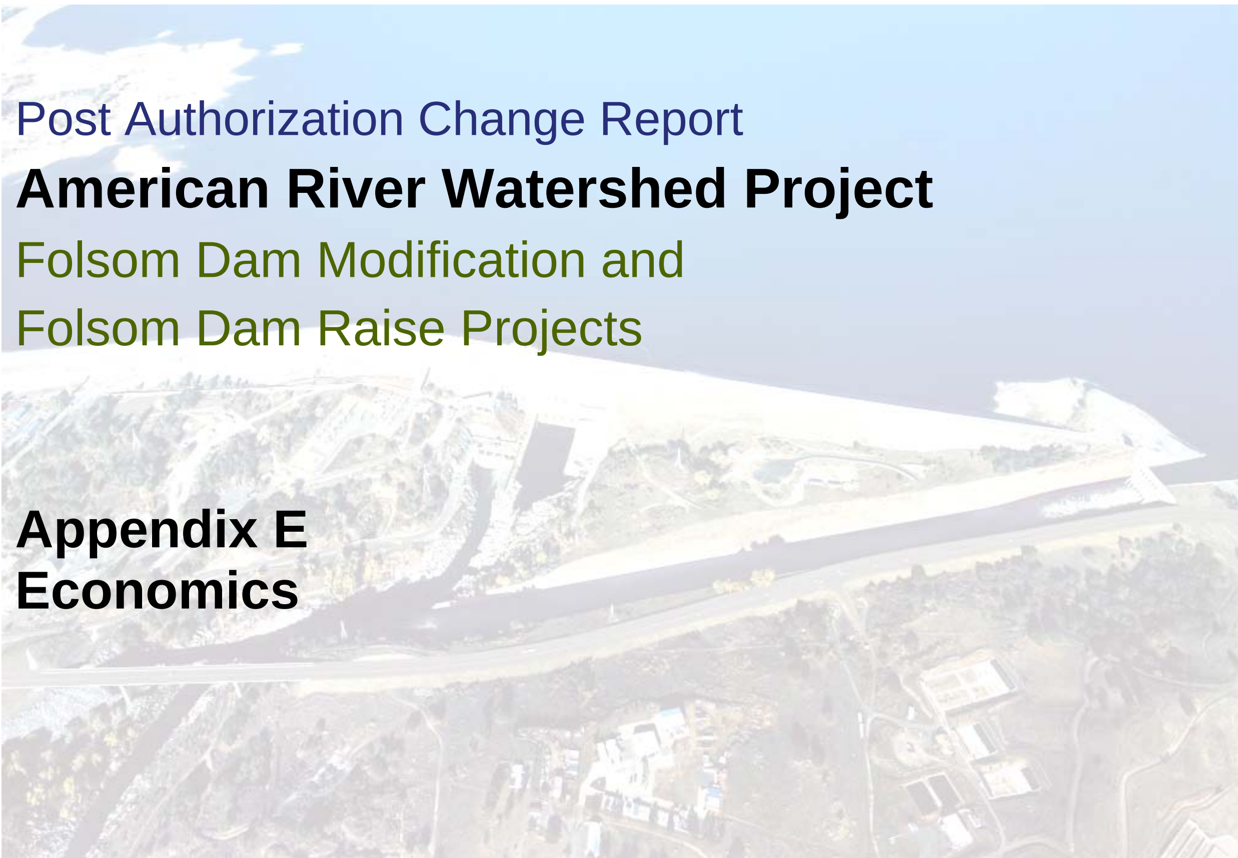
American River Watershed Project

Post Authorization Change Report

American River Watershed Project

Folsom Dam Modification and Folsom Dam Raise Projects

Appendix E
Economics



US Army Corps
of Engineers

Sacramento District
South Pacific Region

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CHAPTER 1.0
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The purpose of this analysis is to determine the benefits and project performance statistics associated with alternative outlet, gate, and dam height modifications to Folsom Dam. In this current risk-based analysis, it is assumed that the authorized Common Features (Water Resources Development Act (WRDA) of 1999) on the Lower American River are completed and are part of the without-project condition.

This current analysis serves as a supplement to a series of documents on the American River Watershed, to include the 1996 Supplement Information Report, which first identified a version of the Folsom Dam Modification as a possible alternative. The most recent document with economic risk-based analysis of Folsom Dam is the American River Folsom Modifications Limited Reevaluation Report (LRR) Economics Appendix, revised in November 2003. Unless otherwise noted, all references to prior studies in this appendix are to the November 2003 revised economics appendix. Values in this document represent October 2006 price levels, a 50-year period of analysis, and the Fiscal Year 2007 Federal discount rate of 4 7/8 percent.

1.2 PRIOR REPORTS

Much of the economic data in previous American River Watershed planning reports have their beginnings in the initial 1991 American River Watershed Investigation Feasibility Report. The floodplains and depth of flooding currently being used in the economic analysis are from this 1991 report. The selected plan from that document was a detention dam at Auburn providing over 500,000 acre-feet of flood storage and reducing the flood risk for Sacramento to a 1 in 200 chance in any given year (using pre-risk-based evaluation methodologies). This project was not authorized by Congress and two of many incremental projects to follow were adopted to help reduce flood damages in the Sacramento area. These were the Sacramento Area Flood Control Agency (SAFCA) North Area Levee Project (Natomas) and Re-operation of Folsom Dam from 400,000 acre-feet of fixed space to a variable 400,000/670,000 acre-feet.

The next report was the 1996 Supplemental Information Report (SIR). The 1996 SIR was the first document to use a risk-based methodology for determining economic benefits on the American River. The economic inventory was revised for this study to include structures not included in the 1991 report (but out of the Federal Emergency Management Agency (FEMA) 100-year floodplain). The SIR identified three final alternatives: the Stepped Release, Folsom Modifications, and Detention Dam plans. The Detention Dam, which reduced flood risk along the American River to a less than 1 in 500 chance of flooding in any given year, was determined to be the National Economic Development (NED) plan but not recommended in the Chief’s Report. Instead, a less controversial Common Features alternative was authorized. This alternative included “features” that were part of all three final alternatives and would not preclude selection at a future time of any of the three. Completion of the Common Features was expected at the time to provide Sacramento with “100-year protection”; this term is no longer used in Corps guidance.

In 1999, the Water Resources Development Act (WRDA) authorized additional levee improvements to supplement the 1996 Common Features and authorized a modified version of the Folsom Modifications Plan identified in the 1996 SIR. WRDA 99 also authorized additional study of flood damage reduction measures beyond the Folsom Modifications.

For economic analysis, three documents resulted from this authorization:

- Common Features LRR, completed in 2001
- Folsom Modifications LRR, revised November 2003
- American River Long Term Study, completed in 2002

The biggest change in the economic analysis was the reevaluation documented in the Folsom Modifications LRR, which was incorporated into the other two reports. During the reevaluation, a new inventory was gathered based on the original 1991 Feasibility Report floodplains but with new structure counts and valuations. The new inventory was completed in 2000. Damage estimates were developed for the first time on the American River using economic uncertainties in the model.

The Common Features report was split into two areas:

- The Lower American River levee improvements, which are functional, and enable the American River to pass the 100-year event[1]
- The Natomas area, which required significant reformulation and development of a General Reevaluation Report (GRR), which was not completed at the time of this report.

The Long Term Study recommended a 7-foot raise of Folsom Dam, providing both additional flood damage reduction and dam safety (enabling the facility to pass 100 percent of the probable maximum flood (PMF)).

