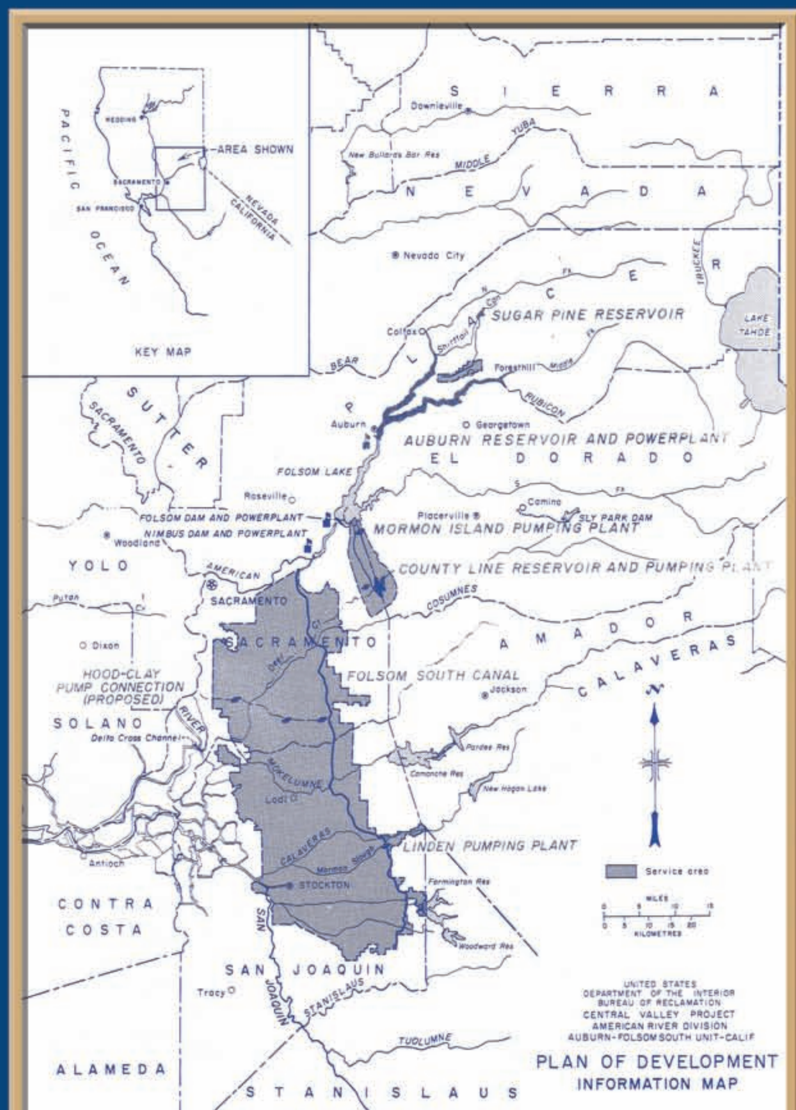
RECLAMATION
Managing Water in the West

Auburn-Folsom South Unit Special Report

Benefits and Cost Update

Central Valley Project California



U.S. Department of Interior
Bureau of Reclamation
Mid-Pacific Region

December 2006

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Auburn-Folsom South Unit Special Report Benefits and Cost Update

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U.S. Department of the Interior
Bureau of Reclamation
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Executive Summary

Report Overview

Reclamation has completed a Special Report (Report) on the Auburn-Folsom South Unit (AFSU), Central Valley Project (CVP). The Report was authorized by the Energy and Water Appropriations Act FY 2006 (PL 109-103) Sec. 209(a) as follows:

The Secretary of the Interior is authorized to complete a special report to update the analysis of costs and associated benefits of the Auburn-Folsom South Unit, Central Valley Project, California, authorized under Federal Reclamation laws and the Act of September 2, 1965, Public Law 89-161, 79 Stat. 615 in order to –

(1) Identify those project features that are still relevant;

(2) Identify changes in benefit values from previous analyses and update to current levels;

(3) Identify design standard changes from the 1978 Reclamation design which require updated project engineering;

(4) Assess risks and uncertainties associated with the 1978 Reclamation design;

(5) Update design and reconnaissance-level cost estimate for features identified under paragraph (1); and

(6) Perform other analyses that the Secretary deems appropriate to assist in the determination of whether a full feasibility study is warranted.

The AFSU was designed as a key component for the development of the water resources in the American River watershed. The original Feasibility Report for the AFSU was completed over 40 years ago in 1963. The 1963 Feasibility Report and subsequent authorization for the Auburn-Folsom South Unit was based upon existing and reasonable foreseeable future conditions as known or assumed in the 1950s. That document contained a feasibility finding for a project integrated into the Central Valley Project that included a dam on the American River in the vicinity of Auburn and a number of additional features. The project as formulated was determined to be the best alternative for managing water supplies on the American River, with the primary purpose of providing an agricultural water supply to an area immediately north of the American River and extending south into San Joaquin County. Other project purposes included hydropower, recreation, fish and wildlife enhancement, and a minor amount of additional flood control.

Public Law 109-103 directed Reclamation to base the current analysis of the multi-purpose Auburn Dam feature on the 1978 design. The 1978 design, which is based upon the 1950s formulation, is documented in the "Feasibility Design Summary, Auburn Dam, Concrete Curved Gravity Dam Alternative" dated August 1980. In addition, the update includes the costs of re-locating Highway 49 and other local roads through the reservoir site, rebuilding of cofferdams, land acquisition, recreation and utility relocations, and mitigation.

Statutory requirements, project operations, demographics, and science have all changed significantly since the original formulation. This placed Reclamation in the position of adapting the 1978 design to meet current conditions which, along with the projected future conditions, are different than what was known or projected 50 years ago. Reclamation based the analysis on various assumptions selected from a broad set of possibilities. The Report therefore, presents a range of outcomes for most evaluation factors, particularly cost and benefit values. In addition, the analysis revealed several general conclusions that Reclamation believes should be addressed if any future deliberation on the AFSU and a multi-purpose Auburn Dam in particular, is undertaken. These observations are summarized in this Executive Summary and represent the main outcome of the Report.

Principles and Assumptions

The technical analysis is based upon the following key principles and assumptions:

1. The scope of Report is dictated by the authorizing legislation, available funding and the completion date (August 30, 2006) established by Congress in Conference Report 109-275, Making Appropriations for Energy And Water Development for the Fiscal Year Ending September 30, 2006, and for Other Purposes.

2. There is no reformulation of the AFSU to reflect current conditions including, but not limited to, changes in downstream flow and temperature requirements, Delta water quality requirements, CVP operational changes, amount and location of water demands, increased population both in downstream floodplain and service areas, and changed hydrology.

3. The 1978 design does not pass the current Probable Maximum Flood (PMF) which influences all of the benefit calculations.

4. No reallocation of reservoir space for various project purposes.

Relevant Features

The Report identifies the multi-purpose Auburn Dam, Reservoir, and Powerplant; relocation of related roads, utilities, and trails; and the Auburn State Recreation Area as features still relevant to the AFSU project. Features identified as not currently relevant and therefore excluded from the Report's analysis were County Line Dam, Reservoir, and Conduit; Sugar Pine Dam, Reservoir, and Conduit; and the Folsom South Canal.

Benefit Values

The analysis indicates that benefits derived from the AFSU, when updated to current levels, have generally increased compared to previous analyses. The benefits update is based only upon those features identified as relevant for the purposes of this report (Auburn Dam, Reservoir, and Powerplant and Auburn State Recreation Area). In summary:

1. Water Supply Benefits. Water supply benefits associated with a multi-purpose Auburn Dam have changed significantly compared to previous analyses. Population growth and changing land use within the AFSU service area indicates a significant shift in water supply needs away from agriculture towards municipal and industrial (M&I) use. Some of the original demand anticipated in the 1965 authorization has been met by new sources regionally and through expansion of the Central Valley Project (CVP) and State Water Project (SWP). The 1963 study projected average annual irrigation and M&I deliveries attributable to Auburn Dam of 365 thousand acre-feet (TAF) and 25 TAF respectively. There was insufficient information or time available to calculate any potential reallocation. However, based upon specified assumptions, the analysis indicates annualized irrigation benefits would now range from \$25.4 million to \$42.5 million, and annualized M&I benefits from \$3.9 million to \$10.4 million. These are only several of a broad range of potential scenarios.

2. Hydropower Benefits. Hydropower benefits associated with a multi-purpose Auburn Dam are potentially significant compared to previous analyses. The primary reason is the increase in the cost of natural gas and other alternative energy sources combined with increased demand. Based upon applicable assumptions, the analysis indicates annualized hydropower benefits could range between \$53 and \$113 million.

3. Flood Control Benefits. Flood control benefits associated with a multi-purpose Auburn Dam are potentially significant compared to previous analyses. Primary reason is the increase in downstream development. The level of attributed benefits will be greatly influenced by (1) the amount of reservoir space allocated for flood control, (2) the coordinated operations of Auburn and Folsom Dams, and (3) the type and extent of downstream flood control improvements implemented. Based upon applicable assumptions, the analysis indicates annualized flood control benefits ranging between \$10 and \$75 million, for the flood control operation and space allocation used in the 1978 design.

4. Recreation. Recreation benefits associated with a multi-purpose Auburn Dam have the potential to be reduced from recreation values from previous analyses. The construction of Auburn Dam will likely shift existing recreation use from

land based to water based. Existing recreation visitation at ASRA, without Auburn Dam, is much greater than originally forecasted in the 1965 authorization. It is possible that the construction of Auburn Dam may lead to a reduction in recreational benefits unless the 1978 Auburn Recreation General Plan is reformulated to accommodate a greater capacity and broader suite of uses. Based upon applicable assumptions, the analysis indicates a change in recreation benefits anywhere from a reduction in benefits of $22.0 to a gain in benefits of $6.0 million.

5. Fish and Wildlife Benefits. The methodologies for calculating fish and wildlife benefits have changed significantly since the 1950s, and resultant benefits will likely be different. Preliminary analysis confirms earlier reports that the addition of a multi-purpose Auburn Dam could help stabilize Folsom Reservoir surface elevations, increase the cold water pool, and lower water temperatures in the American River below Nimbus Dam. However, much more extensive analyses, beyond the scope of this report, would be required to be able to quantify any benefits.

6. Water Quality Benefits. Water quality was not identified as a project purpose in the original authorizing legislation for the AFSU. However, benefits associated with a multi-purpose Auburn Dam may now be significant due to regulatory requirements. The addition of Auburn Dam could improve system flexibility opening up greater opportunities for managing water quality in the Lower American River and the Delta.

Design Standard Changes

The Report concludes that the 1978 Reclamation design for a multi-purpose Auburn Dam would likely never be adopted and constructed as formulated and authorized in 1965. Reasons for this include:

1. Design criteria for dams and other water control structures have changed dramatically since the 1970s. The most significant changes have occurred in the hydrologic and seismic disciplines.

2. The evolution of dam design over the last 30 years has led to a greater understanding of physical processes, and technology has opened many possibilities in materials and construction methodologies not available in the late 1970s.

3. Many of the engineering criteria used in the 1980 design are outdated and would be replaced by state-of-the-practice criteria during future studies.

4. Changed criteria in many of these areas would result in changes to quantities of materials and construction methodologies, both of which would have an important impact on costs.

Risk and Uncertainties

The analysis of risk and uncertainty identified five risk factors having a high probability of significantly impacting project costs:

1. Seismic Design. Seismic design issues dominated the uncertainty costs with respect to dam construction. A better understanding of seismic design could potentially result in changes to the quantities of materials necessary to build the dam to modern earthquake standards.

2. Real Estate. Land costs, both for highway relocation and environmental mitigation purposes, will have a high potential to significantly impact project costs until the project becomes better defined and if the recent growth rate in real estate prices continues.

3. Quantities. Quantities associated with the relocation of Highway 49 and other local roads will continue to have a high degree of uncertainty until alignments become fixed, the design matures, and project becomes better defined.

4. Market Conditions. At present, the construction climate world-wide is characterized by a shortage of skilled labor, increased competition for available materials, and general market volatility. The volatility in unit pricing may not change in the near term. Thus, the impact of this risk factor could continue until such time as the dam would be built.

5. Inflation. As a global risk factor, inflation has the potential to affect the estimated cost of the entire project. Potential impact applies to both the dam and the environmental mitigation.

Costs

In general, the analysis indicates that the cost of designing and constructing the remaining relevant features is significantly higher than previous analyses. Cost figures in the Report represent an appraisal level cost estimate for those features. Depending upon assumptions, total project costs range from $6.0 to $10.0 billion. Within the five risk factors, the most significant cost drivers include mitigation costs (up to $1.5 billion) and land costs (up to $2.3 billion).

Benefit/Cost Ratio

Neither Public Law 109-103 nor the Conference Report directed Reclamation to develop an updated benefit/cost ratio. From a practical standpoint, the range of assumptions adopted in updating cost and benefit values for remaining relevant features precludes any meaningful benefit/cost analysis based upon this Report.

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Abbreviations and Acronyms

AFRP	Anadromous Fish Restoration Program
AFSU	Auburn-Folsom South Unit
ASRA	Auburn State Recreation Area
AW	Applied Water
CFRD	Concrete Faced Rockfill Dam
cfs	cubic feet per second
CG-3	Auburn Dam Concrete Curved Gravity Dam Design
COA	Coordinated Operations Agreement
CPI	Consumer Price Index
CVM	Contingent Valuation Method
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVPM	Central Valley Production Model
DBE	Design Basis Earthquake
DPR	California Department of Parks and Recreation
DWR	State of California Department of Water Resources
EAD	Expected Annual Damages
EC	Electrical Conductivity
EGM	Economic Guidance Memorandum
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
ESA	Endangered Species Act
ETAW	Evapotranspiration of Applied Water
EWA	Environmental Water Account
FDA	Flood Damage Analysis
FLSRA	Folsom Lake State Recreation Area
FMS	Flow Management Standard
FPUD	Foresthill Public Utility District
GDPUD	Georgetown Divide Public Utility District
H:V	Horizontal to Vertical
HEC	USACE Hydraulic Engineering Center, Davis, CA
HEP	Habitat Evaluation Procedure
HMR	Hydrometerological Report
IFIM	In-stream Flow Incremental Methodology
Interior	United States Department of the Interior
JFP	Joint Federal Project
LCPSIM	Least Cost Planning Simulation Model

LOD	Level of Development
M	Magnitude
M&I	Municipal And Industrial
MAF	Million Acre-Feet
MCE	Maximum Credible Earthquake
msl	Mean Sea Level
MW	Megawatt
NEPA	National Environmental Policy Act
NGA	Next Generation Attenuation
OBE	Operating Basis Earthquake
OPCC	Opinion of Most Probable Construction Cost
P&Gs	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, 1983
PCWA	Placer County Water Agency
PL	Public Law
PMF	Probable Maximum Flood
PMP	Positive Mathematical Programming
PSHA	Probabilistic Seismic Hazard Analysis
RCC	Roller-Compacted Concrete
Reclamation	United States Department of the Interior, Bureau of Reclamation
RM	River Mile
RTS	Reservoir Triggered Seismicity
SIR	USACE 1996 American River Supplemental Information Report
SRA	State Recreation Area
SWP	California State Water Project
SWRCB	California State Water Resources Control Board
TAF	Thousand acre-feet
TCM	Travel Cost Method
TCD	Temperature Control Device
TM	Technical Memorandum
UDV	Unit Day Value
UHS	Uniform Hazard Spectra
USACE	United States Army Corps Of Engineers
USFWS	United States Fish and Wildlife Service
WBS	Work Breakdown Structure
WCC	Woodward - Clyde Consultants
WQCP	Water Quality Control Plan
WRDA	Water Resources Development Act of 1974

Technical Summary

Technical Summary

This Special Report was authorized in November 2005, under Public Law 109-103, Energy and Water Development Appropriations Act of 2006, Sec. 209(a) to update the costs analysis and associated benefits of the relevant features of the Auburn-Folsom South Unit, and to determine whether a full feasibility study is warranted. The associated benefits were last calculated in 1963.

