weir would be lengthened 1,000 feet and the bypass would be widened an equal amount. This widening was sized to accommodate an objective release of 145,000 cfs. About 1/3 of the existing north levee would be used to construct the new levee 1,000 feet to the north (about 7.8 acres of borrow material). The rest of the existing north levee would be graded and seeded to provide mounds for wildlife habitat. The remainder of the fill material needed for levee construction would be obtained from the Port of Sacramento.

The new weir would have the same configuration and section as the existing weir. The new weir would consist of twenty-five 40-foot-wide bays and would be located to the north of the existing weir along the alignment of the railroad line. A temporary railroad line and road would be constructed that bypass the weir construction. The temporary railroad alignment uses 750-foot radii with transition segments. The speed of the train would be about 15 mph on the temporary bypass. The Sacramento River Road would be connected along a new alignment to the existing road after passing over the new weir. Upon completion of construction of the new weir, the temporary railroad and road bypass would be removed.

In addition, there is an old landfill that would have to be removed when the bypass is widened. The landfill occupies about 20 acres of land and averages about 5 feet in depth. Two agricultural pumping plants and a gaging station would be relocated, along with four buildings.

Sacramento Bypass Borrow Site and Construction Staging Area. The borrow material for this alternative would consist of dredge tailings from the Sacramento Deep Water Ship Channel as well as levee material from existing Bypass north side levee. An additional borrow site is located between Bradshaw Road and Happy Lane. Staging areas have been chosen to minimize environmental effects. They would be located in agricultural fields near the work sites. Staging areas are shown in Appendix D, “Real Estate.”

Raise and Strengthen Levees in the Yolo Bypass, Sacramento River, Sloughs. Levees along Yolo Bypass west bank in index areas 1R and 3 have seepage problems. The corrective

TABLE 5-9. Recommended Levee Fixes for Hydraulic Mitigation

River/Slough/Bypass	Length (feet)	Recommended Fix
Index Area 1L	6 miles	Line treatment
Index Area 1R/Yolo Bypass Channel	6,000	Slurry wall
Index Area 1R/Yolo Bypass Channel	6,000	Slurry wall
Index Area 1R/Yolo Bypass Channel	6,000	Slurry wall
Index Area 3/Shag Slough	6,000	Slurry wall
Index Area 3/Shag Slough	6,000	Slurry wall
Index Area 3/Steamboat Slough	2,500	Seepage/stability berm
Index Area 3/Steamboat Slough	1,500	Seepage/stability berm
Index Area 3/Sutter Slough	730	Drainage collection system/berm
	600	Drainage collection system
Index Area 3/Sacramento River	1,000	Seepage/stability berm
Index Area 3/Sutter Slough (349-1)	1,500	Stability berm
Index Area 3/Steamboat Slough (501-8)	2,000	Drainage collection system/berm wide
Index Area 3/Steamboat Slough (501-9)	2,500	Seepage/stability berm
Index Area 3/Steamboat Slough (3-2)	8,000	Stability berm
Index Area 3/Steamboat Slough (3-3)	300	Seepage berm
Index Area 3/Cache Slough (501-1A)	1,200	Seepage/stability berm
Index Area 3/Cache Slough (2098-10)	2,500	Stability berm
Index Area 3/Cache Slough (2098-10A)	400	Seepage/stability berm
Index Area 3/Yolo Bypass (2068-1)	2,500	Stability berm
Index Area 3/Yolo Bypass (2068-2)	10,000	Stability berm

action would be slurry walls to provide a seepage barrier. Levee work on Sutter, Steamboat and Cache Sloughs and Yolo Bypass in index area 3 are based on the Sacramento River Flood Control System Evaluation for the Lower Sacramento River Area, Phase IV, August 2000 and the Sacramento River Flood Control System Evaluation for the Lower Sacramento River Area, Phase IV, February 1993.

The length of the levee improvements in index area 1L amount to approximately 6 miles along the left bank of the Yolo Bypass from I-5 downstream to the north end of the Sacramento bypass. The proposed treatment for this site is to chemically stabilize the clay material using hydrated lime stabilization techniques. Lime stabilization would involve blending and compacting approximately 4 percent lime into the outer 4 feet of the levee slope, followed by recompaction in approximate 9-inch horizontal loose lifts. These improvements are based on the Sacramento River Flood Control Project, Mid-Valley Area, Phase III, June 1996 (Plates 5-14 and 5-15).