The Folsom Modifications revised economics report (November 2003) identified the recommended project as new and enlarged existing outlets capable of releases of 115,000 cfs and improvements allowing for the use of surcharge storage up to elevation 474 feet. First costs for this project were estimated at approximately $215 million with annual benefits of $32 million and annual costs of $16 million providing a benefit-to-cost ratio of 2.0 to 1. This project was estimated at the time to reduce the risk of flooding to a 1 in 140 chance in any year.

1.3 REASONS FOR COMBINING AUTHORIZATIONS AND PROJECT PURPOSES

In this appendix, project elements from both the Folsom Modifications and the Long Term study (Folsom Dam Raise) are being considered not only for the purpose of flood damage reduction but also for dam safety. During the design refinements for Folsom Modifications, it was believed that due to significant increases in the cost estimates, the authorized project may

[1] FEMA certification for the American River was not obtained using the Corps' standard risk-based analysis methodology. This study was initiated prior to Corps guidance regarding conditional non-exceedence probability, and a waiver permited the Sacramento District to route the base flood (computed 100-year probability event) and evaluate in conjunction with FEMA freeboard consideration.

not be optimal or even economically feasible. Various outlet configurations, both in number and location, were evaluated. During this preliminary analysis, it appeared that adding operational gates to the proposed United States Department of the Interior, Bureau of Reclamation (Reclamation), dam safety auxiliary spillway may provide a more efficient way to meet two project purposes. From this analysis, a Joint Federal Project (JFP) including a new auxiliary spillway and operational submerged tainter gates was identified.

1.4 GOALS OF THE JOINT FEDERAL PROJECT

The Folsom Joint Federal Project was intended to meet not only the objectives of the Corps but Reclamation and the local sponsor as well. As mentioned, this economic analysis includes elements of three authorizations, the Folsom Modification and Folsom Dam Raise projects, and Reclamation's dam safety project.

The objectives of the Joint Federal-Project (JFP) in terms of economic outputs and project performance are:

1) Reduce flood damages as effectively and efficiently as possible within a limited schedule and without complete reformulation.
   a) More flood damage reduction measured in both lower residual damage and annual exceedence probability is desired.
   b) Net benefits need to be positive (annual benefits exceed annual costs) for all alternatives considered.
   c) Any selected alternative will be on the "rising limb" of the net benefit curve (relative to project performance). In other words, for Federal planning objectives, no smaller plan (at lower cost) would provide greater net benefits.
2) Safely pass the 200-year design flow event without levee failure (based on design non-risk-based criteria).
3) Pass the PMF without placing the dam structure in danger of failure.

This appendix documents revisions to the economics since the Folsom Modifications 2003 report, discusses limitations to the analysis, and describes results and successes of various alternatives at meeting the three goals listed above.

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CHAPTER 2.0
ASSUMPTIONS AND REVISIONS TO THE WITHOUT-PROJECT ECONOMICS

2.1 PURPOSE AND SCOPE

During the week of August 10th 2006, an Economic Advisory Panel of senior U.S. Army Corps of Engineers (Corps) economists met in Sacramento to discuss economic issues related to the Combined Project and identify what could be done to improve the analysis for the Joint Federal Project (JFP). The group noted 13 recommendations for the analysis (see **Attachment 1**). Many of these require significant inputs from the Project Delivery Team (PDT) and cannot be completed within the schedule of the Post Authorization Change (PAC) Report. The PDT is currently working on two tracks to address these recommendations:

1) Those that require limited effort will be included in this appendix for the PAC Report
2) Those that require detailed analysis will be deferred to a new Economic Reevaluation Report

2.2 WITHOUT-PROJECT ASSUMPTIONS FOR THE PAC REPORT

In addition to the assumption of the Common Features being in place, following the recommendations of Economic Advisory Panel, the base economic condition will include the dam safety component as the first increment of Federal action. Reclamation has a recommended stand-alone dam safety project that includes an auxiliary spillway and fuseplug to pass the PMF. Any alternative that meets both flood damage reduction objectives and can pass the PMF will remove the need for the stand-alone dam safety project, providing a potential cost savings benefit.

For this PAC, the assumption for economic purposes is that the downstream impacts will be no greater than from the completed Common Features project. No downstream inventory will be collected or project performance evaluated for downstream reaches. The study area will remain as described in the 2003 Folsom Modifications LRR. Detailed evaluation of downstream impacts will be deferred to the Economic Reevaluation Report.

In the 2003 Folsom Modifications report, residential without-project damages were determined using FEMA-based curves from 1988. The Economic Advisory Panel recommended replacing these curves with curves developed by the Institute of Water Resources (IWR) in 2004 that can be found in Economic Guidance Memorandum EGM 04-01. This change has been incorporated in the current analysis and is reflected in the revised without-project residential damages in this appendix.

Past economic analysis for this study has focused on National Economic Development (NED). The recommendation of the Economic Advisory Panel, to be consistent with EC 1105-2-409, was to broaden the focus to include some evaluation of the other three accounts; Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ).

Further discussion of these three accounts will be deferred to the Economic Reevaluation Report, including a discussion of the following Other Social Effects:

- Population at risk
- Loss of life potential

Several factors that contribute to the damage functions for emergency costs, public utilities and infrastructure were revised for this PAC report analysis. Costs for dewatering and levee repairs were also added to the without-project condition.

Recommended economic revisions deferred to the Economic Reevaluation Report include:

- New without-project floodplains
- New economic inventory
- New study impact areas to potentially include downstream
- Non-residential content surveys to address changes in content values (or percentages to structures) and potential content damages by depth
- Recommendations requiring non-economic PDT lead:
  - Reexamine potential operations, maintenance, repair, replacement & rehabilitation (OMRR&R) savings from gate replacement
  - Address uncertainties in cost
  - System risk and completeness of alternative plans

2.3 ECONOMIC REEVALUATION REPORT – REVISION OF THE WITHOUT-PROJECT CONDITIONS

As mentioned in **Section 2.2**, many of the recommendations of the Economic Advisory Panel cannot be completed in time for this PAC report and have been deferred to the concurrent Economic Reevaluation Report. Hydrologic and hydraulic revisions are currently being finalized, including development of new floodplains. The critical economic tasks that will lead to revised without-project damage estimates include: a) development of new structural inventory, b) new area-specific non-residential content values and content depth-damage functions, and c) revised emergency costs that address “lessons learned from post-Katrina” and more accurately reflect catastrophic urban losses. In addition to NED losses, the other accounts to include RED and OSE will be included in the Economic Reevaluation Report. These revised without-project estimates for the ERR are scheduled to be completed by April 30, 2007.

2.4 STUDY AREA – ECONOMIC REACHES

For the 2003 LRR, the inventory was grouped geographically into four economic reaches, the Downtown Area, Rancho Cordova, South Sacramento, and North Sacramento (the Natomas reach was excluded as the project does not provide benefits for that area). The area is extensive, with about 55,000 acres subject to inundation. The reaches and extent of the floodplain can be seen in **Figure 2-1**.