The Auburn-Folsom South Unit was authorized as an integral part of the Central Valley Project in September 1965, under Public Law 89-161, 79 Stat. 615 and other Federal Reclamation laws. Proposed features included an Auburn Dam, Reservoir, and Powerplant on the North Fork of the American River; Sugar Pine Dam, Reservoir, and Conveyance; County Line Dam, Reservoir, and Conveyance; and Folsom South Canal. Construction was started in 1967, but suspended in 1979, after the substantial completion of the excavation and foundation preparation work for Auburn Dam.

The purpose of this Special Report is limited to:

1. Identify those project features that are still relevant.
2. Identify changes in benefit values from previous analyses and update to current levels.
3. Identify design standard changes from the 1978 Reclamation design which require updated project engineering.
4. Assess risks and uncertainties associated with the 1978 Reclamation design.
5. Update design and reconnaissance-level cost estimate for features identified under number 1 above.
6. Perform other analyses that the Secretary deems appropriate to assist in the determination of whether a full feasibility study is warranted.

This Special Report does not reformulate any of the features of the Auburn-Folsom South Unit, nor does it reassess the water demands for the associated service areas.

Need for Auburn-Folsom South Unit

The Auburn-Folsom South Unit was intended to provide a supplemental water supply for both irrigation and municipal and industrial needs; to alleviate the badly depleted ground water conditions in the Folsom-South service area; to generate additional hydropower; and to provide for fish protection and enhancement, additional recreation, and increased flood protection when combined with Folsom Dam and Reservoir downstream.

Principle Features

The four core features are:

1. The Sugar Pine Dam, Reservoir, and Conduit is the only feature that have been completed. Since title for this feature was transferred to Foresthill Public Utility District in 2003, it is no longer an integral part of the Central Valley Project and therefore is excluded from any further consideration in this report.
2. The County Line Dam, Reservoir, and Conduit feature was also not considered relevant for this Special Report. It has little influence on continued construction of the Auburn-Folsom South Unit and there is little regional support for this feature.
3. The Folsom South Canal was designed for five reaches totaling 68.8 miles. Only two of the five reaches have been completed for a total of 26.7 miles, extending southward from Nimbus Dam. Construction was suspended in 1973 due to concerns regarding minimum water flows for fish and wildlife below Nimbus Dam. Work on Folsom South Canal has not been reinitiated primarily due to unresolved issues regarding upstream storage capacity and available water for diversion at Nimbus Dam.
4. The key feature of the Auburn-Folsom South Unit is the Auburn Dam, Reservoir, and Powerplant.

Relevant Features

Of the four principal features for the Auburn-Folsom South Unit, only Auburn Dam, Reservoir, and Powerplant is considered relevant and therefore included in the update analysis for this Special Report. Without implementing new storage in the American River watershed, the other features would not provide the intended benefits.

The original site was located about 40 miles northeast of Sacramento on the North and Middle forks of the American River. Construction was initiated in 1967, with the relocation of some local roads and construction of the Auburn-Foresthill Bridge, which was completed in August 1973. By 1975, a 265-foot high coffer dam and a 33-foot diameter diversion tunnel under the river left abutment had been completed and work was underway on the dam excavation and foundation preparation when a 5.7 earthquake occurred near Oroville Dam, about 50 miles northwest of the Auburn Dam site.

The earthquake brought into question the safety of a thin-arch concrete dam, an innovative design concept for its time, and initiated a re-evaluation of seismicity of the dam site. In November 1977, several studies explored design alternatives to the thin arch dam at River Miles 19.1 and 20.1. A new design was chosen in 1980, for a 685-foot high double curvature concrete gravity dam (CG-3). This design has a similar alignment and footprint and closely resembles the appearance of the original thin-arch design. No further construction activities have taken place since 1979.

Other Features

There are several other features within or bisecting the reservoir and/or project take-line area which will directly impact project costs for this analysis. These features include Placer County Water Agency (PCWA) pump station currently under construction; relocation of Highway 49; relocation of the Colfax to Spanish Dry Diggings Road (Placer to El Dorado Counties); and relocation of other minor roads and utilities. Additionally, numerous recreation trails currently used for hiking, jogging, biking and equestrian purposes will require relocations.

Benefits Update

The primary purpose of the benefits update is to:

1. Identify changes in environmental conditions and planning methodologies likely to result in changes to the benefit values identified in previous analyses[1].
2. Provide a preliminary estimate of potential project benefits under current conditions and price levels.

Water Supply

As part of the benefits update, a technical evaluation of the potential impacts a multi-purpose dam near Auburn might have on water resources in the American River Basin was preformed. This evaluation considered the impacts of a new dam on water supply delivery and reliability, power generation, and flood control. The 1963 Supplemental Report projected Auburn Reservoir would deliver, on average, 390 TAF annually of which 365 TAF would be allocated for irrigation purposes and the balance for municipal and industrial purposes in the Folsom-Malby service area.

CALSIM II, a joint Reclamation and California Department of Water Resources hydrologic model of the CVP and the State Water Project, was used to simulate a 73-year period approximating future water supply conditions under assumptions of future levels of development, regulatory requirements, and historic climate conditions. Modeling results indicate that a new reservoir near Auburn could provide an additional 343 TAF of annual deliveries to the CVP and SWP during dry and critically dry year-types and long-term average annual increase in deliveries of approximately 208 TAF. Table TS - 1 provides a comparison of water supply for Auburn Reservoir based upon reservoir capacity and hydrologic data at the time of analysis.

For study purposes, Auburn Dam's water supply was distributed between irrigation and municipal and industrial uses to determine a potential range of economic benefits. The scenarios used in this study are only two of many possible scenarios. The two with-project scenarios considered for analysis are Scenario 1, which proportionately approximates the allocation of water between agriculture and M&I per the 1963

[1] The 1965 Authorization of Auburn Dam was based on the accomplishments and benefits as described in the 1963 authorizing Feasibility Report and associated Economic Analysis Appendix.

feasibility report and Scenario 2, which places a greater proportion on delivery of water for M&I purposes.

Table TS - 1
Water Supply Comparison
(Quantities in Acre-Feet)

Auburn Reservoir	1965 Authorization	2006 Update
Reservoir Capacity	2,500,000	2,326,000
Avg. Annual Inflow	1,550,000	1,363,000
Avg. Annual Yield	390,000	208,000

Agricultural and M&I Benefits

In the 1963 study, both Auburn Dam and the Folsom South Unit were combined in the benefit estimations. The increase in water storage at Auburn was intended to be delivered to new farms (converted from dry farming to irrigation) in Sacramento and San Joaquin counties, and M&I purposes south of the Delta through the added conveyance of the Folsom South Canal. Estimates for agricultural water supplies have changed since the 1963 study. Land use has become more urbanized with farmland going out of production in both counties. Sacramento and San Joaquin County water users originally identified in 1963 may no longer be the primary customers. However, water from Auburn Dam could help meet other water demands throughout the state with the CVP and SWP providing conveyance.

Overall irrigation benefits are measured in terms of the expected change in social value. Social value is the sum of producer profits and consumer surplus. The overall annual equivalent benefits have an estimated value of $42.5 million for Scenario 1 and $25.4 million for Scenario 2.

M&I benefits in this analysis are based on foregone groundwater conjunctive use operations. The overall annual equivalent benefits have an estimated value of $3.87 million for Scenario 1 and $10.35 million for Scenario 2.

Hydropower Benefits

Hydropower Benefits in the 1963 report were based on a powerplant with three 80 Megawatt (MW) turbines for a total plant capacity of 240 MW. The electric power benefits were measured in terms of the cost of achieving the same power generation results by the most likely alternate means in absence of the project.

The power benefits for this preliminary update were for a proposed 4-unit 800 MW Auburn Reservoir Powerplant. The hydropower generation benefits were based on the annual cost of constructing and running an equivalent sized natural gas turbine powerplant.

The resulting annual power generation benefits based on the construction and operating cost of an equivalent natural gas powerplant range from $53 to $113 million.

Flood Control Benefits

In 1963, the flood control benefits were determined based on Auburn Dam effectively adding 250,000 acre-feet of flood control space to the existing flood control measures. Without Auburn Dam, the areas along the Lower American River had an estimated 1 in 200 chance of flooding in any one year. The 1963 report based its flood damage cost estimates on a population estimate from the mid 1950s. Without Auburn, the U.S. Army Corps of Engineers estimated the average annual flood damage along the Lower American River to be $487,000. With the additional Auburn Dam flood storage space, the average annual damages were reduced to $112,000 resulting in a net $375,000 in average annual flood damage reduction benefits.

Since the 1963 report, changes in growth within the flood plain and changes in hydrology have had the biggest impact on flood risk for the Sacramento Area. Currently with over 110,000 structures within the flood plain and property at risk valued over $36 billion, the potential damages from flooding are far greater than listed in the 1963 report. Maximum potential damages from a single event have increased dramatically from the $55 million estimated in the 1963 report to current estimates of over $ 17 billion. The probability of flood risk has also increased. The U.S. Army Corps of Engineers 1991 Feasibility Study reported that Folsom Dam will only provide Sacramento County with protection level equivalent to a 1 in 70 chance of flooding.

Flood damage reduction benefits for an Auburn Dam are dependant on possible future without-project conditions. For this study, three without-project conditions where considered:

1. Current Baseline (“A”) condition allows for a variable flood control space from 400,000 to 670,000 acre-feet at Folsom Dam depending on storage in several upstream reservoirs.
2. 1965 Authorization (“B”) condition sets flood storage at Folsom at a fixed 400,000 acre-feet.
3. Alternative Future (“C”) condition includes the completion of Folsom Modifications using four new auxiliary spillway outlets plus the proposed 7-foot Dam Mini Raise and 495,000 to 695,000 acre-feet re-operation.

As with the future without-project conditions, there is more than one possible future condition that includes the Auburn Dam with flood control space as described in the 1965 Authorization. The most likely with-project conditions are:

4. Auburn Dam-65 Authorization (“D”) condition sets the total flood control space between Folsom and Auburn at 650,000 acre-feet of which 125,000 acre-feet to be interchangeable between Auburn and Folsom Reservoirs. This with-project condition does not include re-operation, or Folsom modification and dam raise,

assuming that they are either not constructed prior to Auburn Dam nor that these projects are discontinued.

5. Auburn Dam with Folsom Mods (“E”) condition includes the Folsom modifications using four new auxiliary spillway outlets plus the proposed 7-foot Dam Mini Raise as part of the without-project condition and re-operation is discontinued. Auburn Dam is then added completed and operated as described in condition “D.”

Auburn Dam, if operated for flood damage reduction as described in the 1963 study without either modification to flood control pool elevation or modification to the design, will provide significantly less flood protection than described in earlier studies. Using the defined flood control pool elevation of 1083.4 feet msl, without redefining spillway operations and coordinating operations with Folsom Dam, may cause the Auburn Dam to overtop. This created a problem for modeling the flow routings without reformulating Auburn. The compromise was to create two scenarios, both having potential impacts either on other benefit categories, dam safety, or increased project costs. Scenario 1 allows operations to drop the reservoir below the flood control elevation to keep the dam from overtopping, utilizing more than the 250,000 acre-feet of additional flood control space described in the authorization. The impact on economic benefits with this operation would be a reduction in the storage available for water supply and hydropower, potentially causing an overestimation in total project benefits. Scenario 2 restricts releases from dropping the reservoir below the flood control elevation and allows flows for rare events to exceed capacity. Without design modifications, these flows would overtop Auburn Dam. These model routings would keep the flood control pool within the storage described in the authorization and would not have any negative impacts on the other benefit categories. But additional construction costs may be required to modify Auburn Dam so these flows could be passed safely. Preliminary results are shown in Table TS - 2.

Table TS - 2
Expected Annual Benefits - Flood Damage Reduction from Auburn Dam
(Values in $ Millions, October 2006 Prices)

Condition	Benefits Increase - Damage Reduction	Chance of Flooding with Auburn
With Flood Control Ops Dipping into Water Conservation Pool		
Auburn Dam with Re-operation	68.4	1 in 385
Auburn Dam with 65 Authorized Flood Storage	75.0	1 in 385
Auburn Dam with Folsom Mods	30.0	1 in 500
With Flood Control Ops Restricted to Flood Control Pool		
Auburn Dam with Re-operation	46.7	1 in 195
Auburn Dam with 65 Authorized Flood Storage	53.3	1 in 195
Auburn Dam with Folsom Mods	9.6	1 in 220

Recreation Benefits

For the purposes of the Recreation Benefits update, the study area includes the Auburn State Recreation Area (ASRA) and the Folsom Lake State Recreation Area (FLSRA) and also includes the recreation demand area for the state recreation areas, the counties of Placer, El Dorado, and Sacramento.

Significant changes in demographic and socioeconomic conditions, as well as recreational use associated with the study area have occurred since the time of the analysis documented in the 1963 Supplemental Report. The most significant changes affecting the previous recreational estimates include changes in without-project recreational use, changes in expected visitation, and current user day values for recreation in the study area. Additionally, assumptions applied in the 1963 analysis regarding recreational visitation capacity of Auburn Dam and Folsom Lake resulted in much higher estimates of visitation than currently considered feasible by the California Department of Parks and Recreation (DPR) or projected in DPR's 1978 General Plan for Auburn and Folsom Lake State Recreation Area Plan.

Attendance estimates of the California Department of Parks and Recreation (DPR) over the period of 1995-2005, for the ASRA average over 700,000 for the ten-year period and over 900,000 for the most recent five-year period. Recreation visitation estimates of the California Department of Parks and Recreation (DPR) over the period of 1995-2005, for the FLSRA average over 1.2 million for the ten-year period and over 1.3 million for the most recent five-year period.

The methodology used for the recreational benefit update is based upon estimating the difference in the values of recreational benefits with and without the construction of Auburn Dam over the 100-year period of analysis and using the current Federal discount rate of 5.125%.

Table TS - 3
Net Recreation Benefits with Auburn Dam (Current Conditions)

	Net Average Annual Benefits
Auburn State Recreation Area	-$5,023,900
Folsom Lake State Recreation Area	$221,200
Auburn and Folsom Lake SRAs	-$4,802,700

The unit day value (UDV) method for estimating the value of recreation benefits was used for this benefit update. The UDV method relies on expert or informed opinion and judgment to develop point ratings for the alternative future conditions in the study area as they relate to recreation. For this study, DPR staff of the Auburn and Folsom State Recreation Areas developed the point ratings for with- and without-project conditions at both the SRAs. The results of the benefit calculations are presented in Table TS - 3.

Based on the updated analysis, the recreation benefits attributed to the project in the 1963 Supplemental Feasibility Report do not appear to be reasonable based upon current conditions in the study area. The most significant change in conditions since the previous study is the highly valued recreational use that is currently taking place in the ASRA. Another key finding that caused results to shift from previous analysis was the reduction in visitation that results from the lower capacities at the recreation areas from those levels assumed in the 1963 analysis.

To examine the sensitivity of the results of the recreation analysis to higher user day values, the unit day values were replaced with applicable values from the 2005 US Department of Agriculture Forest Service Study and Snake River Study and net benefits were recalculated using the same visitation estimates. Depending on the source of published day use values and visitation assumptions, the recreation benefit estimates from the construction of Auburn Dam vary significantly. Table TS - 4 shows a summary of the range of possible benefits described in this section.

Table TS - 4
Range of Net Annual Recreation Benefits

	Table TS - 3	Forest Service Values	Snake River Values
Auburn SRA	-$5,023,900	-$22,730,200	$2,613,700
Folsom Lake SRA	$221,200	$1,020,300	$3,344,000
Auburn and Folsom Lake SRAs	-$4,802,700	-$21,709,900	$5,957,700

Fish and Wildlife Benefits

In the 1960 and 1963 economics analyses, a major benefit of the Auburn Reservoir was assumed to be in temperature benefits to the American River downstream from Nimbus Dam. Water stored in Auburn Reservoir would be released throughout the summer and fall and provide cold water flows into Folsom Reservoir, which could then be released downstream of Nimbus Dam. It is likely that a new analysis of potential fishery benefits from Auburn Reservoir would also identify cold water flows as a benefit to the overall American River system. However, the original calculations of benefits would likely be significantly revised.