Yolo Bypass and Associated Sloughs, Borrow Sites and Staging Areas. The borrow locations for construction in these downstream areas would be dredge tailing disposal sites at Grand Island and the Port of Sacramento. Staging areas would be located in agricultural fields near the work sites.

Best Management Practices

The Corps has incorporated the following BMPs into Alternative 5. These measures would avoid or reduce adverse effects during construction:

- Litter and construction debris would be removed from the floodway and disposed of at an appropriate upland site.
- Any temporary access roads constructed in the floodway or near any body of water would have adequate provisions (e.g., sediment barriers, drainage settling basins) to prevent entry of sediment into the water.
- After project construction, temporary access roads and the temporary construction bridge would be removed, regraded to original contours where feasible, and reseeded with grasses.
- Refueling of equipment and vehicles would occur only in a designated part of the staging areas where potential spills can be readily contained.
- Equipment and vehicles operated in the staging areas in the floodway or near any water bodies would be checked and maintained to prevent leaks of fuels, lubricants, or other fluids.
- Any spills of hazardous material would be cleaned up immediately. Spills would be reported in construction compliance reports.

- Appropriate erosion control measures would be incorporated into the storm water pollution prevention program.

- All construction material placed in water shall be nontoxic. Any combination of wood, plastic, concrete, or steel is acceptable provided there are no toxic coatings, chemical antifouling products, or other toxic treatments that may leach into the surrounding environment.

- Cofferdams would be used for in-water construction. Water would be removed and routed to either (1) a sedimentation pond located on a flat, stable area that will prevent silt-laden water from reentering the river, ditch, or reservoir or (2) a sedimentation tank/holding facility that allows only clean water to return to the river and includes disposal of settled solids at an appropriate offsite location.

- A qualified biologist would examine the cofferdam prior to dewatering. If determined to be appropriate by the biologist, a fish salvage program would be conducted prior to complete dewatering. The rescued fish would be released downstream of the construction site.

- Construction areas in the Sacramento and Yolo Bypasses would be graded to slope back into the bypass drainage system to provide passage and escape for fish.

5.5.3 Real Estate Requirement

Lower American River

Lands would be required for environmental mitigation. No additional land requirement has been identified.

Downstream of American River

Real estate acquisition would be required for modifying the Sacramento Weir and widening the Sacramento Bypass by 1,000 feet. Lands also would be required for levee modification for hydraulic mitigation in the Yolo Bypass, Sacramento River, and associated sloughs. Lands would also be required for environmental mitigation.

5.5.4 Operation

In the stepped operation, the initial step flow is 115,000 cfs, the discharge capacity of the Folsom Dam outlets. Discharge increases as the reservoir stage encroaches into the flood space and reservoir inflow continues to increase. For this plan, discharge progressively increases to 145,000 cfs whereas under without-project conditions, the discharge is held to 115,000 cfs. Once 145,000 cfs is reached, it is held until flood conditions are such that under without-project conditions, flood damages would have begun. At this point, about frequency 0.0167 or 1 chance in 60 years, discharges would increase to the channel capacity of 160,000 cfs, depending on inflows to and water surface of Folsom Lake. The Lower American River channel and levees would be improved as described above to better accommodate the emergency flow of 160,000

cfs. Hydraulic mitigation features downstream from the American River are based on a release of 145,000 cfs. Although effects are not severe enough to consider this a taking of property, mitigation is deemed necessary because the Sacramento and Yolo Bypasses are designed for 115,000 cfs maximum flow from the American River, and the additional releases would actively encroach on design capacities and increase flood risk.

With- and without-project hydrographs for a 200-year event at Fair Oaks are compared on Plate 5-17. The resultant flow frequency curve is shown on Plate 5-18.

5.5.5 Accomplishments and Residual Risk

This plan would have the capability to help increase flood protection to Sacramento by reducing the probability of flooding. Table 5-10 shows the residual damages and percent of the without-project damages and the reduction in the probability of flooding Sacramento due to levee failure. The conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 52.6 percent.