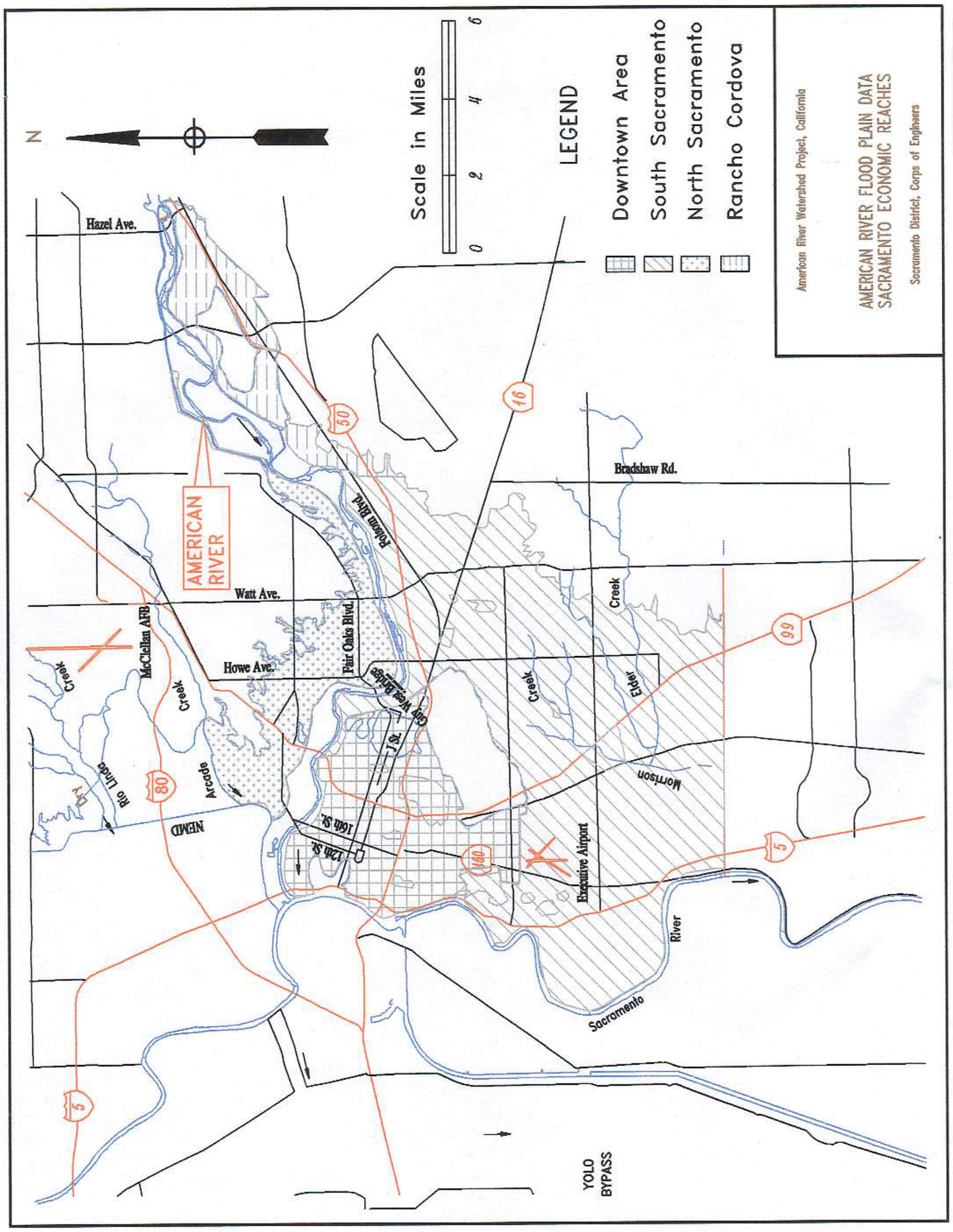

FIGURE 2-1
STUDY AREA AND STUDY REACHES

2.5 INVENTORY

2.5.1 Residential

The structural inventory completed for the 2003 LRR was not modified for this current analysis. The original floodplains, developed in 1989 for the 1991 Feasibility Study, included 100-year and 400-year frequency delineations with depths delineated for the 80-, 100- and 400-year floods for 93 different subareas. While these frequencies have changed due to new flow-frequency relationships and completed project elements, the corresponding outflows still would produce similar flooding characteristics (same depths, area extent, duration) but at different frequencies (the original 100-year would be equal to 70-year current and the original 400-year would be around 600-year current). The original floodplains were digitized and used for developing the inventory utilizing digital parcel data. The inventory represents all residential structures in the floodplain, including new development up to the year 2000. All new development was adjusted for elevation to guarantee that there are no economic losses associated with any new development within the 100-year floodplain. **Table 2-1** shows the number of residential units by land use and reach.

TABLE 2-1
NUMBER OF STRUCTURES BY LAND USE AND REACH

Reach	Residential Units	Commercial	Industrial	Public	Total
Downtown	21,869	1,610	47	383	23,909
North Sacramento	12,046	1,229	29	303	13,607
Rancho Cordova	6,830	262	20	14	7,126
South Sacramento	64,154	1,528	77	513	66,272
TOTAL	**104,899**	**4,629**	**173**	**1,213**	**110,914**

2.5.2 Commercial- Industrial-Public

The updated inventory includes the original 1989-1990 inventory plus revisions from both the 1996 SIR and the 2003 LRR. This inventory was a complete count (without sampling) and is representative of conditions as of 2000. **Table 2-1** shows the number of commercial, industrial, and public structures by area.

2.5.3 Valuation of Structure and Content

All structure values were revised using Marshall & Swift Valuation to October 2006 prices for the Sacramento area. The values in **Table 2-2** were based on M&S price revisions, which were based on depreciated replacement values found in the Folsom Modifications Report 2001. Each structure in the report had a unique structure value taken from the assessor data. To verify and adjust those values to represent depreciated replacement values in (at the time current) October 2000 prices, a sample of 365 residential and 200 non-residential structures were valued in detail based on field visitation, square footage, estimated depreciation, and Marshall & Swift dollars per square foot (SF) based on use, class, and type. For the residential sample, the range was from a low of $23,000 (700 SF poor) to a high of $384,000 (4,700 SF very good) for the structure value. The commercial sample had a larger range from $45,000 to $27,000,000. These values were then compared to the recorded improvement value for each observation in the sample and factors were determined based on these and applied to the population. For this 2006 PAC report, these 2000 values were brought forward using M&S Comparative Cost Multipliers for Sacramento.

Nonresidential content values were determined as a percentage of the structure value. Residential contents were originally set at 50 percent by district convention but with the use of the EGM 04-01 curves, content value is not used in the damage calculations. Nonresidential contents ranged from 24 percent to 209 percent of structure value depending on use category and were taken from the original 1991 feasibility study (primary source: New Orleans District, Lake Pontchartrain). In the economic reevaluation, one of the critical tasks is to conduct surveys (within the floodplain area) to revise content percentages.

Structure and content values for each reach and category are listed in **Table 2-2** with a total of over $38 billion.

TABLE 2-2
VALUE OF DAMAGEABLE PROPERTY ($ MILLIONS)

Land Use	Area Reach				Total
	Downtown	North Sacramento	Rancho Cordova	South Sacramento	
Residential					
Structures	2,702	2,115	1,246	7,364	13,427
Contents	1,350	1,057	623	3,684	6,714
Commercial					
Structures	1,929	1,635	470	2,330	6,364
Contents	2,180	1,847	538	2,652	7,217
Industrial					
Structures	30	19	34	206	289
Contents	34	19	36	214	303
Public					
Structures	1,211	382	29	1,167	2,789
Contents	505	162	23	611	1,301
TOTAL	**9,942**	**7,236**	**2,999**	**18,228**	**38,405**

Note:
1. *October 2006 Price Levels.*

2.6 WITHOUT-PROJECT DAMAGES

Primary revisions to the without-project single event damages from the 2003 report include:

- Increased valuations shown in **Table 2-2**
- Revised residential depth-damage functions
- Revisions to emergency costs

On average, these changes led to an increase in damages for individual events by about 50 percent over the level estimated in the 2003 report. Damages by each category were estimated based on the original 80-, 100-, and 400-year depths (but assigned new frequencies as identified in the current hydrology & hydraulic studies) from the original 1991 study. These damages were then linked to a common index point for all reaches and tied to stages within the channel. Damages for intermediate stages between the original events were interpolated based on discharges to complete the stage damage functions. Note that revisions to emergency costs were limited to temporary relocation assistance based on the number of people evacuated and average costs and durations seen during past floods in Northern California. These estimates do not include any of the type of catastrophic losses seen from Katrina and probably significantly underestimate the true emergency costs that a metropolitan area such as Sacramento would see from a major flood event. As mentioned, emergency cost revisions will be one of the critical tasks of the Economic Reevaluation Report.