Due to declining anadromous fisheries stock, it is unlikely that commercial fishery benefits would reach the projected benefits calculated in 1963. In future analysis, fish and wildlife benefits would most likely be evaluated qualitatively as environmental quality benefit measured in non-monetary units.

Summary of Preliminary Benefit Update

Based on this update, construction of a 2.326 million acre-feet (MAF) dam at Auburn would provide greater dollar benefits (unadjusted for price level) than the 2.5 MAF dam described in the 1963 study. Shifts in demands for water resources and changes in without-project conditions result in a change in the expected distribution of benefits of the dam. In the 1963 study, about 75 percent of the total benefits were from expected agricultural uses. Based on this preliminary evaluation there is a significant shift in benefits away from irrigation, while M&I, flood damage reduction, and hydropower are expected to exhibit benefit increases. With existing recreation visitation at Auburn being much greater than forecast in the 1960s, it is possible that the construction of Auburn Dam may lead to a reduction in recreational values in the study area. It is important to note that these observations are based on a preliminary reconnaissance level reevaluation with general broad-based assumptions.

Table TS - 5
Preliminary Estimate of Auburn Dam Benefits Under Current (2006) Conditions (in $Millions)

Category	Range of Annual Equivalent Benefits From Auburn Dam	Annual Equivalent Benefits (AFSU 1963 Report)
Irrigation [1]	$25.4 to $42.5	$ 45.3
Municipal & Industrial [1]	$3.9 to $10.4	$ 0.9
Hydropower	$53.0 to $113.0	$ 6.5
Flood Damage Reduction [2]	$9.6 to $75.0	$ 0.4
Recreation	-$21.7 to $6.0	$ 6.6
Fish and Wildlife [3]	--	$ 0.5
Total Benefits	**$75.7 to $240.4**	**$ 60.2**

1. Water supply can be distributed between irrigation and M&I to provide a range of benefits. The trade-off is that for one to increase the other use decreases. The distribution shown in this table for the minimum is taken from Scenario 1 described in Section III and the maximum from Scenario 2.
2. The wide range of flood damage reduction benefits listed in the table reflects the uncertainty of operations. Due to changes in hydrology since the 1963 report, the flood control space would need to be increased or additional costs would have be included in the design to meet current PMF flow requirements. Without reformulation, it is hard to determine the benefits of Auburn Dam and account for dam safety.
3. Significant benefits are anticipated but they would most likely not be quantified in monetary units. Due to limited readily available data, time, and funding for this update, the updating of fish and wildlife benefits were considered beyond the scope of this report. In addition, methods used to value ecosystems and habitats have changed significantly since the analysis performed for the authorizing 1963 Supplemental Report.

Engineering Design Technical Review

For the purposes of this Special Report, the CG-3 dam design at River Mile (RM) 20.1 was used as the basis for the Engineering Design Technical Review and Cost update. The basis for the selection of this design for this Special Report is associated primarily with the wealth of information readily available for the CG-3 design at RM 20.1, and a high degree of certainty that a dam of this design and location can safely be constructed.

Auburn Dam was originally designed in the early 1970s, and updated in the late 1970s. Design criteria for dams and other water control structures have changed since then. The most crucial changes have occurred in hydrologic and seismic disciplines. The evolution of dam design over the last 30 years has led to greater understanding of physical processes and technology has opened many possibilities in relation to materials and construction methodologies not available in the late 1970s.

In all, a combination of 21 technical areas or project features were assessed in regards to changes in design standards since the early 1970s. These areas can be loosely categorized into the areas of hydrology, seismic design, dam and appurtenant feature design considerations, foundation design, methods of technical analysis, treatment of major relocations, recreation, and environmental considerations. If future studies are to be carried out in relation to Auburn Dam all of these areas will have to undergo further analysis.

Update of Project Cost

A Total Project Cost estimate for a water resources development project is a combination of physical construction (contract) costs and other non-construction (non-contract) costs that are required to bring a water resources project to completion.

The cost estimates developed for this Special Report are at an appraisal level, and are characterized as an order-of-magnitude estimate. This type of cost estimate may also be called a sub-appraisal, appraisal, or reconnaissance estimate and is not intended to be used to authorize construction of a project as it may lead to substantial funding shortfalls.

For this Special Report, the Total Project Cost for Auburn Dam is $ 9.598 billion. A breakdown of this estimated total project cost is found in the following discussion.

Estimate of Construction Cost

The Total Project Cost estimate developed for this Special Report is developed at an appraisal level. This level has a wide range of accuracy and is typically used to determine if a particular project is worth further investigation, as is the purpose of this Special Report.

The project field costs are broken down into seven principal areas of construction activity. This breakdown is shown in Table TS - 6. The field cost does not include non-contract costs such as legal, lands and damages, environmental permitting and mitigation, and other costs.

Table TS - 6
Project Construction Costs

Description	Amount ($ millions)
Project General Requirements	$ 440.0
Site Preparation	$ 79.0
Concrete Curved Gravity Dam	$ 2,092.0
Hydro-Electric Power Plant	$ 578.0
Electric Power Transmission, Switchyard, and Substation	$ 76.0
Highway and Road Relocation	$ 469.0
Public Access and Recreation	$ 32.0
Subtotal	$ 3,766.0
Unlisted Items (@ 20%)	$ 753.0
Contract Cost	$ 4,519.0
Contingencies (@ 20%)	$ 904.0
Field Cost	$ 5,423.0

A reformulation of the Auburn Dam Project to current water demands, socio-economics and design standards, methodologies, and technology would result in a much different project.

Non-Contract Costs

Non-contract costs refer to work or services provided in support of the project. These costs include, but are not limited to investigations, designs and specifications, construction management, environmental compliance, archeological considerations, and lands and rights[2].

Table TS - 7

Project Non-Contract Costs

Description	Amount ($ millions)
Lands and Rights	
Reservoir Take-Line	$ 38.0
Environmental Mitigation Lands	$ 2,320.0
Major Highway Relocations	$ 22.0
Environmental Mitigation	$ 1,480.0
Environmental Compliance and Planning	$ 15.0
Engineering and Design	$ 100.0
Construction Management	$ 200.0
Total Non-Contract Costs	$ 4,175.0

Non-contract costs include lands needed to implement the Auburn Dam Project. Land requirements fall under the three categories: 1) reservoir take-line; 2) environmental mitigation lands, and 3) major highway relocations. The original cost estimate identified a total land requirement of 49,265 acres, however, future studies may determine a different takeline and thus different acreage including land for environmental mitigation purposes. A cursory evaluation of potential land requirements for mitigation and major highway relocations was made.

Environmental compliance requirements are substantially different today than they were in the original project formulation and subsequent studies in the 1970s and 1980s. Environmental compliance requirements include, but are not limited to the National Environmental Policy Act, Historic Preservation Act, Clean Water Act, Clean Air Act, and the Endangered Species Act, plus several State of California requirements.

Extensive planning efforts would be required if the Auburn Dam Project is to move forward. Planning efforts would include identification of water needs and demands, a complete reformulation of the project, identification of potential benefits, new

[2] An estimated $315,500,000 in "sunk costs" has not been incorporated into the total project cost.

engineering analyses, real estate studies, environmental activities, water rights evaluations, and many other disciplines.

If this project is to move forward, design and engineering activities would essentially start with a complete engineering re-evaluation of the total project. Many standard and criteria changes since the original methodologies would likely lead to the formulation of a much different looking project today.

Risk and Uncertainty Analysis

The risk and uncertainty included in this report is based on that of the cost estimate and not what happens during actual construction. It does not include the total project costs, but rather focuses primarily on a risk assessment of the contract costs, although some owner costs, such as environmental mitigation, are included.

A risk factor is identified as an unexpected or unplanned adverse condition or event. To be considered in this analysis, a risk factor should fall within a specified range of probabilities. Commonly encountered risk factors are not considered in this analysis as they are included in the contingency costs.

The risk factors identified in this report are all considered to have the potential to significantly impact the estimated cost of the dam. Those factors include, hydrologic uncertainty, seismic uncertainty, inadequate borrow sources for aggregate requirements during construction, quantities required during various processes of construction (i.e. excavation and concrete), environmental uncertainty, real estate value and quantities needed, inflation on estimated construction costs, market conditions which may cause reduced availability in labor or building materials, and any legal actions taken against Reclamation to prevent the building of the dam.

The probability range for considering whether a risk factor was significant was between 1:100 or 1 percent chance to 1:2 or 50 percent chance. Due to the qualitative nature of this analysis, the probabilities were broken down into five categories per Table TS - 8.

Table TS - 8
Probability Range

Value	Probability	
1	1:100 – 1:50	Rare events
2	1:50 – 1:10	
3	1:10 – 1:5	
4	1:5 – 1:3	
5	1:3 – 1:2	Likely events

The range of potential risk scores is presented in Table TS - 9.

Table TS - 9 Matrix of Potential Risk Scores						
Probability of Occurrence		**Consequence (Millions of Dollars)**				
		$3 - $10	**$10 - $20**	**$20-$50**	**$50-$100**	**> $100**
	Ranking	**1**	**2**	**3**	**4**	**5**
1:100 – 1:50	**1**	.2	.4	.6	.8	1.0
1:50 – 1:10	**2**	.4	.8	1.2	1.6	2.0
1:10 – 1:5	**3**	.6	1.2	1.8	2.4	3.0
1:5 – 1:3	**4**	.8	1.6	2.4	3.2	4.0
1:3 – 1:2	**5**	1.0	2.0	3.0	4.0	5.0

Summary of Significant Risk Factors

Using a Risk Score of 3 as a cutoff with which to identify the significant risk factors/scenarios, five risk factors are identified as having a high probability of significantly impacting the total project cost:

- Seismic design
- Real estate
- Quantities
- Market conditions
- Inflation

The potential impact of these risk factors is presented in Table TS - 10.

Table TS - 10
Potentially Significant Risk Factors

WBS	Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs ($ 1000s)
Dam						
3	Seismic Uncertainty	Design	5	5	5	$ 752,616
6	Real Estate	Cost	5	5	5	$ 234,512
6	Quantities	Quantity	4	4	3.2	$ 70,353
4	Market Conditions	Material availability	3	5	3	$ 130,740
All	Inflation	6 percent	4	5	4	$ 271,180
Environmental Mitigation						
8	Real Estate	Cost	5	5	5	$ 123,339
8	Real Estate	Quantity	4	5	4	$ 308,347
8	Inflation	6 Percent	4	4	3.2	$ 88,803

There are a number of risk factor/scenarios that do not meet the risk score cut-off of "3," but are of potential importance because of their potential high cost impacts. All of these scenarios have a cost impact ranking of "5" (> $100 million) (Table TS - 11). These six risk factors/scenarios can be characterized as low-probability, high-consequences events. That is, these risk factors have a small likelihood of occurrence (less than 10 percent), but they could cause very high cost impacts if they occur. They apply to both the dam and environmental mitigation.

With regard to the dam, the five risk factor/scenarios range in potential total cost impact from $800 million for Seismic Uncertainty/Source to $101 million for Borrow Source issues. A significant characteristic of these risk factors/scenarios is the fact that they apply to only one WBS feature, the dam construction. The dam is the single largest feature of the project, accounting for 56 percent of the estimated costs and consequently requires the largest amount construction materials and resources. Inflation has the potential to add an approximately $450 million to the construction costs.

Pertaining to environmental mitigation, inflation is the only risk factor of consequence with a potential total cost impact of approximately $150 million.

Table TS - 11
Low Probability-High Cost Risk Factors/Scenarios

WBS	Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs ($ 1000s)
Dam						
3	Seismic Uncertainty	Source	2	5	2	$ 800,215
3	Quantities	Quantity	2	5	2	$ 139,732
3	Market Conditions	Labor availability	2	5	2	$ 104,601
3	Borrow Sources	Quality	2	5	2	$ 101,110
3	Borrow Sources	Quantity	1	5	1	$ 101,110
All	Inflation	10 Percent	2	5	2	$ 451,967
Environmental Mitigation						
8	Inflation	10 Percent	2	5	2	$ 148,006

All of these identified costs in the risk tables above represent a judgment of potential effects of these factors on the project. It is inappropriate to add all of these costs identified above to identify a total risk cost. This analysis does not attempt to predict the probability of one, more than one, or all of these risks occurring at the same time and the consequent statistical effect on the project cost estimate. Such an effort is beyond the scope of this appraisal effort. It should be noted also, that the tables above focus on adverse consequences of risk and uncertainty. At this level of study, as one expects, the risks and uncertainties identified are high. However, there are other possibilities that may also lead to cost savings.

As identified earlier the Auburn-Folsom South Unit was designed according to the design standards that were followed in the 1970s. As discussed earlier, many of these criteria are outdated. Changing criteria in many of these areas will result in changes to quantities of materials and construction methodologies, and will have an important impact on costs. Fundamental impacts to the costs are expected from changes to the dam site location, dam type selection, dam cross-section geometry, use of materials in the dam, and others as listed above or discussed previously. Some of these impacts will increase the cost of the project, while others will reduce this cost. Among those factors potentially reducing the cost of the project, the use of roller-compacted concrete (RCC) is probably the easier to identify. RCC has become the preferred methodology to construct concrete gravity dams, and in a dam like Auburn can result in important savings in the cost of concrete, although there would be additional costs related to relocating the powerplant outside of the body of the dam. The negative risks presented in this report present a picture of uncertainties associated with the historic designs under present conditions.

Section I
Introduction

Sec. I – Introduction

Background

The Auburn-Folsom South Unit was authorized as an operationally and financially integrated part of the Central Valley Project (CVP) in September 1965, by Public Law 89-161. Authorized features of the Auburn-Folsom South Unit include in the following:

- Auburn Multi-purpose Dam, Reservoir, and Powerplant on the North Fork of the American River
- Sugar Pine Dam, Reservoir, and Conveyance
- County Line Dam, Reservoir, and Conveyance
- Folsom South Canal

Construction on the Auburn-Folsom South Unit was initiated in 1967. However, major construction on the Auburn Dam portion of the Auburn-Folsom South Unit was halted in 1975, to re-evaluate the design after the earthquake occurred near Oroville, California.