TABLE 5-10. Accomplishments and Residual Risk of Alternative 5

Without-Project Advance Release Scenarios	Without-Project Damage ($ million)	With Alternative 5 Residual Damage ($ million)	Percent	Percent Chance Exceedance (1-in-X Chance per Year)	
				Without Project	With Project
No advance release	86.0	77.8	90	0.0071 (140)	0.0067 (149)
Moderate advance release (0-100,000-190,000 acre-feet)[1]	72.8	67.0	92	0.0061 (164)	0.0058 (172)

[1] Advance release scenario adopted for alternative analysis

Under this plan, a significantly greater emphasis is placed on reducing the flood threat to Sacramento by increasing reliance on high levees. This is because a major plan component is increasing the objective release from Folsom Dam and modifying levees along the Lower American River to safely accommodate this higher flow. Accordingly, although the chance of levee failure and flooding is significantly reduced with this plan, the initial effects and associated risks when the levees do fail are substantial.

5.6 Alternative 6: Stepped Release to 160,000 cfs and New Outlet at Folsom Dam

5.6.1 Description

In addition to the Stepped Release to 160,000 cfs, this alternative would include stepping early to 145,000 cfs through the use of new low-level outlets that would be added to Folsom Dam as part of this alternative. A new outlet would be added at Folsom Dam to increase the early release capacity from 115,000 cfs to 145,000 cfs. The higher early release would result in conserving flood storage by stepping up to 145,000 cfs earlier than without-project condition.

The release would step to 160,000 cfs in a manner similar to that under Alternative 5. This plan would not include a Folsom Dam safety component.

5.6.2 Plan Components

This plan would include construction of an additional outlet to increase the outlet release capacity from 115,000 cfs to 145,000 cfs. In addition, modifications to the stilling basin located under the auxiliary spillway would be needed. This plan would also change the dam operations by modifying release.

Folsom Dam

A new low-level outlet would be added to Folsom Dam to allow the dam to make an earlier release of 145,000 cfs. The outlet consists of a 6-foot by 12-foot gated conduit through the dam, exiting on the auxiliary spillway face and discharging into the spillway stilling basin. Capacity of the outlet would be 30,000 cfs at gross pool. Because of the erosion potential in the effect area below the auxiliary spillway due to the higher release, a plunge pool to dissipate the force of the higher release would be constructed.

Lower American River

Levee improvements, facility modifications, and relocations would be as described for Alternative 5.

Downstream from the American River

Modifications to the Sacramento Weir and Bypass and hydraulic mitigation would be as described for Alternative 5.

Best Management Practices

The Corps has incorporated BMPs into Alternative 6 to avoid adverse effects during construction. These BMPs are the same as discussed for Alternative 5.

5.6.3 Real Estate Requirement

The real estate requirements under Alternative 6 would be the same as under Alternative 5. Excess material generated by modifications to the stilling basin under the auxiliary spillway would be disposed of at a local landfill.

5.6.4 Operation

With this plan, the low-level outlets would release up to 145,000 cfs, approximately matching inflow to Folsom Reservoir, without a step at 115,000 cfs. The 146,000-cfs flow would be maintained until Folsom Dam inflow and storage conditions are such that under without-project conditions, flows at the mouth of the American River would be at 160,000 cfs and thus stepping up to that flow with the project in place would not be an effect. Folsom Dam

operation would depend on release rules that would govern controlled releases to 145,000 cfs, then to 160,000 cfs. The resultant inflow and outflow hydrographs for a 200-year event at Fair Oaks are shown on Plate 5-17, and flow frequency curves are shown on Plate 5-18.

5.6.5 Accomplishments and Residual Risk

This plan would have the capability to help increase flood protection to Sacramento by reducing the probability of flooding due to levee failure. Table 5-11 shows the residual damages and percent of the without-project damages and the reduction in the probability of flooding Sacramento due to levee failure. The conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 56.2 percent.