The revised single index point (all reaches combined) by category Stage Damage functions is shown in **Table 2-3**. The mean and standard deviation damages in this table represent the economic input into the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) model. Note that the stages in Table 2-3 represent the exterior elevation (within the river channel using infinite channel height in the model) and not the interior flood depths. HEC-FDA needs to link the damages based on this stage (elevation) in the channel to frequency, based on the stage-discharge function to determine the exceedance probability-damage function. The link between the exterior stage and the flood plain depths was made by comparing the common outflow-stage relationship based on the (original 1991 100-year and 400-year) outflows connected to the original flood plains. The actual depths in the flood plain ranged from 1 to 20 feet depending on event and location. Total event damages would be just over $10 billion for the original 100-year event (about 70-year current) and over $20 billion for the 400-year event (about 600-year current).

TABLE 2-3
WITHOUT-PROJECT STAGE AND EVENT EXCEEDENCE PROBABILITY DAMAGE FUNCTIONS ($ BILLIONS)

Stage in Feet	Event Exceedence Probability		Res.	Com.	Ind.	Public	Auto-Road	Emer. Costs	Total Mean
43.14	0.0167	Mean	0	0	0	0	0	0	**0**
		Std. Dev.	0	0	0	0	0	0	
43.79	0.0157	Mean	5.672	1.332	0.017	0.582	0.027	0.030	**7.660**
		Std. Dev.	0.664	0.206	0.002	0.090	0.004	0.005	
49.45	0.0108	Mean	6.936	1.861	0.039	0.748	0.238	0.330	**10.152**
		Std. Dev.	0.665	0.232	0.004	0.093	0.031	0.051	
56.34	0.0075	Mean	8.421	3.530	0.169	1.123	0.356	0.387	**13.986**
		Std. Dev.	0.699	0.387	0.018	0.123	0.039	0.060	
67.77	0.0053	Mean	10.046	4.517	0.206	1.320	0.472	0.443	**17.004**
		Std. Dev.	0.756	0.449	0.021	0.130	0.047	0.069	
73.55	0.0019	Mean	10.941	5.971	0.253	1.598	0.650	0.519	**19.932**
		Std. Dev.	0.717	0.505	0.022	0.135	0.054	0.081	
74.73	0.0015	Mean	11.134	6.202	0.258	1.639	0.650	0.519	**20.402**
		Std. Dev.	0.732	0.526	0.022	0.140	0.054	0.081	

Note:
1. *October 2006 Price Levels.*
2. *Stage represents the elevation within the channel at the common index point.*

2.6.1 Hydraulic and Geotechnical Data

The stage-discharge and levee failure relationships (PNP/PFP – Probable Non-Failure and Probable Failure Points) have changed slightly (to reflect a move in location of the index point) from the 2003 study, and represent without-project conditions that include the completion of the Common Features. In the model, no damages occur below a stage of 48.6 feet (represents elevation within the channel – not depths in the flood plain), which is the PNP for the study. The existing relationships were entered into the HEC-FDA model and adjusted for the shift in index point. For the PAC analysis documented in this report, the stage-discharge and levee failure relationships are the same under both with and without-project conditions. New stage-discharge relationships and new geotechnical data are currently being developed for the Economic Reevaluation Report that will consider various levee breaks at multiple locations. PNP/PFP for the PAC analysis are listed below and the stage-discharge function with uncertainty is displayed in **Table 2-4**.

- PNP = 48.6 feet 15 percent Probability of Levee Failure
- PFP = 49.6 feet 85 percent Probability of Levee Failure

TABLE 2-4
STAGE-DISCHARGE WITH UNCERTAINTY

Discharge (cfs)	Stage (feet)	Error Limits in Stage (feet)			
		-2 Standard Deviation	-1 Standard Deviation	+1 Standard Deviation	+2 Standard Deviation
2,500	15.69	14.98	15.34	16.04	16.40
6,600	18.57	17.74	18.15	18.99	19.40
12,000	22.04	21.05	21.54	22.54	23.03
30,000	28.56	27.28	27.92	29.20	29.84
50,000	33.46	31.96	32.71	34.21	34.96
70,000	37.18	35.51	36.34	38.02	38.85
90,000	40.11	38.31	39.21	41.01	41.91
115,000	43.14	41.20	42.17	44.11	45.08
145,000	46.23	44.23	45.23	47.23	48.23
160,000	47.64	45.64	46.64	48.64	49.64
180,000	49.33	47.33	48.33	50.33	51.33
192,000	50.51	48.51	49.51	51.51	52.51
210,000	52.01	50.01	51.01	53.01	54.01
234,000	53.93	51.93	52.93	54.93	55.93
300,000	59.68	57.68	58.68	60.68	61.68
375,000	65.85	63.85	64.85	66.85	67.85
560,000	74.73	72.73	73.73	75.73	76.73

Note:
1. Stage represents the elevation within the channel at the common index point.

2.6.2 Hydrologic Data

For this PAC analysis, both the exceedence probability discharge and regulated inflow-outflow relationships were revised from the November 2003 LRR. New relationships were provided for use in the model. For the current evaluation, the model was run with varying regulated inflow-outflow relationships (provided by the Sacramento District Water Management Section) to represent the different project configurations. The hydrologic relationships used in the models to simulate project conditions for each alternative can be found in **Attachment 2** of this appendix.

2.6.3 HEC-FDA Model Results – Without-Project Conditions

In past studies on the American River, the MONTE program was used for flood damage analysis. Currently, HEC-FDA is the standard risk-based flood damage analysis model used at the Corps. For the PAC, the risk-based model used is HEC-FDA version 1.3. Advantages of using the HEC-FDA model for this study instead of MONTE include:

- Consistency with Corps Reporting Requirements (MONTE does not provide all results required to meet the Corps planning guidance found in Engineering Regulation ER-1105-2-101 and Engineering Manual EM-1110-2-1619)
- Widespread acceptance throughout the Corps (compliant with EC 1105-2-407 Planning Models Improvement Program: Model Certification, specifically section 5.a.1)
- HEC-FDA uses the same basic relationships as MONTE
- HEC-FDA allows for stage-damage curves by separate reach and by damage category to be entered into a single model or study file. For this PAC analysis analysis, separate damage curves were entered based on category, but for the single index point without individual reaches.

Expected annual damages (EAD) for the without-project conditions are shown in **Table 2-5**.

TABLE 2-5
WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES FROM HEC-FDA
($ MILLIONS)

	Damage Category						Total Damages
	Residential	Commercial	Industrial	Public	Auto/Roads	Emergency Costs	
Without-Project	115.4	53.8	2.3	15.7	5.7	5.3	198.2

Note:
1. October 2006 Price Levels.

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CHAPTER 3.0
WITH-PROJECT BENEFITS

Flood damage reduction benefits are measured by comparing the without-project expected annual damages to the with-project residual damages for various alternatives. Project conditions and reducing the frequency and/or magnitude of damages are entered into the economic model and benefits equate to the difference between without- and with-project EAD.

3.1 HEC-FDA MODEL RESULTS (WITH-PROJECT CONDITIONS FOR PRELIMINARY ALTERNATIVES)

During the PAC analysis, various routings were provided by Sacramento District's Water Management Section for running project conditions in HEC-FDA. Many of these preliminary routings were used to help determine project sizing and to help establish which measures were required to safely pass the PMF. These preliminary alternatives basically fit into two categories:

1) Measures that allowed for greater discharges at lower than existing elevations in the storage pool
2) Measures that provided a larger effective flood control pool in the reservoir

The following list includes the measures or increments examined at a preliminary reconnaissance level of detail.