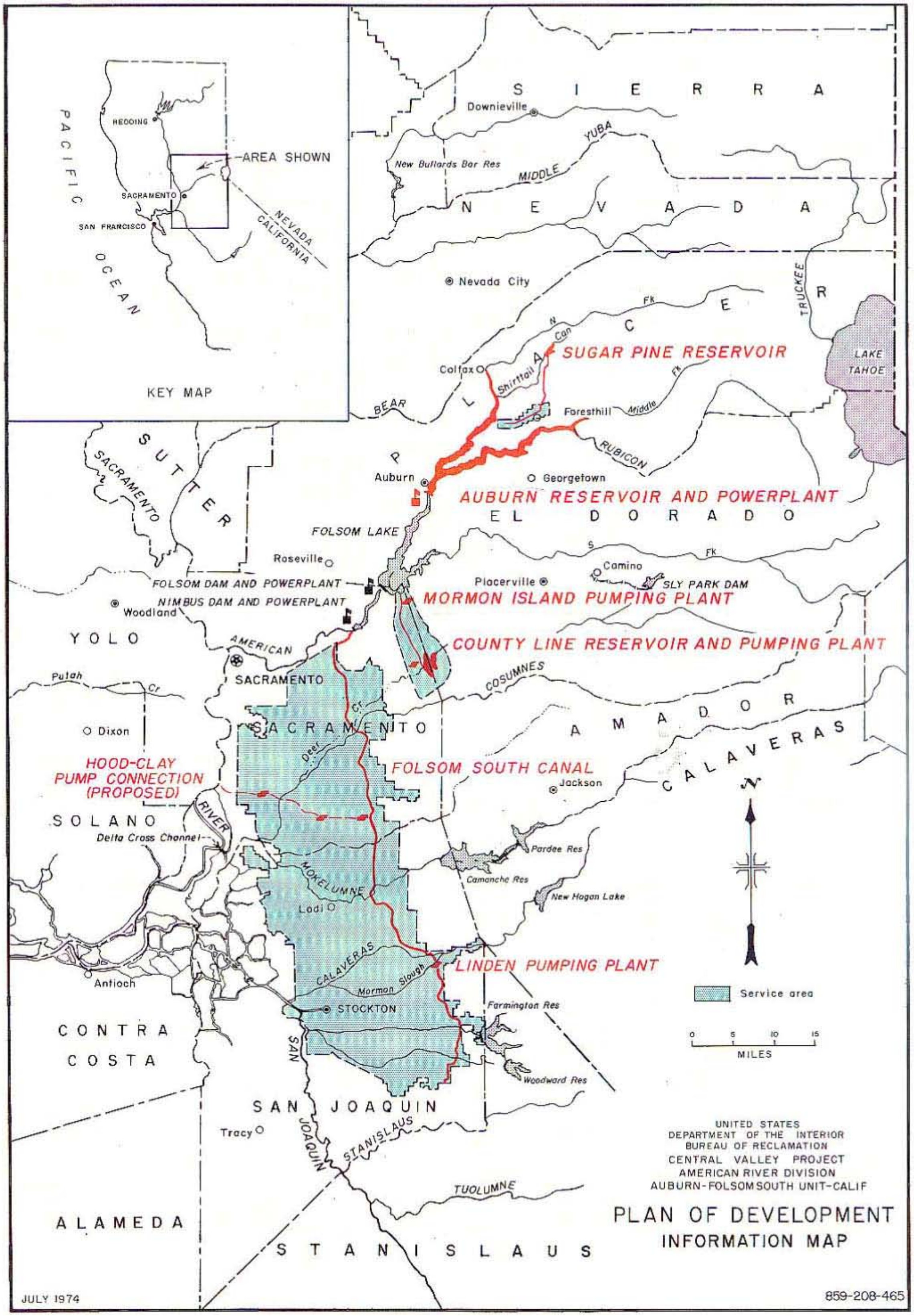
As a result of this seismic evaluation, two new designs were proposed for consideration, an earth-fill dam and a concrete curved gravity dam (CG-3). Both would be located slightly downstream from the original alignment. A feasibility design and estimate was prepared for the concrete gravity dam in 1980. Sugar Pine Dam, Reservoir, and conveyance have been completed in 1982, and ownership was transferred to the Foresthill Public Utility District in November 2003. No construction activity has been initiated on the County Line Dam and associated features. The Folsom South Canal was designed for a total of five reaches and construction of the first two reaches, approximately 27 miles, was completed in 1973.

In Auburn-Folsom South Unit Report - Section 209(a) of Public Law 109-103, dated 19 November 2005, authorized the Secretary of the Interior to complete a Special Report to update the analysis of costs and associated benefits of the authorized Auburn-Folsom South Unit.

Location

The Auburn Dam site is located on the North Fork of the American River, at River Mile 20.1, immediately east of the City of Auburn and northeast of the Sacramento Metropolitan area. Auburn Dam is integral part of the authorized and partially constructed Auburn-Folsom South Unit of the Federal Central Valley Project. The unit includes parts of El Dorado, Placer, Sacramento, and San Joaquin Counties, California, as shown on Figure 1.

Figure 1. Auburn-Folsom South Unit Plan of Development



Purpose and Scope

No construction on Auburn Dam has occurred since August of 1975. The costs and associated benefits of the Auburn-Folsom South Unit were last calculated in 1963. To determine whether a full feasibility study is warranted, these values must be updated to current levels, and associated benefits of the Auburn-Folsom South Unit of the Central Valley Project.

The primary propose of the Auburn-Folsom South Unit Special Report is to identify those features included in the authorized Auburn-Folsom South Unit that would be applicable today if it were decided to continue with implementation of the project.

This report presents the features, capabilities, benefits, design considerations, and appraisal costs associated with the CG-3[1] alternative.

Legislation

Public Law 109-103

Title II, SEC. 209(a) authorizes the Secretary of the Interior to complete a special report to update the analysis of costs and associated benefits of the Auburn-Folsom South Unit, Central Valley Project, California authorized under Federal Reclamation laws and the Act of September 2, 1965, Public Law 89-161, 79 Stat. 615 in order to-

(1) Identify those project features that are still relevant;

(2) Identify changes in benefit values from previous analyses and update to current levels;

(3) Identify design standard changes from the 1978 Reclamation design which require updated project engineering;

(4) Assess risks and uncertainties associated with the 1978 Reclamation design;

(5) Update design and reconnaissance-level cost estimate for features identified under paragraph (1);

(6) Perform other analyses that the Secretary deems appropriate to assist in the determination of whether a full feasibility study is warranted.

[1] In 1978, Reclamation documented the design and engineering associated with the double curvature thin arch concrete dam in a five volume set titled *Design and Analysis of Auburn Dam, 1978*. This is the design referred to in PL 109-103. In November 1977, a series of studies were initiated to examine design alternatives to the thin arch dam. The 1980 CG-3 design used in this analysis was one of the two most viable alternatives to come out of those studies. The CG-3 design is a concrete gravity dam with a similar alignment and footprint closely resembling the appearance of the thin-arch design.

Section II
Relevant Features

Sec. II – Relevant Features

Under its original authorization, the Auburn-Folsom South Unit was intended to provide a new and supplemental water supply for irrigation and municipal and industrial needs and to alleviate the badly depleted groundwater conditions in the Folsom-South service area (Sacramento and San Joaquin Counties south of the American River). The unit was also intended to provide significant increases in hydropower generation, fish protection and enhancement, and recreation. In combination with Folsom Dam and Reservoir and downstream facilities, the unit was designed to provide increased flood protection for much of the Sacramento area.

This section contains brief descriptions of the principal works of the Auburn-Folsom South Unit, why features were excluded from the current evaluation, and other pertinent information. A more detailed description of the principal works along with a history of the events impacting the completion of this project can be found in Project Description Technical Memorandum (Appendix A).

Principal Features of the Auburn-Folsom South Unit

Principal works of the Auburn-Folsom South Unit as authorized by PL 89-161 are described below.

Auburn Dam and Reservoir

Figure II-1. Artist Rendition of Double Curvature Concrete Arch Auburn Dam and Powerplant at River Mile 20.1 on North Fork American River

Auburn Dam, Reservoir, and Powerplant are the key features of the Auburn-Folsom South Unit. Authorized as a multi-purpose dam, it was to be located about 40 miles northeast of Sacramento on the North and Middle forks of the American River upstream from Folsom Reservoir. The authorized project plan for Auburn Dam was a dam and reservoir with a maximum water surface elevation of 1,140 feet above mean sea level (msl) and a capacity of about 2.5 million acre-feet (MAF). Post authorization studies settled on a double-curvature thin-arch dam about 685 feet high, with a crest length of about 4,200 feet (see Figure II-1) and with a total capacity of 2.33 MAF. At gross pool, the project would inundate about 10,050 acres and 33 miles of the

American River canyon (North and Middle forks). The total average annual inflow at the Auburn Dam site is about 1.36 MAF.

The project included a powerplant, relocation of major upstream facilities such as State Highway 49, and major recreation facilities. The Auburn Powerplant was to be built at the downstream toe of the dam on the river right abutment. In combination with Folsom and Nimbus Dams and other facilities of the CVP, Auburn Dam and Reservoir would harness the flows of the American River. Releases from the reservoir would generate power and then be used to supply the Folsom South Canal and downstream service areas.

Construction of Auburn Dam was initiated in 1967 with the relocation of some local roads and construction of the Auburn-Foresthill Bridge. The bridge construction was completed in August 1973. By 1975, work was well underway on the dam foundation and powerplant, and construction of a 265-foot high cofferdam was completed. On August 1, 1975, an earthquake measuring 5.7 on the Richter scale occurred near Oroville Dam, about 50 miles northwest of the Auburn site. The event raised concerns about the safety of dams such as the thin-arch concrete dam proposed for the Auburn site. A seismic hazard analysis led to a reevaluation of the type of dam to be constructed. Consensus from knowledgeable and credible sources was that a safe dam based on updated designs could be constructed at the Auburn site.

No further construction activities took place after 1979, when Reclamation accepted the foundation excavation and treatment contract work as substantially complete. Except for the current construction activities associated with PCWA's pump station project, the dam site today looks much as it did when construction was suspended in 1979.

Sugar Pine Dam, Reservoir, and Conduit

Sugar Pine Dam is located in North Shirttail Canyon approximately 7 miles north of Foresthill, California. Completed in 1982, the dam is an earth and rock-fill structure with a reservoir capacity of 6,921 acre-feet and surface area of 165 acres. The 8-mile long Sugar Pine Pipeline, which carries water from the reservoir to the Foresthill Divide area, was completed in 1983. The pipeline has a capacity of 13 cubic feet per second (cfs). The project was transferred to the Foresthill Public Utility District (FPUD) for operation and maintenance in 1984. Title to the dam and reservoir was transferred to the FPUD on November 7, 2003. At the same time, a Notice of

Figure II-2. Sugar Pine Dam and Reservoir

Assignment was sent to the California State Water Resources Control Board (SWRCB) requesting the assignment of Water Right Application Number 21945 (Permit 15375) to the FPUD.

County Line Dam, Reservoir, and Conduit

Conceptually, County Line Dam was planned to be an earthfill structure 90 feet high, with a crest length of 585 feet. The dam would be located on Deer Creek about 10 miles south of Folsom Dam and create a reservoir with a capacity of 40,000 acre-feet. County Line Reservoir would operate in conjunction with pumping from Folsom Lake to provide water service in the Folsom-Malby area for municipal and industrial (M&I) use.

Folsom South Canal

The Folsom South Canal was designed as a concrete-lined canal in five reaches totaling 68.8 miles. It was intended to convey water from the existing Nimbus Dam on the American River southward to serve a gross area of 500,000 acres and portions of Sacramento and San Joaquin counties. Only the first two reaches have been built for a total length of 26.7 miles. The canal originates at Nimbus Dam on the American River in Sacramento County and extends southward. As originally planned, the canal would terminate about 20 miles southeast of the City of Stockton. The first two reaches of the canal have a capacity of 3,500 cfs, a bottom width of 34 feet, and the maximum water depth is 17.8 feet.

Construction on the canal was suspended in 1973, pending the outcome of studies related to minimum fishery and recreation flows in the American River downstream from Nimbus Dam. Concern was raised after construction began that a minimum river flow greater than anticipated in the planning for the Auburn-Folsom South Unit was needed to support both the new diversion to the Folsom South Canal as well as maintaining resource conditions along the Lower American River.

SWRCB adopted Water Right Decision 1400 in 1972. This decision established flow and storage requirements for the Auburn-Folsom South Unit including minimum flows for various periods of the year from 1,250 cfs for fish and wildlife, and 1,500 cfs for recreation purposes at Nimbus Dam. Maintenance of these flows would require completion of upstream storage at Auburn Dam, and even then would substantially reduce the anticipated amount of water available for diversion at Nimbus Dam.

In 1972, the Secretary of Interior stated this problem needed to be resolved before work on the canal could be restarted. To date, work on the Folsom South Canal has not been reinitiated primarily due to continuing unresolved issues related to completion of Auburn Dam and instream flows along the Lower American River.

Features Excluded from Update Analysis

Without new storage in the American River watershed, County Line Dam and Folsom South Canal would not provide the intended benefits.

Sugar Pine Dam, Reservoir, and Conduit

Sugar Pine Dam, Reservoir, and associated facilities are the only feature that has been fully constructed. With the title transfer of the facility to Foresthill Public Utility District in 2003, Sugar Pine Dam and Reservoir are no longer an integral part of the CVP. Consequently, it is not a relevant feature of the Auburn-Folsom South Unit and is excluded from further consideration.

County Line Dam, Reservoir, and Conduit

County Line Dam and Reservoir would have little influence over whether construction would proceed or not on the Auburn-Folsom South Unit. County Line Dam and Reservoir are separable elements of the Unit. Given changes in water needs and demands in California since the original formulation of the Auburn-Folsom South Unit, a reformulation of County Line Dam and Reservoir is needed to determine if it is still needed and feasible. There is little support in the region for the facility. Based on the limited available information, this project feature was not relevant for the Special Report purposes.

Folsom South Canal

Completion of the remaining 42.1 miles of the Folsom South Canal would allow for full irrigation service to 28,000 acres, supplemental irrigation service to about 416,000 acres, and water for M&I purposes in Sacramento and San Joaquin Counties. This facility also would help to significantly address groundwater overdraft problems in the Folsom South Canal service area. Accordingly, completing the canal is an important component of the unit. However, similar to County Line Dam and Reservoir, major changes have occurred since the unit was originally formulated and full reformulation would be needed, which is beyond the scope of this special report.

Reformulation would consider regional irrigation and M&I water need changes, desired flows in the American River, as well as other environmental concerns related to the canal and the area it would serve. Further, it is highly likely that significant benefits to water supply reliability within the CVP gained from a reservoir near Auburn could be achieved without completion of the canal. Accordingly, this feature of the unit is not considered a relevant feature for evaluation in the Special Report.

Other Pertinent Information

This section presents additional information relevant to the special report purposes.

Placer County Water Agency Pump Station

Prior to initiation of construction of Auburn Dam, PCWA built a 50 cfs pump station on the North Fork American River to convey water supply to the Auburn Ravine Tunnel for delivery to the PCWA service area. To facilitate construction of Auburn Dam, Reclamation removed the original pump station and installed a seasonal pump station and pipeline annually, as needed by PCWA to meet water demands. Over time, this arrangement did not fully meet PCWA's growing water demands, and it became necessary to construct a permanent facility.

Reclamation is in the process of constructing a river diversion and intake structure, pump station, and associated facilities, including pipelines, access roads, power lines, and safety features in the American River Canyon within the Auburn Dam construction area. This project will also include restoring the dewatered segment of the American River through the dam site. The restored segment will allow for beneficial uses of water including recreation and other instream uses. Additional modifications are planned, including the interim closure of the diversion tunnel to ensure safe public access near the project area. A contract will eventually transfer ownership of the pump station and its operation and maintenance to PCWA.

Relevant Features

Of the four principal works, only the Auburn Dam, Reservoir, Powerplant, and related components is considered a relevant feature and included in the update analysis for the Special Report. This is primarily because without implementing new storage in the American River watershed, the other Auburn-Folsom South Unit features would not provide the intended benefits. Accordingly, only Auburn Dam and Reservoir are considered relevant. Section IV – Design Review, summarizes the primary elements of the Auburn Dam, Reservoir, Powerplant, and essential components.

Road, Utility, and Trail Relocations

There are several remaining relocations required with the construction of Auburn Dam and Reservoir including roads, utilities, rails, and an equestrian bridge.

Construction of Auburn Dam and Reservoir would require relocation of several county roads and a portion of State Highway 49. Replacement of these roads is generally contained under provisions of Section 207 of the Flood Control Act of 1960, as amended by Section 208 of the River and Harbors Act of 1962 (PL 87-874) and Section 36 of the Water Resources Development Act of 1974 (WRDA). The Auburn-Foresthill Road and Bridge replacement was completed in 1973, and is now in operation. The two remaining major road relocations are State Highway 49 and the Placer/El Dorado county upstream route. Each roadway relocation will need to meet current Caltrans standards and will require significant additional analysis.

Various other minor roads, bridges, and utilities in the Auburn Reservoir area could be candidates for relocation. However, it is not clear at this time, if these and several other minor roads/bridges were included in the original project or should be considered for relocation. Future efforts are required to develop a detailed inventory of these facilities.

Numerous recreation trails used for hiking, running, biking, and equestrian purposes are located in the Auburn Reservoir area. Several specialty uses, however, may require separate relocation considerations. These include the Tevis Cup horse race and the Western States Run.