TABLE 5-11. Accomplishments and Residual Risk of Alternative 6

Without-Project Advance Release Scenarios	Without-Project Damage ($ million)	With Alternative 6 Residual Damage ($ million)	Percent	Percent Chance Exceedance (1-in-X Chance per Year)	
				Without Project	With Project
No advance release	86.0	74.1	86	0.0071 (140)	0.0065 (154)
Moderate advance release (0-100,000-190,000 acre-feet)[1]	72.8	64.0	88	0.0061 (164)	0.0054 (185)

[1] Advance release scenario adopted for alternative analysis

5.7 Alternative 7: Stepped Release to 180,000 cfs

5.7.1 Description

This plan represents the "high end" of a stepped release plan. Similar to Alternative 5, it consists of increasing the objective releases from Folsom Dam during floods from 115,000 to 145,000 cfs, but the emergency release is increased from 160,000 cfs to 180,000 cfs. Releases in excess of 145,000 cfs would depend on the severity of the storm and its effect on storage in Folsom Reservoir. The levees and some bridges (Howe Avenue and Guy West Bridges) along the Lower American River would need to be modified to accommodate a flow of 180,000 cfs.

Identical to Alternative 5, the increased 145,000-cfs objective release would require extensive downstream mitigation.

This alternative does not include dam safety improvements to Folsom Dam. (Dam safety is a without-project condition).

The plan components, real estate requirement, operation, and accomplishments and residual risk associated with Alternative 7 are described below.

5.7.2 Plan Components

Lower American River

The basic Lower American River features are shown on Plate 5-19.

Raise and Strengthen Existing American River Levees. About 13.5 miles of Federal and non-Federal levees along the north and south banks of the American River would be raised. The average raise for both Federal and non-Federal levees would be approximately 2 feet. Levees would be raised on the river side to avoid effects on land use and development on the land side. The total width of affected areas associated with levee raising would be approximately 30 feet. Of this, permanent effects attributable to expansion of the levee base would average 10 feet. There would also be a 10-foot permanent easement and a 10-foot temporary construction easement. The crown width would be maintained.

A total of 1.1 miles of existing levees would be strengthened with a slurry cutoff wall. The levees that require strengthening are on the left bank at Tiffany Farms and Cordova Meadows near river mile 13. The Tiffany Farms levee is a private levee and the Cordova Meadows levee is a Sacramento County levee. Each site would also have a 10-foot permanent easement and a 10-foot temporary construction easement.

Levee strengthening by a stability berm and lengthening the levee slope would occur on the right bank of the American River from the Sacramento River to about the NEMDC. The stability berm would be 7 feet high and extend the levee base about 15 feet on the land side. Some sections of the landside levee slope would be extended so that the slope would be 2 horizontal to 1 vertical. (See Plate 5-11.)

Erosion protection would be placed along 5.8 miles of the levees so the levees could withstand the higher flow velocities associated with this plan. (See Plate 5-20).

It is not anticipated that the increased flows would erode natural channel banks, leading to undercutting of levees; thus, bank protection is not required.

New Levees and Floodwalls. Work includes constructing 2 miles of new levees and 1.7 miles of floodwalls. New floodwalls would be constructed around Goethe Park and the Nimbus Hatchery. Six short reaches of new levees would be built between river mile 12 (near Bradshaw Road) and river mile 22 (downstream of Hazel Avenue). An objective release of 180,000 cfs would cause the river to flood areas that are not now flooded at the 160,000-cfs flow. The new levees and walls would protect those areas. The new levees would have an average height of approximately 5 feet, with a crown width of 20 feet and average base of 45 feet. There would be 10-foot-wide permanent easements on both sides of the levee. The total width of affected area associated with the new levees would be approximately 75 feet. The Goethe Park floodwall would have an average height of 3 feet, with a 10-foot-wide permanent easement and a 6-foot-wide temporary construction easement. The Nimbus Hatchery floodwall would have an average height of 2 feet, with a 10-foot permanent easement, and a 5-foot temporary construction easement. The total width of affected area associated with the Nimbus Hatchery floodwall would be 15 feet.

Modify Bridges. Flows up to 180,000 cfs in the Lower American River channel would be accommodated by raising the height of the Howe Avenue and Guy West bridges between 3 and 5 feet, and modifying the UPRR trestle.

Howe Avenue Bridge. For the Howe Avenue Bridge, a 180,000-cfs flow water surface would be 1.6 feet above the bottom of the bridge (soffit). This would impede flow and cause backwater, raising the water surface 0.5 feet. The Howe Avenue crossing consists of two bridges, one for northbound traffic, and the other for southbound traffic. Each bridge has two lanes.