A. New or enlarged outlets on the Main Folsom Dam - Looked at variation in the number of enlarged outlets from 2 to 10. The eight-outlet configuration was determined to be equivalent, in terms of targeted project performance, to the Folsom Dam Modifications authorized in 1999.
B. New submerged tainter gates located at the proposed auxiliary spillway - The PDT looked at a range of sizes and number of submerged tainter gates up to a total of six.
C. Replacement of emergency and or main gates - Allows for greater use of available flood control space- Looked at replacing either the three emergency gates or all eight emergency and main gates
D. Dam raises up to 7 feet - Provides greater flood space

Components from the four categories above were mixed and matched in an iterative process to create an array of about 60 preliminary alternatives, and HEC-FDA was run to determine their relative effectiveness in terms of general flood damage reduction and project performance. Increments or added measures that did not significantly increase performance or failed to meet targeted objectives such as passing the PMF were dropped (see **Table 3-1** in **Attachment 3**). The results of these preliminary runs are not comparable to the current detailed HEC-FDA analysis and are not included in this document.

During this preliminary analysis, an alternative with six submerged tainter gates was identified as the Joint Federal Project (JFP), which met the objectives mentioned in **Section 1.4** of this appendix.

3.2 WITH PROJECT CONDITIONS - DETAILED ALTERNATIVE ANALYSIS

More detailed analysis was performed on a smaller set of plan alternatives including the previously authorized (Folsom Modification and Folsom Dam Raise) plans and a potentially more optimal array (in terms of efficiency) of alternatives that also met the two non-NED dam safety objectives (safely pass the 1 in 200 design flow event and safely pass the PMF). A flood damage reduction only plan was also included to compare as functionally equivalent to the JFP for use in the cost allocation. Further refinement of additional alternative components for full optimization will be completed as part of the Economic Reevaluation Report when more detailed data is developed.

The descriptions of the final array of alternatives are listed below:

- No-Action – The future without-project condition includes completed Common Features and reoperation to 400,000/670,000[2]
- Alternative A– Eight Main Dam Outlets and Fuseplug Spillway
- Alternative B – Six Submerged Tainter Gate Auxiliary Spillway
- Alternative C – Six Submerged Tainter Gate Auxiliary Spillway, 3.5-Foot Dam Raise, and Three Emergency Spillway Gate Replacements
- Alternative D – Six Submerged Tainter Gate Auxiliary Spillway, 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements

In addition to the five alternatives in the final array, the following configurations were analyzed in terms of benefits and project performance for comparison to the original authorizations for the Folsom Modifications and Dam Raise:

- 10 Outlets - The authorized Folsom Modifications project consisting of Ten Main Dam Outlets without surcharge storage- During the study, it was determined that constructing the final two outlets would be very high risk, adding unreasonable costs to the project. The benefits and project performance numbers for the 10 outlets are only included for comparison purposes
- 10 Outlets + 7.0-Foot Raise - Adds the authorized 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements to the 10 Outlets and is included only for comparison, not as part of the final array of alternatives.

[2] Re-operation of Folsom for this analysis is considered part of the future without project condition. Any costs of permanent re-operation are part of the without project condition and would not be included as a project cost. In addition, any resource benefits under the with project conditions of reducing re-operation from 400/670k to 400/600k have not been estimated or included. Changes in variable operation could be considered under other project conditions in the future and a more detailed resource analysis could be included in further study of re-operation.

- 8 Outlets + 7.0 Foot Raise - Adds the authorized 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements to Alternative A, included only for comparison, not as part of the final array of alternatives.
- Single Purpose Flood Damage Reduction Only – Four Large Submerged Tainter Gate (26' X 33') Auxiliary Spillway- Developed as a Flood Damage Reduction only equivalent to Alternative B, this plan would not address Dam Safety but will be used as part of the cost allocation computations.

Similar to the without-project condition, these alternatives were evaluated using the HEC-FDA model with outputs for expected annual damages, annual benefits, and project performance. HEC-FDA also can compare single event damages based on exceedence probabilities **Table 3-1** shows single event damages by event for each alternative.

TABLE 3-1
EXCEEDENCE PROBABILITY DAMAGE FUNCTIONS (FROM HEC-FDA)

ALTERNATIVE	EXCEEDENCE PROBABILITY						
	0.020	0.010	0.007	0.005	0.004	0.002	0.001
No Action	1	3,896	11,875	13,201	13,958	14,468	14,860
Alternative A- 8 Outlets	0	359	1,665	7,777	9,835	10,984	12,988
Alternative B – 6STG	0	361	1,668	5,370	7,092	8,368	10,174
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	0	359	1,665	1,781	2,824	7,608	9,583
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	0	359	1,665	1,668	4,071	8,872	10,370
Prior Authorized Plans							
10 Outlets	0	359	1,665	5,772	7,165	8,752	10,480
10 Outlets + 7ft Dam Raise+8S&E Gates	0	361	1,668	1,718	2,963	3,224	3,572
8 Outlets + 7ft Dam Raise+8S&E Gates	0	359	1,665	1,888	3,639	5,287	6,925
FDR Only- 4STG(26x33)	0	361	1,667	4,901	6,934	9,041	10,604

Note:
1. *October 2006 Price Levels, Values in $ Millions.*

HEC-FDA provides additional statistical output for benefit calculation (satisfying the guidance found in ER 1105-2-101) on a probabilistic basis that is not part of the standard output of MONTE. Expected annual benefits and the probability benefits exceed the indicated value are shown in **Table 3-2** for each of the four alternatives and the four comparison plans.

TABLE 3-2
EXPECTED ANNUAL DAMAGES AND BENEFITS FROM HEC-FDA ($ MILLIONS)

Alternative	Expected Annual Damage			Probability Benefits Exceed Indicated Value		
	Without-Project	With-Project	NED Benefits	75 %	50 %	25 %
Final Array of Alternatives						
Alternative A- 8 Outlets	198.2	113.5	84.7	58.9	80.1	105.6
Alternative B – 6STG	198.2	108.3	89.9	62.5	85.0	112.0
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	198.2	91.1	107.1	73.7	101.0	133.8
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	198.2	79.3	118.9	81.5	112.2	148.9
Comparison of Prior Authorized Plans (for comparison purposes only)						
10 Outlets	198.2	108.2	90.0	62.5	85.1	112.2
10 Outlets + 7ft Dam Raise+8S&E Gates	198.2	83.4	114.8	78.9	108.2	143.9
8 Outlets + 7ft Dam Raise+8S&E Gates[2]	198.2	88.4	109.8	75.7	103.6	137.4
Flood Damage Reduction Only- 4STG(26x33)	198.2	109.0	89.2	62.1	84.4	111.2

Note:
1. *October 2006 Price Levels.*
2. *7ft Dam Raise+8S&E Gates (authorized Folsom Dam Raise Project assuming Folsom Modification is in place).*

3.3 PROJECT PERFORMANCE

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided as part of HEC-FDA output. Based on the revised ER 1105-2-101 (January 2006), only two of these statistics are required to describe performance risk in probabilistic terms. These include annual exceedence probability and long-term risk.[3] These two statistics are described below.

[3] Conditional Non-Exceedence Probability is the third performance statistic provided as part of the HEC-FDA output but is not included in this report. ER 1105-2-101 also describes reporting annual exceedence probability (AEP) with associated estimates of uncertainty. The current HEC-FDA model does not provide this data, and AEP with uncertainty has not been estimated for this study. The Corps currently does not have an approved risk-based model capable of providing this output consistent with the guidance.