Recreation Considerations

The Auburn State Recreation Area, managed by California Department of Parks and Recreation (DPR), is located on Federal lands administered by Reclamation within the proposed Auburn Dam and Reservoir Project. Reclamation entered into an agreement with DPR in 1966, which governed the construction and operation of recreation and fish and wildlife enhancement facilities of the Auburn-Folsom South Unit.

Section III
Benefits Update

Sec. III – Benefits Update

The primary purpose of this section is to briefly identify changes in environmental conditions and planning methods that would likely result in changes to the benefit values identified in previous analyses (principally the 1963 authorizing Feasibility Report and the associated Economic Analysis Appendix) and to provide a preliminary estimate of potential project benefits under current conditions and price levels.

The benefit update will focus on benefits attributable to completion of Auburn Dam only. The other three elements of the Auburn-Folsom South Unit were determined to be non-relevant for the purposes of this report and are not included in this update. A Benefits Update Technical Memorandum is included as Appendix D to this report and will provide a more in-depth discussion. The TM includes information documenting economic benefits found in prior Auburn-Folsom South Unit reports; it identifies significant changes impacting the benefit updates; it defines the methodologies and modeling required to develop a preliminary estimate of potential current benefits; and it displays the results of the analyses, discusses the level of detail, and discusses limitations of the methodologies applied.

Water Supply

As part of the benefits analysis update, a technical evaluation of the potential impacts of a multi-purpose dam near Auburn, on water resources in the American River Basin as well as the CVP and SWP systems, was performed. The evaluation considered the impacts of a new dam on water supply, delivery and reliability, power generation, and flood control.

Reference to Technical Memorandum (Appendix B) attached to this report, will provide more details on the hydrologic and temperature modeling tools used. The Department of Water Resources/ Reclamation joint CALSIM II planning model was used to simulate the CVP and SWP on a monthly time-step from water year 1922 to 1994. The modeling assumptions regarding CVP and SWP operations, the temperature modeling tool, and model limitations, are discussed in the technical memorandum at Appendix B.

Table III - 1 Auburn Reservoir 1963 Supplemental Report

	Acre-feet
Reservoir Capacity	2,500,000
Avg. Annual Inflow	1,550,000
Avg. Annual Yield	390,000
Irrigation	365,000
M&I	25,000

The 1963 Supplemental Report projected Auburn Reservoir would deliver on average 390 TAF annually of which 365 TAF would be allocated for irrigation purposes and the balance for municipal and industrial purposes in the Folsom-Malby service area.

CALSIM II

CALSIM II is a monthly time-step computer model that simulates the major water resource systems and their operation in California's Central Valley and Sacramento-San Joaquin Delta region. The focus of the CALSIM II representation is primarily on the Central Valley Project and State Water Project systems. Its purpose is to provide quantitative hydrologic information related to scenario-based CVP-SWP operations and assumptions related to climate, water demands, and the regulatory environment.

Study Application

For this report, two CALSIM II model studies were used to estimate changes to the American River system. Both "with" and "without" project models were developed to compare results representing future levels of development (2020 LOD). The Water Right Decision 1641 version of CALSIM II was used for this analysis.

CALSIM II study models are used to simulate a 73-year period approximating future conditions under assumptions of future levels of development and historic climate conditions.

Limitations of CALSIM II Modeling

The monthly time-step is a major limitation for operations that occur on a smaller timescale, such as flood and hydropower operations. Daily fluctuations in operation, deliveries, and hydrologic inputs to the system are not captured in the CALSIM II model. In addition, several conveyance and operational constraint issues were not addressed in this analysis which may impact water supply and project storage. They represent both operational agreements and additional facilities including modifications to the existing CVP-SWP Coordinated Operations Agreement (COA); completion of the Folsom South Canal which would provide an additional conveyance facility for water stored in the Auburn-Folsom reservoir complex; potential new water demands for a new water supply facility; and implementation of CVPIA 3406 (b)(2) or the CALFED Environmental Water Account.

CALSIM II Model Results

Table III-2 contains a summary of CALSIM II results for both "without-project" and "with-project" alternatives. CVP and SWP deliveries were selected as the metric for evaluating water supply benefits of new storage, although any portion of the new supply could be dedicated to environmental actions. The aggregate benefits of increased storage within the coordinated CVP and SWP system may allow for enhanced flexibility in delivery allocations, and the results shown in Table III-2 presents one possible allocation distribution. As shown, a new reservoir near Auburn can provide an additional 343 TAF of annual deliveries to the CVP and SWP during dry and critically dry year types. The average annual increase in deliveries for the 73-year study period is about 208 TAF. Also, an increase in overall system storage, both in terms of a seasonal pool at Auburn and higher Folsom Lake levels, can potentially increase cold water reserves for fishery purposes.

Table III - 2 (PRELIMINARY) CALSIM II Water Supply Summary				
Auburn-Folsom South Unit Study Comparison of Benchmark with Auburn Project CALSIM-II Future (2020) Level of Development (1922-1994)				
	Without-Project (TAF)	**With-Project (TAF)**	**Change (TAF)**	**Change (%)**
STORAGE (End of September)				
Auburn	--	1,357	--	--
Folsom	510	643	134	26%
Oroville	1,958	1,960	2	0%
Shasta	2,549	2,535	(13)	-1%
Trinity	1,299	1,303	4	0%
FLOW				
Below Nimbus Dam	2,316	2,270	(46)	-2%
Below Auburn Dam	--	1,260	--	--
Surplus Delta Outflow	8,112	7,848	(264)	-3%
Required Delta Outflow	5,632	5,651	19	0%
DELIVERY SUMMARY				
American River Deliveries	643	664	21	3%
CVP Total Deliveries	5,296	5,434	138	3%
SWP Total Deliveries	4,317	4,387	70	2%
CVP Dry and Critical Year Deliveries	4,596	4,825	229	5%
SWP Dry and Critical Year Deliveries	3,235	3,349	114	4%

Regulatory Changes Since 1978

Planned as an integrated component of the CVP, the provisions of several regulatory requirements and agreements will affect the operation of the Auburn-Folsom South Unit (AFSU). Prior to 1992, the operation of the CVP was affected by SWRCB Decision 1485 (D-1485), the Coordinated Operations Agreement (COA), and SWRCB Orders 90-05 and 91-01. Signed by President Bush in 1992, the CVPIA modified CVP operations. In May 1995, SWRCB adopted the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB Order 95-1).

Water Rights Decisions

The State of California, through the State Water Resources Control Board (SWRCB), regulates CVP operations. The SWRCB grants water rights for all surface waters in California based upon available water, priority of rights, and flows needed to preserve instream public trust uses. The SWRCB also identifies Delta water quality requirements to protect beneficial water uses.

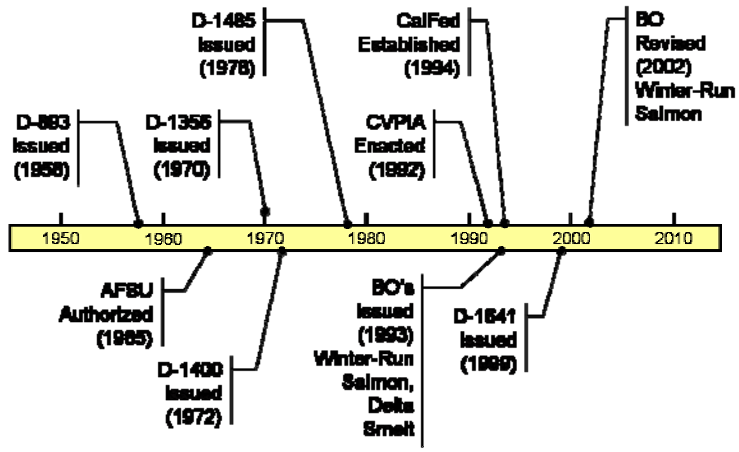


Figure III - 1. Regulatory Requirements Influencing AFSU Operations

Prior to 1978, three SWRCB water rights decisions, D-893, D-1356, and D-1400, established water rights and flow standards for the American River, which would directly influence the operation of Auburn-Folsom South Unit. Issued in 1958, Decision 893 granted water rights to the United States by direct diversion at Folsom Dam. D-893 identified irrigation and M&I water supplies, salinity control, power production, recreation, and flood control as project purposes and set minimum flow standards for fish conservation purposes.

As issued and amended in 1970, Decision 1356 granted water rights to the United States by direct diversion at Auburn Dam. D-1356 identified irrigation and M&I water supplies, water quality control, power production, recreation, and fish and wildlife enhancement as project purposes and reserved jurisdiction over flow standards for recreation and the protection of fish and wildlife, salinity control in the Sacramento-San Joaquin Delta, and coordination requirements between the SWP and CVP.

As part of the water rights permits for Auburn Dam, the SWRCB issued Decision 1400 in 1972, superseding D-893 if Auburn Dam is constructed. D-1400 provides higher instream flows for the Lower American River than D-893. Although Auburn Dam was not constructed, Reclamation uses a Modified D-893 flow regime as baseline operations for Folsom Dam when water is available. During drier periods, Reclamation reverts to the original D-893 requirements for baseline operations.[1]

Pre-CVPIA Delta Operations Affecting the American River

SWRCB D-1485

In 1978, the SWRCB issued D-1485, which established or revised the terms and conditions for salinity control, for protection of fish and wildlife, and to coordinate permit terms for the CVP and the SWP. The SWRCB concurrently issued a Delta Water Quality Control Plan (1978 Delta Plan). The basis for D-1485 and the Delta Plan was that water quality was to be maintained at a level that would have existed if the CVP and SWP were not implemented. D-1485 included flow, water quality, and export standards

[1] The Water Forum, representing water, business, environmental, and public entities in the Sacramento Region, is currently working with Reclamation to adopt a Flow Management Standard (FMS) for the Lower American River under its water right permits for the Central Valley Project (CVP).

to protect the beneficial uses in the Delta. These standards were implemented by the SWRCB through the water rights permits of the CVP and SWP.

SWRCB Order 98-09 and Decision 1641 (D-1641) subsequently modified these requirements. However, the premise of protecting water quality was established in D-1485. These requirements and subsequent orders require that Delta outflow be increased during specific periods to maintain water quality.

Coordinated Operations Agreement (COA)

In 1986, Reclamation and the State of California, Department of Water Resources (DWR) agreed upon the COA to establish the rationale for the coordination of reservoir releases and Delta exports between the CVP and SWP. The COA defines conditions under which existing in-basin and in-Delta demands are met, and establishes shared responsibilities of the CVP and SWP in meeting these requirements to establish "balanced conditions." The purpose of the COA is to ensure that each project receives its share of the available water supply and bears its share of the joint responsibilities to protect beneficial uses.

The COA will be modified in the future to accommodate differences in sharing percentages that are required under subsequent regulations and CVPIA implementation actions.

Post-CVPIA Delta Operations Affecting the American River

On October 30, 1992, the President signed into law the Reclamation Projects Authorization and Adjustment Act of 1992 (PL 102-575), that included Title 34 - The Central Valley Project Improvement Act (CVPIA). The CVPIA amends previous CVP authorizations to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and fish and wildlife enhancement as a project purpose equal to power generation. The CVPIA identifies a number of specific measures to meet these new purposes and directs the Secretary of the Interior to operate the CVP consistent with these purposes. One provision, 3406(b)(1), established the Anadromous Fish Restoration Program, and another provision, 3406(b)(2), dedicated a portion of CVP yield for fish, wildlife, and habitat restoration.

CVPIA Anadromous Fish Restoration Program

The CVPIA Anadromous Fish Restoration Program (AFRP) goal is to double the natural production of five anadromous fish species – steelhead, Chinook salmon, American shad, striped bass and sturgeon – per the law. To achieve this goal, Reclamation and the Fish and Wildlife Service are evaluating programs to improve instream flow patterns and quantities, modify operations that contribute to predation or entrainment/entrapment, and improve habitat conditions including temperature, flow fluctuations, and riparian vegetation that provide food web support. The Comprehensive Assessment and Monitoring Program was established under CVPIA to develop a monitoring program for actions considered by AFRP.

CVPIA Section 3406 (b)(2)

Section 3406 (b)(2) of the CVPIA directs the Secretary of the Interior to: "…dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this Title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and to help to meet such obligations as may be legally imposed upon the Central Valley Project under State or Federal law following the date of enactment of this Title, including but not limited to additional obligations under the Federal Endangered Species Act…"

Reclamation and the Fish and Wildlife Service have been working with stakeholders and regulatory agencies to develop a 3406 (b)(2) Water Program that defines how the 800,000 acre-feet can be used and accounted. Initial proposals were challenged in Federal court and, subsequent to findings by the court, are being redefined. The current proposal includes a list of actions contributing to the CVPIA goal of doubling production of the targeted anadromous fish, including goals for the Lower American River.

Effect of AFRP upon American River Flows

The CVPIA AFRP program includes goals for American River to improve conditions for Chinook salmon, steelhead, and American shad. The goals have been included in proposals developed by the Fish and Wildlife Service to use the 3406 (b)(2) water, minimize flow fluctuations, and provide cold water to improve sustainable fish populations below Nimbus Dam.

SWRCB D-1641

Adopted in 1999, and revised in 2000, Decision 1641 is the culmination of numerous SWRCB orders and decisions addressing water quality and water right requirements for the Bay-Delta Estuary.

Decision 1641 is part of the SWRCB's implementation of the 1995 Bay-Delta Plan. Many of the objectives in the 1995 Bay-Delta Plan are best implemented by making changes in the flow of water or in the operation of facilities that move water. One of the most significant measures established in Order 98-09, and carried through to D-1641, was the Delta Outflow Objectives. The Net Delta Outflow Index sets minimum flow standards for all months and all water year types. Commonly referred to as "X2", the Delta Outflow Objectives is based upon a 2.64 EC (2 ppt) criteria and its location as measured at Chipps Island and Roe Island. The triggers for X2 flows can change within days following a high flow event and can require freshwater releases from CVP and SWP reservoirs in the Sacramento River. Because Folsom Lake is the closest reservoir to the Delta, its water is released for several days to a week, until waters released from Oroville Reservoir and Shasta Lake reach the Delta.

The standard specifies the number of days in each month, February through June, when the maximum daily average electrical conductivity (EC) at Chipps and Roe Islands must be less than 2.64 mmhos/cm. This requirement was established to allow maturity of organisms that become established in brackish water in the western Delta during the initial high flow event, and could be compromised if higher salinity water is present in the western Delta and Suisun Bay prior to maturity.

Effect of D-1641 upon American River Flows

One of the most significant effects on CVP American River operations by the Water Quality Control Plan (WQCP) included in Order 98-09 and D-1641, is associated with X2 flow requirements. Although the flows are to be provided by Shasta Lake, Folsom Lake, and Oroville Reservoir, the travel time for water from Shasta Lake and Oroville Reservoir to the Delta can be almost one week longer than from Folsom Lake. Therefore, to maintain the X2 position in the western Delta and Suisun Bay, the CVP will release water from Folsom Dam when water is needed immediately following a high flow event (especially a storm-related event). The release of this water on the American River can reduce Folsom Lake storage that may not be refilled by runoff in the spring. This is especially true if X2 flows are required in the late spring during a year with minimal or even moderate snowpack. There are methods to use Shasta Lake and Oroville Reservoir water to fulfill subsequent requirements to provide CVP water for export that would have been provided by Folsom Lake. However, because of the location of Folsom Lake, the American River water rights holders, and CVP Water Service Contractors, it is extremely difficult to provide Shasta Lake or Oroville Reservoir water to these users. Furthermore, the CVP is required to provide minimum instream flows and maximize coldwater conditions downstream of Nimbus Dam. If the water is released for X2 in the spring, and the reservoir does not refill, it may be impossible to meet these requirements.

It should also be noted that releases from Folsom Dam cannot be immediately halted when waters from Shasta Lake and/or Oroville Reservoir arrive in the Delta. The higher flows in the American River must be reduced in accordance with ramping criteria to avoid stranding or desiccation of spawning areas, as discussed in the following portions of this report.