Howe Avenue Bridge would be raised 5.3 feet so the soffit would be at the elevation of the PFP. Nearby bridges over University Avenue and La Riviera Drive would be equally raised. To minimize effects on traffic, the bridge would be replaced with a new structure at a higher elevation. This approach would allow the existing number of traffic lanes to be maintained throughout the construction period. The stages of construction are listed below and shown on Plate 5-20.

- Stage 1 – Construct a new segment of bridge to the planned grade between existing structures.
- Stage 2 – Move southbound traffic to new bridge segment.
- Stage 3 – Demolish the existing southbound bridge.
- Stage 4 – Construct the second segment of the new structure.
- Stage 5 – Shift all traffic over to the new segments.
- Stage 6 – Demolish the existing northbound bridge.

The adjacent overcrossing structures at University Avenue and La Riviera Drive could be raised in the same construction period as the main spans over the American River and would not be subject to the limitation of working within the riverbanks.

Union Pacific Railroad (UPRR) Trestle. The UPRR crossing of the American River near river mile 2.5, upstream of the NEMDC, is a main line owned by UPRR. The right bank trestle of this crossing is about 1,110 feet long and 8 feet wide. It is single-track timber pile trestle. This trestle crosses the existing north levee of the American River approximately 5 feet below the levee crown. The trestle would be inundated during high flows with this plan. Since the velocities are very low in this area, there are no hydraulic or structural problems with leaving the existing structure in place. Therefore, this trestle would not be raised. A flood gate, however, would be constructed where the track crosses the north levee below the levee crown. The structure would be closed whenever there is a potential for high flows along the river. There is also a potential that extreme log and debris loading would overstress some of the piles. To remedy this, the plan includes structural strengthening of the trestle. (See Plate 5-21.)

Guy West Pedestrian Bridge. This suspension bridge links the Campus Commons neighborhood to the California State University, Sacramento campus. It is an important and heavily-used bicycle and pedestrian commute route across the river, as well as a local landmark. It is owned by the City of Sacramento. The bridge would be raised 3 feet. The operation would uniformly raise the entire suspension span. The bridge approaches would be raised 3 feet and meet the grade of the existing paths. Construction would take about 1 year. Traffic would be rerouted to the H Street bridge, located ½ mile downstream. Traffic would use the existing H Street bridge walkway on the upstream side of the bridge. (See Plate 5-22.)

Modify Local Drainage Facilities. Pumping stations and drainage facilities that are designed to convey drainage from the landside of levees to the American River with existing 115,000-cfs release would be modified for the 145,000-cfs release. Modifications would be as described for Alternative 5.

Modify Water Intake Facilities. Required modifications to some water intake facilities located along the American River would be as described for Alternative 5.

Lower American River Utility Relocation. Utility relocation would be about as described for Alternative 5. All relocations, including recreation features, would be identified during final design.

Lower American River Borrow Sites. Borrow sites would be the same as under Alternative 5.

Lower American River Construction Staging Areas. Construction staging areas would be the same as under Alternative 5.

Downstream from American River

The stepped release to the emergency 180,000-cfs flow would occur after downstream areas would have already flooded under without-project conditions. Thus, hydraulic mitigation is limited only to the increase in the objective release of 145,000 cfs. Hydraulic mitigation is therefore the same as described for Alternative 5.

Best Management Practices

The Corps has incorporated BMPs into Alternative 7 to avoid adverse effects during construction. These BMPs are the same as discussed for Alternative 5.

5.7.3 Real Estate Requirement

Under Alternative 7, real estate acquisition would be required to support raising and strengthening existing American River levees by 2 feet for approximately 13.5 miles; providing erosion protection of some levee slopes; constructing 3.7 miles of new levees, floodwalls, or both; raising three bridges; modifying interior drainage facilities; and, downstream of the American River, modifying the Sacramento Weir and widening the Sacramento Bypass by 1,000 feet. The increased flows associated with this alternative also would require levee work in the

Yolo Bypass, Sacramento River, and associated sloughs. Real estate requirements for this hydraulic mitigation would be the same as under Alternative 5.