- Annual exceedence probability (AEP) measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.

Table 3-3 shows both AEP and long-term risk for each of the alternatives in the final array.

TABLE 3-3
PROJECT PERFORMANCE – ALTERNATIVES

Alternative	Annual Exceedence Probability	Long-Term Risk (years)		
		10	30	50
Final Array of Alternatives				
No Action	0.0124	11.8 %	31.3 %	46.5 %
Alternative A – 8 Outlets	0.0068	6.6 %	18.5 %	28.9 %
Alternative B – 6STG	0.0064	6.2 %	17.6 %	27.5 %
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	0.0054	5.3 %	15.1 %	23.8 %
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	0.0047	4.6 %	13.3 %	21.1 %
Comparison of Prior Authorized Plans (for comparison purposes only)				
10 Outlets	0.0065	6.3 %	17.7 %	27.7 %
10 Outlets + 7ft Dam Raise+8S&E Gates	0.0050	4.9 %	14.1 %	22.4 %
8 Outlets + 7ft Dam Raise+8S&E Gates	0.0053	5.2 %	14.7 %	23.3 %
Flood Damage Reduction Only- 4STG(26x33)	0.0065	6.3 %	17.7 %	27.7 %

3.4 OBJECTIVES: PASSING 200-YEAR EVENT AND PMF

In addition to reducing flood damages, two additional dam safety objectives of any alternative are to:

- Pass the 200-year design flow event
- Pass the PMF

Table 3-4 shows which alternatives can safely pass the PMF and can pass design flow events that are greater than the 200-year event. The single purpose flood damage reduction only is shown for use in Separable Cost Remaining Benefits (SC-RB) analysis.

TABLE 3-4
DESIGN FLOW EVENT & PMF

Alternative	Pass Indicated Design Flow Event (Without Uncertainty)	Safely Pass the PMF
No Action	90-year	NO
Alternative A – 8 Outlets	180-year	YES (with FUSE)
Alternative B – 6STG	200-year	YES
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	240-year	YES
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	275-year	YES
Flood Damage Reduction Only-4STG(26x33)	200-year	NO

3.5 BENEFITS PRIOR TO THE BASE YEAR

Project components that become functional in reducing flood damages prior to completion of the entire plan will provide benefits prior to the base year and need to be amortized and included in the average equivalent benefits. Construction schedules and completion dates along with routings for intermediate measures are required to complete this section, but were not available at the time of preparation of this preliminary report. Analysis of benefits prior to base year is deferred to the economic reevaluation.

3.6 FUTURE CONDITIONS

For this PAC study, future without-project hydrology, hydraulics, and economic inventory was not considered to be significantly different than the current existing conditions. Within the without-project flood plains Sacramento is built out, allowing for no future growth. Therefore, damages shown in **Table 3-2** represent both existing and future conditions. For comparison over the period of analysis, all benefit values were discounted using the Fiscal Year 2007 discount rate of 4.875 percent over the 50-year period. These computed average annual equivalent values are equal to the benefit values shown in **Table 3-2** for each alternative.

CHAPTER 4.0
BENEFIT-COST ANALYSIS – NET BENEFITS

NED benefits from **Table 3-2** are compared with annual economic costs of the alternatives analyzed in **Table 4-1**. These alternatives safely pass the PMF, provide flood damage reduction benefits, and all but Alternative A provide savings in dam safety costs by eliminating the need to construct Reclamation's auxiliary spillway with fuseplug (as proposed in their single purpose dam safety plan). As shown in **Table 3-4**, alternatives B, C, and D pass the 200-year design flow. **Table 4-1** shows both the total annual costs and those economic costs attributable to the flood damage reduction increment of the plan.

TABLE 4-1
AVERAGE ANNUAL EQUIVALENT NED BENEFITS AND COSTS OF FLOOD DAMAGE REDUCTION

Alternative	Project First Costs	Annual FDR Benefits	Total Annual Costs	FDR Annual Costs[3]	Net Benefits FDR	Benefit/ Cost Ratio
Alternative A – 8 Outlets	630	84.7	33.0	33.0	51.7	2.6
Alternative B – 6STG	876	89.9	45.3	35.2	54.7	2.6
Alternative C – 6STG+3.5ft Dam Raise+3E Gates	988	107.1	50.1	40.0	67.1	2.7
Alternative D – 6STG+7ft Dam Raise+8S&E Gates	1,439	118.9	83.9	73.8	45.1	1.6
Key: FDR = Flood Damage Reduction						

Notes:

1. *October 2006 Price Levels, Values in $ Millions.*
2. *50-year period of analysis and FY07 4-7/8 percent discount rate.*
3. *Flood Damage Reduction costs are based on total project cost minus the annual costs of a single purpose dam safety project equal to $10.6 million in annual costs. These annual costs include O&M and interest during construction for each alternative.*
4. *The project first costs for Alternative A excludes the $200 million cost of the stand alone single purpose dam safety project (Fuse Plug).*

. These costs include O&M and interest during construction for each alternative.

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ATTACHMENT 1
FOLSOM JOINT FEDERAL PROJECT ECONOMICS ADVISORY PANEL

Following a meeting with SPK, the Bureau of Reclamation, and HQ on 24 June 2006, David Moser, CEWRC-IWR, was asked to assemble a team of economists to assist the Folsom Dam Joint Federal Project team in meeting a December deadline for submission of a Draft PAC Report. Subsequently, an Ad-hoc team of Corps economists was formed to review the economic analysis of the Folsom JFP.

The Economics Advisory Panel Team members included:

- Dr. Dave Moser, IWR
- Jim Conley, SPD
- Brian Harper, IWR
- Carol Hollaway, IWR
- Kevin Knight, SPN
- Mitch Laird, LRL
- Brian Shenk, NWP

The team met at SPK from 8-10 August 2006. The team's mission was to provide peer support with the intent of reviewing procedures, products, and underlying assumptions and to discuss other economic benefit categories available to the effort. The team looked at the plan formulation and assumptions that have shaped the current study. A teleconference was held with Keven Lovetro and Brian Maestri, MVN, during the effort.

Project information was presented by:

- Kurt Keilman, Tetra Tech Inc.
- Ignatius Anyanwu, SPK
- Gary Bedker, SPK
- Dan Tibbetts, SPK
- Bob Carl, HEC

The team submitted the following recommendations for consideration.

1. Impacts beyond the current study boundary need to be assessed. Downstream impacts need to be evaluated so that induced flood damages, and potential mitigation costs, are captured in the benefit-cost calculations.

2. Examine system risk of the multiple components of the regional flood damage reduction system - lesson learned from Katrina. Total system performance depends upon individual components performing at their design level of reliability. Will the system

perform as expected? Do design criteria and design standards for individual components assure system reliability? Performance of the existing system must be adequately assessed in order for base conditions to be established. Potential benefits of project improvements are uncounted if reliability of the existing system is overstated relative to actual performance.

3. The proposed plans need to be reviewed for completeness. Incremental fixes as presented in the existing analysis may foreclose future opportunities for a more comprehensive solution. In other words, a partial plan now takes benefits off the table for later improvements.

4. It was noted that floodplain maps are almost 20 years old. The economic analysis will be current only if the H&H and geotech input data are current. Any limitations of the engineering inputs compromise the quality of the economic analysis. Until the engineering data can be brought up to date, uncertainties in the existing data should be evaluated and captured in the analysis.

5. The analysis is NED-centric and should be broadened to display the four accounts as described in EC 1105-2-409 and the P&G. Such an analysis would evaluate potential loss of life, social and cultural consequences of flooding, and ecological impacts. These impacts are not typically measured in monetary terms and do not contribute to the benefit-cost ratio (BCR); however, they may play an important role in plan selection. The Folsom JFP team is working towards this objective and is encouraged to continue. Volume VII of the IPET report presents a model framework. Another example can be found in the Louisiana Coastal Protection & Restoration (LaCPR) risk-informed decision process that is being developed.