Winter-Run Chinook Salmon and Steelhead Revised Biological Opinion

NMFS issued an interim biological opinion in September 2002, for operations of the CVP and SWP from April 1, 2002 through March 31, 2004. This opinion was intended for use by Reclamation during continued negotiations with long-term Water Service Contractors and evaluation of methods to use 3406b(2) Water and the CALFED Environmental Water Account (EWA) program.

The opinion considered the operational criteria proposed by the CVP and SWP for this time period and identified the terms and conditions for continued operations in a manner to avoid significant impacts to or loss of spawning and rearing habitat, and to allow for continued existence of the species. The opinion included specific requirements to minimize flow fluctuations in the Lower American River and the Feather River. It also required development of a Fisheries Management Plan for Clear Creek; monitoring program for Chinook salmon and steelhead; operations to improve instream temperatures on Clear Creek, American River, and Stanislaus River; modification of the Delta Cross Channel gates; modification of Delta export operations to reduce take; and modification of data collection and reporting procedures.

Effect upon American River Flows

The modified biological opinion specifically includes flow ramping criteria that will reduce the flexibility of releasing water from Folsom Dam for instream and Delta water needs. In addition, efforts to maintain cold water within Folsom Lake for release in the fall months also will reduce the ability of using water from Folsom Lake to meet X2 events in a timely manner or provide coldwater releases for salmon and steelhead in the Lower American River.

Previous Data Used for Basis of Benefits Update

Of the previous reports, the update of economic benefits for this Special Report focuses on the benefits as reported in the 1963 authorizing Supplemental Report and Economic Technical Appendix. The 1965 authorization of Auburn Dam was justified based on accomplishments and benefits as described in that report. These benefits are summarized by category in Table III - 3.

An across-the-board update to current (2006) dollars using the Consumer Price Index (CPI) was determined to be an invalid method of updating the benefits from 1963. Such an indexing would not take into consideration changes in conditions, interest rates, assumptions, economic development or design. Also, indexing would not reflect the reduced scope of the benefits update; it would not consider changes in benefits valuation methodologies and categories; and it would not account for changes in land use, population, water demands, institutional and regulatory requirements, technology, or other changes in the existing and future without-project conditions.

Table III - 3
Benefits Attributable to Auburn-Folsom South Unit (1963 Report)

Benefit Category	Annual Equivalent Benefits [3] ($1,000s)
Irrigation [1]	$ 45,319
M &I Water Supply	$ 879
Hydropower	$ 6,546
Flood Control	$ 375
Recreation [2]	$ 6,574
Fish & Wildlife	$ 478
Savings in Transportation Costs	$ 100
Savings in Operation Costs-North Fork Debris Dam	$ 10
Total	$ 60,281

1. This irrigation estimate includes the gross irrigation of $45,537,000 minus the $218,000 attributable to existing CVP facilities. This $218,000 was listed as a separate benefit line item in the 1963 report.
2. In the analyses documented in the 1963 Supplemental Report, annual operation, maintenance and repair costs of $1,167,000 were subtracted from the total benefits for a reported benefit estimate of $5,407,000. Under current procedures, these would be addressed as a project cost and not a reduction in benefit.
3. 1958 price levels

In the last forty years, significant changes have occurred which impact the possible accomplishments of the Auburn-Folsom South Unit described in the 1963 report. Of the benefit categories in Tables III - 3, only Irrigation, Municipal & Industrial Water Supply, Hydropower, Flood Control, Recreation, and Fish and Wildlife were evaluated in detail.

Population Change

The biggest impact on changes in demands for water resource use is population growth both in the state and local communities directly associated with Auburn Dam. As noted in the 1963 Supplemental Report, rapid population growth led to reformulating and identification of a more optimally-sized (2.5 MAF) Auburn Dam. Further growth from the 1960s to the present, again created a shift in the needs for water resources and has impacts on various benefit categories. Table III - 4 shows population estimations from 1960 to 2005, for the State of California and several counties that would have received the most direct benefit from the 1965 authorized project. Table III - 4 also displays projected growth for these same areas out to the year 2030.

Table III - 4

Population Growth

	Estimations[3]			Projections[4]	
	1960	2005	Percent Change[1]	2030	Percent Change[2]
California	15,717,204	36,132,147	230%	48,110,671	306%
Placer County	56,998	317,028	556%	603,637	1059%
El Dorado County	29,390	176,841	602%	266,788	908%
San Joaquin County	249,989	664,116	266%	1,457,128	583%
Sacramento County	502,778	1,363,482	271%	2,579,720	513%

1. Percent change from 1960 to 2005.
2. Percent change from 1960 to 2030.
3. Source: US Bureau of Census.

Source: California Department of Finance, Demographic Research Unit, Population Projections by Race /Ethnicity for California and its Counties 2000-2050.

Overview of Economic Study Scenarios

For economic study purposes, Auburn Dam's water supply was distributed between irrigation and municipal and industrial uses to determine potential economic benefits. The scenarios presented in this study are only two of many possible combinations and utilize two independent economic models. Water supply inputs to the economic models are based on estimated water deliveries from CALSIM II modeling studies that specify deliveries in the 73 years of historical hydrology under the without-project and with-project scenarios. Year types were categorized as "wet", "average", and "dry" with varying probabilities based on historical record. Two with-project scenarios were considered for analysis.

Scenario 1. Greater emphasis on increasing deliveries to agricultural.

Scenario 2. Greater emphasis on increasing deliveries to Municipal and Industrial (M&I).

Agricultural Water Supply Benefits

Changes Affecting Benefits Estimation

In the 1963 study, both Auburn Dam and the Folsom-South Unit were combined in the benefit estimations. The increase in water storage at Auburn was intended to be delivered to new farms (converted from dry farming to irrigation) in Sacramento and San Joaquin counties through the added conveyance of the Folsom South Canal. Completion of the Canal was halted in 1973, with less than 40 percent of the canal completed. In addition to the current limitations on direct conveyance to the proposed new farms discussed in the 1963 Supplemental Report, land uses in Sacramento and San Joaquin counties have changed dramatically since the 1960s. Irrigation demand for the full 713,000 acre-feet provided by both projects may no longer exist in these two counties. Both counties have become more urbanized with farmlands actually going out of production, and harvested land decreasing in both counties (over 25,000 less acres in Sacramento County from 1998 to 2004, and 21,000 less in San Joaquin from 1990 to 2002).

Under current conditions, additional irrigation water made available from the construction of Auburn Dam would reduce costs and increase reliability of delivery for existing farms throughout the state and would not be limited to Sacramento and San Joaquin Counties. With the CVP and SWP providing conveyance, additional supply could be used throughout the state of California including agricultural uses south of the delta. Benefits for the current analysis are based on either reducing existing costs or increasing production based on comparing with- and without-project conditions by region and by crop type.

Methodology

Agricultural economic analysis of benefits from irrigation was performed for this preliminary benefit update using the two "with - project" scenarios described earlier. Increases in deliveries to irrigation with Auburn Dam are shown in Table III - 5.

Table III - 5
Average Increases in Irrigation Deliveries

CVPM Year Type	Scenario 1 (acre-feet)	Scenario 2 (acre-feet)
Wet	64,500	44,500
Average	166,200	102,600
Dry	318,300	201,100
Weighted Average	195,400	122,400

The Central Valley Production Model (CVPM) was used to estimate the irrigation benefits of Auburn Dam. The CVPM is a regional economic model of irrigated agricultural production that simulates the decisions of agricultural producers (farmers) in the Central Valley of California from Shasta/Redding area to Kern County Water Agency/Bakersfield area. The model includes 22 crop production regions in the Central Valley and 20 categories of crops. The CVPM predicts cropping patterns, land use, net income, and water use within the Central Valley by considering land availability, water availability and cost, irrigation technology, market conditions, and production costs.

CVPM assumes that the diversity of crop mix is caused by factors that can be represented as increasing marginal production cost for each crop at a regional level. For example, CVPM costs per acre increase for cotton farmers as they expand production onto more acreage. The CVPM includes tradeoff functions, or isoquants, between water use and irrigation system cost. For purposes of the CVPM irrigation tradeoff functions, water use is defined as applied water (AW) divided by evapotranspiration of applied water (ETAW).

In the CVPM, both applied water and irrigation system cost are decision variables. Profit maximizing (or cost minimizing) conditions require that the ratio of water price to irrigation technology price be equal to the ratio of the marginal products of water and irrigation technology.

Results

The CALSIM II water deliveries were applied to the Positive Mathematical Programming (PMP) calibrated CVPM model, and the model was run with demands based on 2030 level of development for the base case (without-project condition) and each with-project scenario. The following assumptions and decision criteria were made for the agricultural analysis:

- The potential sources for agricultural water include: CVP contract supply, CVP water rights and exchange supply, SWP contract supply, SWP interruptible supply, local surface water, and local groundwater.
- Wet year shadows values were used to value Article 21 deliveries.
- No analysis was performed to determine the economic value to the agricultural sector of water transferred from agriculture to urban, or from urban to agriculture.
- The local surface and groundwater levels for the calibration and PMP CVPM model runs were estimated by subtracting project deliveries from total field applied water and then multiplying this difference by a ratio of groundwater to local deliveries used in a previous CVPM study.
- The local surface and groundwater levels for the CALSIM II augmented CVPM model runs were estimated by subtracting project deliveries from total field applied water and then multiplying this difference by a ratio of groundwater to local deliveries used in a previous CVPM study, with adjustments made for dry and wet year type conditions.

The results are reported in Table III - 6 by year type for each scenario. Overall irrigation benefits are measured in terms of the expected change in social value. Social value is the sum of producer profits and consumer surplus. Producer profits are equal to total revenue minus total costs. Consumer surplus represents the additional value consumers receive when they purchase a good at lower price than what they are willing to pay. In many cases people are often willing to pay more for the good, and thus their perceived value for that good exceeds market prices. This value above market prices is called consumer surplus. The overall annual equivalent benefits have an estimated value of $42.5 million for Scenario 1 and $25.4 million for Scenario 2.

Table III - 6

Average Annual Irrigation Benefits

Benefits for All 22 CVPM Regions - Expected Change in Net Income ($ thousands, 2006 Prices)		
Scenario 1	Expected Change in Net Income	$41,763
	Expected Change in Consumer Surplus	$991
	Adjustments for Changes in Article 21 Water Deliveries	-$243
	Expected Change in Social Value	$42,511
Scenario 2	Expected Change in Net Income	$24,795
	Expected Change in Consumer Surplus	$641
	Adjustments for Changes in Article 21 Water Deliveries	-$155
	Expected Change in Social Value	$25,412

Limitations of Approach

Irrigation benefits in this analysis were based solely on the increased storage capacity. These increases were added to the existing CVP and SWP using demands estimated in year 2030. Changes in system wide allocations, conveyance, and pumping capacities would lead to varying benefit estimates.

Both CALSIM II and CVPM models are currently being revised and updated at the time of this report. Neither model has been optimized for the addition of Auburn Dam.

Variation in the allocation of pool space or the optimum size of Auburn Dam was not considered in this benefit update analysis. Further studies would be needed to show the full range of benefits of potential irrigation deliveries made possible by increased storage at Auburn Dam.

M&I Water Supply Benefits

1963 Methodology

Benefits attributable to municipal and industrial (M&I) water supply from Auburn Dam were based on the annual equivalent costs for the least cost single-purpose M&I project. These costs included the construction of a reservoir with a capacity of 110,000 acre-feet on Alder Creek and a portion of the proposed Folsom-South Unit needed to handle the M&I deliveries. Deliveries would have reduced the dependency of pumping groundwater, which was the only source of M&I for several communities in the service area such as the City of Stockton, at the time of the study. In the 1963 study, these single-purpose costs were estimated at $13.1 million for Alder Creek Dam and $9.5 million for the smaller Folsom South Canal, required to meet the M&I accomplishments of Auburn-Folsom South Unit. Amortized over 100 years, these avoided costs provided an estimated annual equivalent M&I benefit of $879,000.

Changes Affecting Benefit Estimation

For this preliminary benefit update analysis, it is assumed that the Folsom South Canal will not be completed prior to or as part of the Auburn Dam project. Without the Folsom South Canal, Sacramento and San Joaquin County water users as identified in the 1963 Supplemental Report may no longer be the primary customers of the M&I deliveries. Some of the original demand, referred to in the 1963 study, has been met by new sources including the completion of the New Melones Dam.

More efficient and diverse deliveries of M&I water throughout the state are now possible with the completion of the California Aqueduct to Southern California in the mid 1970s and extensions to the central coast in the mid 1990s. Water from Auburn Dam could help in meeting demands throughout the state delivered through both the CVP and SWP. Benefits for these deliveries would be measured based on reduction in costs of alternative sources to include the costs of conservation and recycling.

Methodology

The M&I analysis uses the same CALSIM II data inputs as described earlier. Initially the Least-Cost Planning Simulation Model (LCPSIM) was going to be used to estimate the M&I economic benefits to for this study. LCPSIM is a yearly time-step simulation/ optimization model that was developed to assess the economic benefits and costs of enhancing urban water service reliability at the regional level. However, because the current version of LCPSIM has only been developed to utilize the CALSIM II data provided for one region, the model was determined to be inappropriate for this preliminary update. The current version could not provide benefits for Sacramento Valley, Central Coast, Bay Area, or San Joaquin Valley urban areas. Instead, to account for demands throughout the state, foregone groundwater conjunctive use operations were used to estimate the per acre-foot benefits for M&I deliveries.

Results of Analysis

M&I benefits were determined for the same two project scenarios as applied in the Irrigation Analysis described earlier. In Scenario 1 there is greater emphasis on increasing deliveries to agriculture. In Scenario 2 there is greater emphasis on increasing deliveries to Municipal and Industrial (M&I).

All M&I benefits in this analysis are based on foregone groundwater conjunctive use operations. The cost of these operations is an estimated $140 per acre-foot. It was also assumed that CVP and SWP average delivery cost are $30 per acre-foot. The cost difference of $110 indicates the minimum price per acre-foot local urban water users would be willing to pay for additional water (assuming that without the project, local water users will need to expand local conjunctive use activities). Table III - 7 summarizes the increases in M&I deliveries for each scenario by year type due to the addition of storage at Auburn. Benefits are determined as a function of the change in total average annual water deliveries, comparing without-project and with-project deliveries.

Table III - 7 Summary of Urban Water Supply Delivery Changes		
Year Type	Scenario 1 (acre-feet)	Scenario 2 (acre-feet)
Wet	8,300	34,800
Normal	19,800	71,100
Dry	68,700	158,200
Expected Average	96,800	264,100

Table III - 8 shows the calculated M&I benefits for each scenario.

Table III - 8 Average Annual M&I Benefits		
	Scenario 1 (in $)	Scenario 2 (in $)
Increase in acre-feet delivered	35,200	94,100
$ per acre-feet	110	110
Total	$ 3,872,000	$ 10,351,000

Limitations of Approach

As with the irrigation benefits identified previously, the updated M&I benefits from the completion of the authorized Auburn Dam are based solely on the increased storage capacity. Due to lack of specific regional modeling, the same value per acre-foot was applied to all regions. Changes in system wide allocations, conveyance, and pumping capacities would lead to varying benefit estimates. None of the models used have been optimized for the addition of Auburn Dam. Completion of Folsom-South Unit was not included in this update. Potential future urban water users might provide additional benefit if direct dedicated conveyance systems were completed.

Both irrigation and M&I benefits are dependant on allocation of available water supply. In this analysis, even under Scenario 2 only a limited supply was directed towards M&I. In formulation, the optimal trade-off between irrigation and M&I should be examined. In addition, variation in the allocation of pool space or the optimum size of Auburn Dam was not considered in the analysis for this preliminary update.