5.7.4 Operation

In the stepped operation, the initial step flow would be 115,000 cfs, the discharge capacity of the low-level outlets. Folsom Dam discharge increases as reservoir stage encroaches into the flood space and reservoir inflow increases. For this plan, discharge progressively increases to 145,000 cfs whereas under without-project conditions, the discharge is held to 115,000 cfs. Once 145,000 cfs is reached, it is held until flood conditions are such that under without-project conditions, flood damages would have begun. At this point, about percent exceedance of 0.0059 or 1 chance per 170 years, discharges would increase to the new channel capacity of 180,000 cfs, depending on inflows to and water surface of Folsom Lake. Because conditions below the mouth of the American River for these very rare events would be no worse than with the project, the hydraulic mitigation was limited to the 145,000-cfs release that would be experienced during the more frequent floods.

5.7.5 Accomplishments and Residual Risk

This plan would have the capability to help increase flood protection to Sacramento by reducing the probability of flooding due to levee failure. Table 5-12 shows the residual damages and percent of the without-project damages and the reduction in the probability of flooding Sacramento due to levee failure. The conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 59.7 percent.

TABLE 5-12. Accomplishments and Residual Risk of Alternative 7

Without-Project Advance Release Scenarios	Without-Project Damage ($ million)	With Alternative 7 Residual Damage ($ million)	Percent	Percent Chance Exceedance (1-in-X Chance per Year)	
				Without Project	With Project
No advance release	86.0	71.3	83	0.0071 (140)	0.006 (167)
Moderate advance release (0-100,000-190,000 acre-feet)[1]	72.8	61.8	85	0.0061 (164)	0.0051 (196)

[1] Advance release scenario adopted for alternative analysis

As with Alternatives 5 and 6, a significantly greater emphasis is placed on reducing the flood threat to Sacramento by increasing reliance on high levees. This is because a major plan component is increasing the objective release from Folsom Dam and modifying levees along the Lower American River to safely accommodate this higher flow. Accordingly, although the chance of levee failure and flooding is reduced with this plan, the initial effects when the levees do fail and associated risks are substantial.

5.8 Alternative 8: Stepped Release to 160,000 cfs and Seven-Foot Dam Raise/482-Foot Flood Pool Elevation

5.8.1 Description

This alternative provides very high flood protection by combining all the features of Alternative 5 with all the features of Alternative 3. Features include dam safety and downstream hydraulic mitigation as described previously. The plan components, real estate requirement, operation, accomplishments, and residual risk associated with Alternative 8 are described below.

5.8.2 Plan Components

The plan components under Alternative 8 would be a combination of those under Alternative 5 and Alternative 3.

5.8.3 Best Management Practices

The Corps has incorporated BMPs into Alternative 8 to avoid adverse effects during construction. These BMPs are the same as discussed for Alternatives 5 and 3.

5.8.4 Real Estate Requirement

The real estate requirements under Alternative 8 would be the same as the combined land requirements under Alternatives 3 and 5.

5.8.5 Operation

Operation of this alternative would be consistent with that of Alternatives 3 and 5.

As part of the operation and maintenance program, the local sponsor has agreed to implement an Adaptive Management Plan to ensure that there are no unforeseen effects on vegetation and wildlife.

5.8.6 Accomplishments and Residual Risk

This plan would have the capability to help increase flood protection to Sacramento. Table 5-13 shows the residual damages and percent of the without-project damages and the reduction in the probability of flooding Sacramento due to levee failure. The conditional probability of nonexceedance (i.e., no levee failure) for the 200-year storm in Sacramento is about 68.0 percent.

TABLE 5-13. Accomplishments and Residual Risk of Alternative 8

Without-Project Advance Release Scenarios	Without-Project Damage ($ million)	With Alternative 8 Residual Damage ($ million)	Percent	Percent Chance Exceedance (1-in-X Chance per Year)	
				Without Project	With Project
No advance release	86.0	59.5	69	0.0071 (140)	0.0051 (196)
Moderate advance release (0-100,000-190,000 acre-feet)[1]	72.8	52.5	72	0.0061 (164)	0.0045 (222)

[1] Advance release scenario adopted for alternative analysis