6. Ensure that the economic inputs reflect current conditions – particularly with respect to development and changed land use since the last structure inventory was conducted. For example, a survey should be conducted to validate content values (and resulting content damage functions) for non-residential structures.

7. Project feasibility is much more sensitive to cost uncertainties than benefit uncertainties. Cost uncertainties should be addressed. Estimates are volatile in response to perceived risks and complexity of the construction process.

8. The economic analysis should differentiate between economic costs and financial costs if they are different due to market power. The BCR should be calculated using NED costs, a reflection of opportunity costs. The P&G require that costs be based on opportunity costs of the project inputs. Investment in a market analysis may be warranted. Further discussion of this issue can be found in ER 1105-2-100, App D, Section D-3.

9. Replace FIA Damage functions with generic curves found in EGM 04-01. FIA curves limit structure damage to no more than 50 percent of structure value, even at 20 feet of water depth. The standard curves in EGM 04-01 are believed to be a more accurate predictor of damages. The EGM states “The generic functions developed and provided in

this EGM represent a substantive improvement over other generalized depth-damage functions such as the Flood Insurance Administration (FIA) Rate Reviews."

10. Develop damage function for public utilities and other infrastructure not already accounted for in the analysis. (Note: Event duration could reach 2 months). Katrina demonstrated that public utility damages could increase total physical damages by 20 percent. Post-Katrina recovery also shows that levee repairs could add an additional 10 percent to this total.

11. Examine base condition assumptions regarding OMRR&R of gates and other components of the existing project. Replacement of these features may be treated as advanced maintenance in the economic analysis. For example, if gate replacement would occur in 2015 without the project, a portion of with-project cost or OMRR&R would be offset by this avoided future cost.

12. Sunk costs should not be included in the BCR calculations.

13. The base condition should include the dam safety component as the first increment of Federal action, in order to appropriately identify flood damage reduction economic benefits and economic costs.

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ATTACHMENT 2
HYDROLOGIC DATA USED IN HEC-FDA MODEL

For the HEC-FDA model and all alternative runs, the same exceedence probability discharge functions were used. Below is the probability function as displayed in HEC-FDA.

Statistics of Logs for LP III

Mean (M): 4.5810

Standard Deviation (S): 0.4300

Skew (G): -0.0770

Equivalent Record Length (N): 100

Plot...

Tabulate...

American River Folsom Mods

Discharge-Probability Function Report for WITHOUT PROJECT
(Analytical)

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	1603	1018	1234	2017	2311
0.9900	3601	2520	2930	4322	4819
0.9500	7319	5542	6228	8461	9233
0.9000	10630	8355	9237	12077	13055
0.8000	16628	13577	14761	18576	19901
0.7000	22887	19082	20550	25360	27066
0.5000	38592	32761	34967	42599	45478
0.3000	64627	54621	58305	72015	77593
0.2000	87980	73484	78735	99140	107806
0.1000	134390	109551	118370	154520	170719
0.0400	210011	165738	181163	247661	278998
0.0200	279400	215460	237487	335350	382876
0.0100	360499	272019	302205	439850	508453
0.0040	487544	358154	401804	606912	712245
0.0020	600500	432827	488962	758181	899272
0.0010	729157	516179	586979	933015	1117784

Transform Flow – Regulated Inflow-Outflow Relationships

Changes in with project conditions for all the alternatives were simulated in the model by modifying the inflow outflow curves in the HEC-FDA. All other inputs remain the same for each alternative. HEC-FDA input is entered as 1) most likely, 2) minimum and 3) maximum outflow. Model runs for HEC-FDA were based on the relationships shown below.

1 in X chance per year	WITHOUT-PROJECT				8OUT (Alternative A)			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24267	25004	22280	21210	24305
1.5655	29000	22882	22882	24268	29000	22648	22648	25594
1.8517	37002	22953	22953	24310	37002	22648	22183	35548
2	40722	22987	22987	24336	40722	22648	22625	25752
5	90369	23905	23905	29553	90369	50208	50000	54221
10	136522	27853	27853	49696	136522	101606	75749	101606
15	167533	52518	52518	70144	167533	102183	97461	115000
20	191482	71978	71978	84572	191482	103518	103518	115000
25	211227	91220	91220	101344	211227	115000	115000	115000
30	228145	106603	106603	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115960	299276	115000	115000	115000
70	316636	133044	115000	151970	316636	115000	115000	115000
80	332148	160000	118982	160000	332148	115000	115000	115000
90	346204	160000	150141	196043	346204	115000	115000	115000
100	359078	240000	160000	240000	359078	115000	115000	115000
110	370972	240000	160000	240000	370972	160000	115000	160000
120	382040	240000	204435	240000	382040	160000	115000	160000
130	392399	255432	240000	265977	392399	160000	135000	160000
140	402144	288125	240000	295662	402144	160000	160000	160000
150	411351	315547	240000	323117	411351	160000	160000	160000
160	420081	346850	240000	346850	420081	160000	160000	160000
170	428387	364879	271190	376333	428387	160000	160000	160000
180	436312	385514	290319	398094	436312	160000	160000	210395
190	443894	419707	317559	429234	443894	175912	160000	237616
200	451163	438116	337325	441126	451163	228533	160000	265382
210	458146	458146	354551	458146	458146	259433	160000	312955
220	464869	464869	369380	464869	464869	273444	199318	330475
230	471351	471351	394549	471351	471351	297861	221317	341462
240	477611	477611	405916	477611	477611	319870	235664	362285
250	483665	483665	431032	483665	483665	341516	266729	389561
275	497992	497992	474981	497992	497992	401100	297491	423796
300	511307	506546	487545	507222	511307	435128	341468	457852
350	535457	512295	503588	512295	535457	494007	444237	494007
400	556967	518044	509462	518721	556967	496437	475823	496437
450	576401	525186	515283	525186	576401	509594	495660	509594
500	594159	532961	521877	533418	594159	512944	507246	512944
550	610531	541465	529874	541465	610531	519727	512986	519727
PMF	890916	900627	900627	900627	890916	732335	727483	788807

1 in X chance per year	8OUT+7.0DR+8G				4STG (26x33) (Single Purpose FDR Only)			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24305	25004	22280	21210	24305
1.5655	29000	22648	22648	24525	29000	22648	22648	24525
1.8517	37002	22648	22183	24871	37002	22648	22183	24871
2	40722	22648	22625	24993	40722	22648	22625	24993
5	90369	50208	50000	54221	90369	50208	50000	54221
10	136522	102860	82951	102860	136522	115000	84067	115000
15	167533	104105	93298	115000	167533	115000	115000	115000
20	191482	111238	103692	115000	191482	115000	115000	115000
25	211227	115000	108650	115000	211227	115000	115000	115000
30	228145	115000	115000	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115000	299276	115000	115000	115000
70	316636	115000	115000	115000	316636	115000	115000	115000
80	332148	115000	115000	115000	332148	115000	115000	115000
90	346204	115000	115000	115000	346204	115000	115000	115000
100	359078	115000	115000	115000	359078	115000	115000	115000
110	370972	115000	115000	122819	370972	160000	115000	160000
120	382040	115000	115000	141298	382040	160000	115000	160000
130	392399	121200	115000	158764	392399	160000	135000	160000
140	402144	129400	116023	162473	402144	160000	160000	160000
150	411351	147192	124180	172459	411351	160000	160000	160000
160	420081	160000	133400	204039	420081	160000	160000	160000
170	428387	160000	148153	233274	428387	160000	160000	160000
180	436312	189960	160000	273731	436312	160000	160000	160000
190	443894	215414	160000	307998	443894	160000	160000	195395
200	451163	241748	180470	334312	451163	160000	160000	241507
210	458146	276267	201479	346313	458146	201668	160000	269490
220	464869	314006	225482	357632	464869	235476	160000	285319
230	471351	339677	232377	358049	471351	266910	186276	289297
240	477611	347259	254853	369559	477611	293140	205067	326252
250	483665	351741	286576	375897	483665	330387	238792	366878
275	497992	367322	347076	382030	497992	377745	285439	401100
300	511307	380695	360343	394693	511307	435128	340672	435128
350	535457	398229	377228	416890	535457	481559	420747	481559
400	556967	417485	392298	431352	556967	523129	462483	556967
450	576401	435973	413170	442216	576401	576401	506534	576401
500	594159	445950	422681	461618	594159	594159	544670	594159
550	610531	461737	439686	477523	610531	606369	593677	610531
PMF	890916	859253	848963	859253	890916	779120	773224	780483