Hydropower Benefits

1963 Evaluation Methodology

Hydropower Benefits in the 1963 report were based on a power plant with three 80 MW turbines for a total plant capacity of 240 MW. The electric power benefits were measured in terms of the cost of achieving the same power generation results by the most likely alternate means that would exist in absence of the project. The most likely alternative source of power in 1963, was assumed to be a modern steam-electric power plant, built and operated by a privately financed, taxpaying corporation located in the San Francisco area. Benefits were determined as a function of both dependable capacity and average annual commercial energy production.

Dependable capacity was based on the equivalent steam-electric power plant which would produce the equivalent annual power generation during the dry cycle as the Auburn-Folsom powerplant. The dry cycle used was from July 1930 to December 1933. The estimated equivalent cost of a steam-electric power plant to produce the capacity was determined to be $23.39 per Kilowatt hour (kWh). The cost includes a 5.0 % increment for increased dependability of hydropower and a tax component of $7.86 per kW.

The annual benefits were determined for a 100-year project life using a 2.875 % discount rate. Total system power generation benefits were estimated for the CVP with and without Auburn-Folsom South Unit. The overall power generation for the CVP project was determined using the established power delivery contracts in place with Pacific Gas and Electric (PG&E) at the time. The annual power benefits for the CVP without Auburn-Folsom South Unit was determined to be $25,021,000 and the CVP with Auburn-Folsom South Unit was determined to be $31,567,000. The benefit for hydropower generation at Auburn-Folsom South Unit power plant was determined as the difference between the “without” and “with” at $6,546,000.

Changes Affecting Benefit Estimation

One basic change affecting the benefit estimation is the available data in terms of period-of-record. Available hydrologic data has been extended to include 40 additional years of data. Technology has also advanced providing different least cost alternative power sources in addition to more efficient generation. The alternative power source is now based on natural gas turbine generation. Changes in infrastructure, such as additions to the Western Interconnect allow for widespread distribution of electricity.

Methodology for Preliminary Update

The power benefits for the preliminary update were for a proposed four-unit 800 MW Auburn Reservoir powerplant. The hydropower generation benefits were based on the annual cost of constructing and running an equivalent sized natural gas turbine power plant. Annual benefits were determined as a function of both dependable capacity and average annual commercial energy production. Annual benefits were determined for a 100-year project life using a 5.125 % interest rate.

Power Generation Scenarios

The power generation potential at a hydropower plant is unique to each facility. Extensive analysis is required to develop power generation equations for a specific facility. This type of analysis has not been completed for the proposed Auburn Reservoir powerplant. Instead three scenarios were developed to provide a range of possible values using a general power equation and the power equation developed for a reference hydropower facility to encompass the probable power generation potential of the facility. The scenarios encompass the highest and lowest likely power generation using conventional general hydropower generation equations and the power curve for a similar reference facility.

The three scenarios investigated are listed below.

1. New Melones Power Equation. The first scenario was based on the power curve developed for the New Melones Powerplant with a scaled increase in powerplant output for comparison with the proposed Auburn facility. (New Melones is a 300 MW facility with a reservoir of similar dimensions and volume to the proposed Auburn Reservoir).

2. 4-Unit Power Equation. The second scenario was based on a conventional general hydropower power generation equation for the full four-unit 800 MW Auburn Powerplant.

3. 2-Unit Power Equation. The final scenario was based on the conventional general hydropower generation equation based on a two-unit 400 MW powerplant.

The two-unit powerplant scenario was included since the CALSIM II simulated operation of the Auburn Reservoir, acting in conjunction with Folsom filling, does not maintain optimal water level conditions for continuous and reliable operation at the full power generation potential. The two-unit scenario would give the lower bound of the power generation potential and assumes that the remaining two units may be used for peak power production when available.

Dependable Capacity

Dependable capacity is based on the equivalent natural gas power plant which would produce the same annual power generation during the dry cycle as the Auburn plant. The dry cycle used was the period from July 1930 to December 1933. The following table lists the resulting average annual power generation for the three power generation scenarios over the CALSIM II period of record of July 1930 to December 1933.

Average Annual Power Generation

The average annual power generated from the Auburn Powerplant was determined using power generation equations for each of the scenarios based on the average monthly outflows and reservoir elevations from the CALSIM II model.

Results of Preliminary Update

The power benefits were calculated as the cost of achieving the same power generation results by the most likely alternate means that would exist in absence of the project. The capital cost of construction for the equivalent power plant was based on the size of plant needed to produce the dependable capacity. The cost of operating a facility was based on the average annual power generation output of the power plant.

Table III - 9 lists the resulting average annual power generation for the three scenarios, the dependable capacity dry cycle, and the resulting equivalent natural gas power plant size in megawatts (MW) and for the Auburn Dam Powerplant over the CALSIM II period-of-record 1922 to 1994.

Table III - 9
Average Annual Power Generation

Scenario	Dry Cycle (GWh)	Equivalent Dependable Capacity (MW)	Auburn Power Plant (GWh)
New Melones Power Equation	1,541	271	3,618
4-Unit Power Equation	1,201	211	2,822
2-Unit Power Equation	808	142	1,667

Table III - 10 shows the resulting estimates of benefits for the three scenarios. The power generation benefits are based on a total annualized cost of $31.50 per kW of dependable power capacity. This cost includes the replacement of the natural gas power plant after a useful life of 60 years. The scenarios analyzed represent the most likely envelope of the actual power generation potential for the Auburn Reservoir powerplant. The resulting annual power generation benefits based on the construction and operating cost of an equivalent natural gas power plant range from $53 to $113 million.

Table III - 10
Power Generation Benefits for Auburn Powerplant

Scenario	New Melones Power Equation	4-Unit Power Equation	2-Unit Power Equation
Average Annual Power Generation (GWh)	3618	2822	1667
Annual Benefits x $1000	$113,000	$88,000	$53,000
Annual Capital Construction Costs x $1000	$8,518	$6,638	$4,466
Fixed O&M x $1000	$3,456	$2,694	$1,812
Variable O&M x $1000	$4,463	$3,481	$2,056
Water x $1000	$892	$696	$411
Chemicals x $1000	$446	$348	$206
Fuel x $1000	$95,114	$74,183	$43,821
$/kW hour	0.0288	0.0288	0.0290

Limitations of Approach

The power generation benefits described in this section are dependent on many variables. The two variables which have the largest effect on the power generation benefits are the operation of the reservoir and the price of natural gas, which represents the variable cost of the alternative power source. The operation of the dam dictates the amount of flow that is released from the reservoir at any given time and the amount of flow available to run through the turbines. As seen in the Table III - 10, if the operation results in insufficient flow to operate all four of the power generating turbines, the power generation and associated benefits are greatly reduced. The costs associated with power generation account for the majority of the annual power benefits. Approximately 84 percent of this cost is related directly to the cost of natural gas. Changes in the price of natural gas can greatly influence the alternative cost of the power produced.

Flood Control Benefits

1963 Methodology

In the 1963 Supplemental Report, flood control benefits were determined based on Auburn Dam effectively adding 250,000 acre-feet of flood control space to the existing flood control measures. Folsom Dam had 400,000 acre-feet dedicated to flood control and the 1965 authorization allowed for half of this space to be shifted to Auburn Dam. Without Auburn, the areas along the Lower American River had an estimated 1 in 200 chance of flooding in any year at the time of the study. Without Auburn, the U.S. Army Corps of Engineers estimated the average annual flood damage along the Lower American River to be $487,000. With the additional Auburn Dam flood storage space, the average annual damages were reduced to $112,000 resulting in a net $375,000 in average annual flood damage reduction benefits. The U.S. Army Corps of Engineers report did not address the frequency of flood risk rating for the Lower American River with the added flood storage space at Auburn.

Changes Affecting Benefit Estimation

Many changes have occurred since the 1963 Auburn Dam Supplemental Report that significantly impacts the potential flood damage reduction benefits. These include development in the study area, changes in existing hydrologic and hydraulic conditions, completed and proposed (authorized) project components on the Lower American River, and the methodology the Federal government currently uses to compute flood damages.

Development in the Area – Population Growth

The area at risk benefiting from the additional flood space at Auburn Dam lies primarily within the City and County of Sacramento along the American River. The benefits found in the 1963 report were based on population estimates from the mid 1950s. By comparison, there are now nearly 270,000 people at risk of direct flooding from a potential levee failure along the American River, a significant increase.

As shown in Table III - 3, Sacramento County has grown by over 270 percent since 1960, and the City of Sacramento has grown by nearly 240 percent in the same time period. Much of this growth has occurred in areas that could not be developed prior to the completion of Folsom Dam and the extension of levees along the Lower American River.

Changes in Existing Hydrologic and Hydraulic Conditions

The frequency of flood risk along the American River has changed dramatically since 1954, when Folsom Dam first became operational. At the time of completion, Folsom Dam was believed to provide flood protection along the Lower American River for up to a 1 in 500 year event. But in the following year 1955, the largest flood of record occurred, and the chance of flooding was revised downward to 1 in 200 in any given year. Between 1963 and 1986, three larger events occurred, again revising the frequency of flood risk to 1 in 70 chance of flooding as reported in the U.S. Army Corps of Engineers 1991 Feasibility Study.

In addition to the change in frequency of flooding, the magnitude of the risk has also increased. Based on the hydraulics from the 1991 Feasibility Report, the existing 400-year flood plain would cover an area of over 110,000 acres (including Natomas) compared to the 9,000 acres inundated from the 1950 flood (largest recorded event prior to the completion of Folsom Dam). Current estimates of damage from a single 1 in 400 chance event (based on conditions described in the 1991 Feasibility Report) are over $17 billion compared to the largest flood from the 1955 study estimated at only $55 million. While much of this change is due to the growth in Sacramento area population and increases in the value of property at risk, the increases in floodplain extent and depths inundated based on more recent hydrologic and hydraulic modeling are also a significant factor in the increased magnitude of potential flood damages.

Current Approved Methodology for Computing Flood Damages

Based on U.S. Army Corps of Engineers policies and required procedures, all flood damage reduction studies will adopt a risk-based analysis as described in ER 1105-2-101. This policy is the biggest difference in methodology in the current analysis when compared to the 1963 report. The 1996 U.S. Army Corps of Engineers American River Supplemental Information Report (SIR) was the first study involving Folsom and Auburn Dams to utilize risk-based analysis. In risk-based analysis, the basic parameters determining annual damages and flood risk include uncertainty, and are described in statistical terms such as mean and standard deviation vs. single estimated values.

Methodology for Update

The economic and flood damage models currently being used on the U.S. Army Corps of Engineers American River Folsom Modifications Limited Re-evaluation Report 2002 are the basis for determining flood damage reduction accomplishments for this preliminary update. The without-project condition from this study serves as the baseline for estimating the number of structures at risk, value of damageable property and potential flood damages from specific events.

The economic flood damage model used was HEC-FDA Version 1.3 which is the standard U.S. Army Corps of Engineers program developed by the Hydrologic Engineering Center (HEC) in Davis, CA, for determining expected annual damages (EAD) using risk-based analysis. HEC-FDA (Flood Damage Analysis) is a Monte Carlo simulation program that integrates hydrology, hydraulics, geo-technical and economic relationships to determine potential damages, flooding risk and project performance. Uncertainty is incorporated for each relationship, and the model samples from a distribution for each observation to estimate damage and flood risk.

Structures at Risk of Flooding

The original flood plains for this study included 100-year and 400-year frequency delineations. 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 less likely frequencies. Structural inventory at risk was gathered and assigned to four land use types to include residential, commercial, industrial, and public. The number of structures within the original 400-year flood plain are estimated to be 110,900 units with an estimated value of both structure and content totaling $36.7 billion updated to October 2006 price levels.[2]

Without-Project Conditions – Future Action without Auburn Dam

Flood damage reduction benefits for an Auburn Dam are dependant on possible future without-project conditions. Current operations at Folsom allow for a variable flood control space from 400,000 to 670,000 acre-feet depending on storage in several upstream reservoirs. Prior to this re-operation, flood storage at Folsom was set at a fixed 400,000 acre-feet. This 400,000 fixed operation was the baseline for the 1965 authorization and has been considered as the with-project operation under both 1991 and 1996 U.S. Army Corps of Engineers studies identifying a single purpose flood storage detention dam at Auburn. Auburn accomplishments in this update have considered both operations in determining benefits. In addition to operation, two proposed authorized projects could be completed either in conjunction with Auburn or without. So for this analysis, three without-project conditions (without Auburn Dam) have been considered as possible future actions:

A. <u>Current Baseline (“A”)</u>. This condition is based on the Lower American River Common Features in place and using 400,000 to 670,000 acre-feet re-operation.

B. <u>65 Authorization (1965 Baseline) (“B”)</u>. Same as “Current Baseline” above but using 400,000 acre-feet fixed operation.

C. <u>Alternative Future (“C”)</u>. Alternative Future Federal Action. This condition includes the completion of Folsom Modifications using four new auxiliary spillway outlets plus the proposed 7-foot Dam Mini Raise, and 495,000 to 695,000 acre-feet re-operation.

With-Project Conditions – Future Actions with Auburn Dam

As with the future without-project actions, there is more than one possible future condition that includes the Auburn Dam with flood control space as described in the 1965 authorization. The most likely with-project conditions are listed below:

D. <u>Auburn Dam-65 Authorization (“D”)</u>. Completed Auburn Dam with a total flood control space between Folsom and Auburn set at 650,000 acre-feet. The actual

[2] For the Joint Federal Project (JFP), the Corps is initiating an effort to update the flood plain information to reflect greater potential damages in the model.

operation allows for 125,000 acre-feet to be interchangeable between Auburn and Folsom Reservoirs. This with-project condition does not include re-operation, Folsom Modification, and Dam Raise assuming that they are either not constructed prior to Auburn Dam or that these projects are discontinued.

E. Auburn Dam with Folsom Mods ("E"). Folsom Modifications using four new auxiliary spillway outlets plus the proposed 7-foot Dam Mini Raise are included and completed as part of the without-project and re-operation is discontinued. Auburn Dam is then added completed and operated as described in condition "D."

Single Event Damages by Frequency

Damages from individual events were estimated based on depth of flooding relative to the first floor and the value of the structure and contents at risk. Depth damage relationships were used to determine the percent of value damaged at a given depth. Uncertainties in structure and content values, first floor elevation, and percent damaged were used in Monte Carlo simulation. These results were then linked to corresponding channel stages to create stage-damage functions with uncertainty and integrated with the Probability-Discharge (with inflow vs. outflow), Stage-Discharge, and Levee Failure Probability functions (all with uncertainty) to derive damages by computed frequency. Single event mean damages are shown in Table III - 11 below.

Table III - 11
Single Event Mean Damages Under Varying Project Conditions
(Values in $ Millions, October 2006 Prices)

Exceedance Probability (Event)	Current Baseline	1965 Auth.	Alter. Future	with Auburn "D"		with Auburn "E"	
				Operation Scen. 1	Operation Scen. 2	Operation Scen. 1	Operation Scen. 2
1:50	0	0	0	0	0	0	0
1:100	48	101	0	0	0	0	0
1:111	62	131	0	0	0	0	0
1:125	3,877	3,351	0	0	16	0	0
1:143	4,078	4,361	278	4	106	0	0
1:167	4,211	5,552	1,292	4	648	0	0
1:200	4,267	6,537	1,716	334	3,359	0	1,098
1:250	5,376	7,546	2,271	991	4,048	146	5,227
1:500	7,425	8,451	5,240	4,912	5,335	4,975	7,057
1:1000	8,602	9,761	7,381	7,357	6,935	6,943	8,675

Scenario 1 These with-project results are based on operations that drop the reservoir below the flood storage elevation described in the 1965 authorization. This would have negative impacts on other benefit categories.

Scenario 2 These results are based on Auburn Dam project with flood control operation restricted to authorized flood control pool. This operation will require that either: 1) discharges from rare events are allowed to exceed capacity and overtop the dam or 2) modifications to design of the dam to pass the larger flows. Impacts are potential increases in costs of Auburn Dam.

Results of Preliminary Update

As described above, the HEC-FDA model uses Monte Carlo simulation to integrate the hydrologic, hydraulic, geo-technical, and economic relationships to determine expected annual damages and project performance. To simulate both the various without- and with-project conditions, the regulated (inflow vs. outflow) flow curves with uncertainty were modified to represent the changes in releases from Folsom Dam.