1 in X chance per year	6STG (Alternative B)				10OUT			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24305	25004	22280	21210	24305
1.5655	29000	22648	22648	24525	29000	22648	22648	24525
1.8517	37002	22648	22183	24871	37002	22648	22183	24871
2	40722	22648	22625	24993	40722	22648	22625	24993
5	90369	50208	50000	54221	90369	50208	50000	54221
10	136522	115000	84067	115000	136522	115000	84067	115000
15	167533	115000	115000	115000	167533	115000	109893	115000
20	191482	115000	115000	115000	191482	115000	110841	115000
25	211227	115000	115000	115000	211227	115000	115000	115000
30	228145	115000	115000	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115000	299276	115000	115000	115000
70	316636	115000	115000	115000	316636	115000	115000	115000
80	332148	115000	115000	115000	332148	115000	115000	115000
90	346204	115000	115000	115000	346204	115000	115000	115000
100	359078	115000	115000	115000	359078	115000	115000	115000
110	370972	160000	115000	160000	370972	160000	115000	160000
120	382040	160000	115000	160000	382040	160000	115000	160000
130	392399	160000	135000	160000	392399	160000	135000	160000
140	402144	160000	160000	160000	402144	160000	160000	160000
150	411351	160000	160000	160000	411351	160000	160000	160000
160	420081	160000	160000	160000	420081	160000	160000	160000
170	428387	160000	160000	160000	428387	160000	160000	160000
180	436312	160000	160000	160000	436312	160000	160000	160000
190	443894	160000	160000	195395	443894	160000	160000	204232
200	451163	160000	160000	241507	451163	160000	160000	241507
210	458146	169505	160000	269490	458146	182778	160000	269490
220	464869	213882	160000	285319	464869	224165	160000	317548
230	471351	252314	186276	289297	471351	252314	186276	321975
240	477611	280939	205067	326252	477611	280939	205067	359543
250	483665	296855	238792	366878	483665	296855	238792	366878
275	497992	377745	285439	401100	497992	368775	285439	401100
300	511307	411824	340672	435128	511307	411824	340672	435128
350	535457	481559	420747	502926	535457	481559	420747	481559
400	556967	523129	454020	556967	556967	510789	462483	510789
450	576401	576401	518967	576401	576401	522275	496822	522275
500	594159	594159	544670	594159	594159	525716	508328	525716
550	610531	610531	593677	610531	610531	525716	517559	525872
PMF	890916	810818	810434	821326	890916	921292	907425	921292

1 in X chance per year	6STG+3.5DR+3G (Alternative C)				6STG+7.0DR+8G (Alternative D)			
	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge	Peak Unregulated Inflow	Mean Peak Discharge	Minimum Peak Discharge	Maximum Peak Discharge
1.01569	5000	3500	3500	4242	5000	3500	3500	4242
1.2977	20002	17823	17385	20133	20002	17823	17385	20133
1.4393	25004	22280	21210	24305	25004	22280	21210	24305
1.5655	29000	22648	22648	24525	29000	22648	22648	24525
1.8517	37002	22648	22183	24871	37002	22648	22183	24871
2	40722	22648	22625	24993	40722	22648	22625	24993
5	90369	50208	50000	54221	90369	50208	50000	54221
10	136522	115000	84067	115000	136522	115000	84067	115000
15	167533	115000	115000	115000	167533	115000	115000	115000
20	191482	115000	115000	115000	191482	115000	115000	115000
25	211227	115000	115000	115000	211227	115000	115000	115000
30	228145	115000	115000	115000	228145	115000	115000	115000
35	243016	115000	115000	115000	243016	115000	115000	115000
40	256328	115000	115000	115000	256328	115000	115000	115000
45	268407	115000	115000	115000	268407	115000	115000	115000
50	279485	115000	115000	115000	279485	115000	115000	115000
60	299276	115000	115000	115000	299276	115000	115000	115000
70	316636	115000	115000	115000	316636	115000	115000	115000
80	332148	115000	115000	115000	332148	115000	115000	115000
90	346204	115000	115000	115000	346204	115000	115000	115000
100	359078	115000	115000	115000	359078	115000	115000	115000
110	370972	160000	115000	160000	370972	160000	115000	160000
120	382040	160000	115000	160000	382040	160000	115000	160000
130	392399	160000	135000	160000	392399	160000	135000	160000
140	402144	160000	160000	160000	402144	160000	160000	160000
150	411351	160000	160000	160000	411351	160000	160000	160000
160	420081	160000	160000	160000	420081	160000	160000	160000
170	428387	160000	160000	160000	428387	160000	160000	160000
180	436312	160000	160000	160000	436312	160000	160000	160000
190	443894	160000	160000	160000	443894	160000	160000	160000
200	451163	160000	160000	160000	451163	160000	160000	160000
210	458146	160000	160000	160000	458146	160000	160000	160000
220	464869	160000	160000	160000	464869	160000	160000	160000
230	471351	160000	160000	160000	471351	160000	160000	160000
240	477611	160000	160000	210237	477611	160000	160000	160000
250	483665	195784	160000	233229	483665	160000	160000	160000
275	497992	252254	160000	266574	497992	160000	160000	160000
300	511307	300760	211666	313821	511307	193319	160000	236156
350	535457	406164	307835	431276	535457	303211	222457	328643
400	556967	473985	372216	500903	556967	380459	292796	422479
450	576401	518382	454042	541383	576401	464254	346709	490524
500	594159	558062	494709	594159	594159	505636	441729	534352
550	610531	610531	537645	610531	610531	549076	481994	573439
PMF	890916	839626	832728	839650	890916	863342	863342	869516

ATTACHMENT 3
EXCLUSION OF PRELIMINARY ALTERNATIVES

In addition to the eight alternatives listed in the tables in **Section 3** of this appendix, additional preliminary model runs were performed to determine the final array. The following table explains in qualitative terms why many of these were not included.

Alternatives	Reason Excluded from Final Array
2 New Outlets – Main Dam 2 New + 2 Enlarged Outlets – Main Dam 4 Enlarged Outlets – Main Dam 2 New + 4 Enlarged- Main Dam	All were less effective and less efficient than Alternative A consisting of 8 outlets. None of these came close to passing the objective 1 in 200 flow.
Combinations: Both Outlets at Main Dam + submerged tainter gates at the Auxiliary Spillway 2STG + 2OUT 2STG + 4OUT 2STG + 6OUT 4STG + 2OUT 4STG + 4OUT	All less efficient than the 6 STG (Alternative B). None provided greater output than 6 STG.
2STG 3STG 4STG(17x33)	None of these are able to pass the PMF without either construction of upstream storage or inefficient raises of Folsom Dam

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