HEC-FDA Model Results- Expected Annual Damages

HEC-FDA runs up to 500,000 iterations creating various frequency-damage functions representing the ranges of values based on the uncertainties in probability-discharge, inflow-outflow at Folsom Dam, stage-discharge, stage-damage and levee failure probabilities for each with- and without-project condition. These frequency-damage functions are then integrated and mean values represent the expected annual damages.

Operations at Auburn Dam

Auburn Dam, if operated for flood damage reduction as described in the 1963 study, without either modification to flood control pool elevation or modification to the design, will provide significantly less flood protection than described in earlier studies.

Using the defined flood control pool elevation of 1083.4 feet msl without redefining spillway operations and coordinating operation with Folsom, may cause the Auburn Dam to overtop. This created a problem for modeling the flow routings without reformulating Auburn. The compromise was to create two scenarios, both having potential impacts either on other benefit categories, dam safety, or increased project costs.

The U.S. Army Corps of Engineers, Sacramento District, provided flood routings for two scenarios and preliminary results based on these routings are shown below in Table III - 12.

1. Scenario 1 allows operations to drop the reservoir below the flood control elevation of 1083.4 feet to keep the dam from overtopping for all modeled events, utilizing more than the 250,000 acre-feet of additional flood control space described in the authorization. The impact on economic benefits with this operation would be a reduction in the storage available for water supply and hydropower, potentially causing an overestimation in total project benefits.

2. Scenario 2 restricts releases from dropping the reservoir below the flood control elevation and allows flows for rare events to exceed capacity. Without design modifications, these flows would overtop Auburn Dam. These model routings would keep the flood control pool within the storage described in the authorization and would not have any negative impacts on the other benefit categories. However, additional construction costs may be required to modify Auburn Dam so these flows could be passed safely.

Table III - 12 Expected Annual Damages Under Varying Project Conditions Values in $ Millions, October 2006 Prices			
Condition	Description	Scenario 1 Expected Annual Damages [1]	Scenario 2 Expected Annual Damages [2]
A	Current Baseline – Common Features @ 400/670k Re-operation	111.2	111.2
B	1965 Authorization – 400k Fixed Operation	117.8	117.8
C	Alternative Future - Folsom with 4 new Auxiliary Spillway Outlets + 7’ Dam Raise 495/695k Re-operation	66.0	66.0
D	Auburn Dam (Total flood space exceeds authorized 650k)	42.8	64.5
E	Auburn Dam plus Folsom Mods (4 aux outlets) plus Dam Raise	36.0	56.4

1. These with-project results are based on operations that drop the reservoir below the flood storage elevation described in the 1965 authorization. This would have negative impacts on other benefit categories.
2. These results are based on Auburn Dam project with flood control operation restricted to authorized flood control pool. This operation will require that either: 1) discharges from rare events are allowed to exceed capacity and overtop the dam or 2) modifications to design of the Dam to pass the larger flows. Impacts are potential increases in costs of Auburn Dam.

Flood Damage Reduction Benefit Results

Benefits were estimated based on comparing the residual with-project flood damages to the three without-project conditions. These are described in this update as flood damage Options 1, 2, and 3.

- Option 1: A – D
- Option 2: B – D
- Option 3: C – E

HEC Flood Damage Analysis (FDA) computes both mean expected annual damages reduced and the probability that damage reduced exceeds an indicated value. In other words, the model provides a range of flood damage reduction benefits for each option listed. Preliminary results are shown in Table III - 13.

Table III - 13
Expected Annual Benefits - Flood Damage Reduction from Auburn Dam
Values in $ Millions, October 2006 Prices

Option or Alternative	Expected Annual Damage			Probability Damage Reduced Exceeds Indicated Values		
	Without-Project	With-Project	Benefits-Damage Reduced	75 %	50 %	25 %
With-Project Conditions Based on Operations Below Flood Control Elevation [1]						
1) A – D	111.2	42.8	68.4	43.8	62.4	87.0
2) B – D	117.8	42.8	75.0	48.1	68.4	95.2
3) C – E	66.0	36.0	30.0	17.5	26.3	38.6
With-Project Conditions Based on Restricting Operation to Flood Control Pool [1]						
1) A – D	111.2	64.5	46.7	30.2	42.9	59.2
2) B – D	117.8	64.5	53.3	34.5	48.9	67.4
3) C – E	66.0	56.4	9.6	5.3	8.3	12.4

1. These with-project expected annual damage (EAD) estimates are from Table III - 14. This operation would reduce storage available for water supply and hydropower and could lower total project benefits.

HEC-FDA Model Results – Project Performance

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with U.S. Army Corps of Engineers ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and conditional non-exceedance probability by events.

1. Annual exceedance probability measures the chance of having a damaging flood in any given year.
2. Long-term risk provides the probability of having one or more damaging floods over a period of time.
3. Conditional non-exceedance probability indicates the chance of not having a damaging flood given a specific magnitude event.

Project performance statistics for the various with- and without-project conditions are displayed in Tables III - 14 and III - 15.

Table III - 14
Project Performance Statistics - Annual Exceedance Probability and Long Term Risk

Condition	Annual Exceedance Probability	Chance of Flooding in a Given Year	Long Term Risk		
			Over 10 Years	Over 30 Years	Over 50 Years
A	0.0080	1 in 125	7.7 %	21.4 %	33.1 %
B	0.0085	1 in 118	8.2 %	22.6 %	34.7 %
C	0.0045	1 in 222	4.4 %	12.7 %	20.3 %
With-Project Conditions Based on Operations Below Flood Control Elevation [1]					
D	0.0026	1 in 385	2.5 %	7.4 %	12.0 %
E	0.0020	1 in 500	2.0 %	5.9 %	9.7 %
With-Project Conditions Based on Restricting Operation to Flood Control Pool [2]					
D	0.0051	1 in 196	5.0 %	14.3 %	22.7 %
E	0.0045	1 in 222	4.4 %	12.7 %	20.2 %

1. This operation would reduce storage available for water supply and hydropower and could lower total project benefits.
2. This operation would not impact other benefit categories but would have an impact on project costs.

Table III - 15
Project Performance Statistics - Conditional Non-Exceedance Probability

Condition	Conditional Non-Exceedance Probability by Events				
	4% (1 in 25)	2% (1 in 50)	1% (1 in 100)	0.4% (1 in 250)	0.2% (1 in 500)
A	100 %	98.1 %	73.4 %	16.6 %	2.1 %
B	100 %	97.3 %	69.6 %	14.0 %	1.7 %
C	100 %	99.8 %	93.6 %	49.3 %	15.1 %
With-Project Conditions Based on Operations Below Flood Control Elevation 1					
D	100 %	100 %	98.3 %	71.6 %	32.6 %
E	100 %	100 %	98.7 %	75.1 %	36.4 %
With-Project Conditions Based on Restricting Operation to Flood Control Pool 2					
D	100 %	99.7 %	92.1 %	43.8 %	11.8 %
E	100 %	99.9 %	95.0 %	52.6 %	16.6 %

1. This operation would reduce storage available for water supply and hydropower and could lower total project benefits.
2. This operation would not impact other benefit categories but would have an impact on project costs.

Limitations of Update Approach

The preliminary flood damage reduction benefits found in this update are based on the best available information at this time. However there are several limiting factors regarding the evaluation of flood damage reduction benefits for Auburn Dam.

1. At the time of this report, the baseline economics from the American River Folsom Modifications Report upon which data in this preliminary benefits update was derived is still under review and refinement. Damage estimates and project performance for the without-project could still be revised. Elements that could impact the without-project condition:

a) Hydrologic model is currently under a full Independent Technical Review.

b) Folsom Modifications options are still being evaluated. Most likely preferred alternative based on current data is four new auxiliary outlets but alternative optimization is not yet completed.

c) The Dam Raise at Folsom is still being optimized for both flood damage reduction and dam safety considerations.

d) New Flood Plains and Structural Inventory. The U.S. Army Corps of Engineers is currently considering revising the existing conditions hydraulics and economics. Flood plains used in the damage model have been modified based on frequency to reflect current conditions but are based on models from the 1992 Feasibility Study.

2. Operations between Folsom and Auburn for the authorized 650,000 acre-feet flood control space have not been optimized. Conditions, primarily current projects added since the 1965 authorization, and hydrology, have significantly changed and could impact the effectiveness of the operations modeled in this update.

3. Considerations of various allocations of the available space of the authorized Auburn Dam have not yet been modeled. With changes in resource demands, the 250,000 in additional flood control space from the 2.5 million acre-feet for the authorized dam may not lead to the optimal solution.

4. Optimal sizing of Auburn to reflect current conditions, costs, and demands was not considered in this update.

Recreation Benefits

1963 Supplemental Report

Recreation Benefits and Evaluation Methodology

The 1963 Supplemental Report for project justification concluded Auburn Reservoir would provide an average water surface area of about 8,700 acres during the recreation season, April through September. The report also concluded Folsom Reservoir could be held at higher operating levels providing an additional surface area of nearly 1,500 acres during the recreational season. These water surface areas totaling nearly 10,200 acres could be used for boating, swimming, and other water sports, and land around the perimeter could be used for picnic and camping areas. The report estimated the annual equivalent recreation benefits attributable to Auburn Reservoir are evaluated at $6,574,000, which includes the increase in use of Folsom Reservoir because of a higher minimum pool.

The recreation benefit evaluation methodology documented in the 1963 Supplemental Report was derived by multiplying expected recreation visits by recreational user day values. Some of the key factors and assumptions for the analysis included:

1. Demand for outdoor recreation in the Central California area would increase rapidly due to population growth and more leisure time.
2. Auburn Reservoir was expected to provide many new recreational opportunities and was also expected to make Folsom Reservoir more attractive due to more stable water levels.
3. With-project visitation estimates used in the analysis included approximately 3,900,000 visitor days in 1973, capping at approximately 5,100,000 visitor days in 1985 (90% being water related recreation and 10% camping).
4. Without-project recreation at the Auburn Dam site was estimated at approximately 86,000 visitor days in 1973, capping at approximately 125,000 visitor days in 1985.

Without-Project Recreational Use

The 1963 Supplemental Report recreation analysis was based in large part on the "Project Report on the Recreation Resources of the Auburn-Folsom South Unit" prepared by the National Park Service in 1963. The report cites relatively little recreational use of the proposed Auburn Dam inundation area; in part due to lack of access. The report noted that while the lower portions of the reservoir, in the vicinity of Auburn, are readily accessible by U.S. Highway 40 and State Highway 49, only a few minor roads lead down to the existing reservoir, known as Lake Clementine which would be inundated by the proposed project. The report estimated approximately 50,000 annual visitor-days were spent in the entire proposed Auburn Reservoir area in 1963.

The report estimated existing recreation would increase to a level of 125,000 visitor days by 1985, valued at $82,500. The estimated 1985 level of visitation was held constant from 1985-2072.

Expected With-Project Recreational Use

The 1963 Supplemental Report noted that Auburn Dam would create a reservoir surface of 10,390 acres, with approximately 143 miles of shoreline. The proposed reservoir would be within easy driving distance of concentrations of population. Day use would probably predominate with some family camping and organized group use in the more level portions overlooking the dam as well as along the more secluded Forest Hill Divide area.

The report estimated 2,000,000 general recreation visitor days and 500,000 camping days in 1962 with Auburn Dam in place. Additionally, incremental recreation use at Folsom Lake State Recreation Area (Folsom SRA) with Auburn Dam in place was estimated at 1,263,500 additional general recreation visitor days and 45,600 camping days in 1962. The report estimated existing recreation at the Auburn site would increase to 5,000,000 general recreation visitor days and 574,000 camping days by 1985. The additional recreation at Folsom SRA was estimated to increase to 4,900,000 general recreation visitor days and 160,000 camping days by 1985. The estimated 1985 level of visitation at both sites was held constant from 1985-2072.

Net Recreation Benefits

Table III - 16 summarizes the 1963 Recreation Benefit Estimate as presented in the Supplemental Report. Note that these values are presented in 1958 price level and were calculated over a 100 year period of analysis at a discount rate of 2.875%.

Table III - 16
Recreation Benefit Estimate in 1963 Supplemental Report

Fiscal Year	Project Year	Annual Benefits ($) or Annual Increase [1]	Present Worth Factor (2-7/8%)	Present Worth ($) at 2-7/8%
AUBURN RESERVOIR				
1973 - 1985 [2]	1 - 12	2,524,371	10.029	25,317,000
1973 - 1985 [3]	1 - 12	89,761	61.806	5,548,000
1986 - 2072	13 - 100	3,601,500	22.710	81,790,000
Total (Auburn)				112,655,000
Annual equivalent (Auburn)				3,441,000
FOLSOM RESERVOIR				
1973 - 1985 [2]	1 - 12	2,037,296	10.029	20,432,000
1973 - 1985 [3]	1 - 12	107,326	61.806	6,633,000
1986 - 2072	13 - 100	3,325,200	22.710	75,515,000
Total (Folsom)				102,580,000
Annual equivalent (Folsom)				3,133,000
Total present worth at 1958 price level (Auburn and Folsom)				215,235,000
Annual equivalent at 1958 price level (Auburn and Folsom)				6,574,000

1. Recreation benefit estimates net out lost recreation estimated to be valued at approximately $57,000 in 1973, and increasing to an annual value of $82,500 in years 1985 through 2072.
2. Values given on these lines represent the level of accomplishment in fiscal year 1973, and do not include any build-up during the 12-year period from 1973 to 1985.
3. Values given on these lines represent the build-up in accomplishments between 1973 and 1985. The level existing in 1973, is not included.

Primary Changes Affecting Benefit Estimation

Significant changes in demographic and socioeconomic conditions, as well as recreational use associated with the study area have occurred since the time of the analysis documented in the 1963 Supplemental Report. A simple indexing of 1963 recreation benefits to 2006, is not considered a reasonable approach to updating recreational benefits associated with construction of Auburn Dam under current conditions. The most significant changes affecting the previous recreational estimates include changes in without-project recreational use, changes in expected visitation, and current user day values for recreation in the study area. Additionally, assumptions applied in the 1963 analysis regarding recreational visitation capacity of Auburn Dam and Folsom Lake resulted in much higher estimates of visitation than currently considered feasible by the California Department of Park and Recreation (DPR).

At the time of the Supplemental Report, relatively little recreation use was documented in the inundation area of the proposed Auburn Dam. The main recreational activity in the area was water related recreation occurring at Lake Clementine. The lands acquired for Auburn Dam construction and operation have been under the management of the California Department of Parks and Recreation (DPR) since entering into an agreement with the U.S. Bureau of Reclamation in 1977. The project lands managed by DPR were later designated as the Auburn State Recreation Area. Today, the Auburn State Recreation Area provides a natural area offering a wide variety of recreation opportunities to over 900,000 visitors annually.

Methodology for Preliminary Update

The U.S. Water Resources Council published the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G)" in 1983, to guide the formulation and evaluation studies of the major Federal water resources development agencies. The Principles and Guidelines (P&G's) identifies procedures for evaluating the beneficial and adverse effects of actions on recreation. The P&Gs identifies a nine-step framework for evaluating recreation benefits. This framework was applied in this preliminary benefits update.

Economic Factors Applied in Benefit Calculations

This benefit update was based upon a one-hundred year period of analysis and the current Federal discount rate of 5.125% and values are presented in October 2006 price level. For the purposes of economic analysis for this update, the base year (year when benefits of dam construction begin to accrue) is assumed to be 2025. For this recreation analysis, it is further assumed that all recreation infrastructure required to achieve estimated benefits is in place at the time of the base year.

Study Area

For the purposes of this recreation benefits update, the study area includes the Auburn State Recreation Area (ASRA) and the Folsom Lake State Recreation Area (FLSRA). The study area also includes the recreation demand area for the state recreation areas, the counties of Placer, El Dorado, and Sacramento. This study area is within 2 to 3 hours travel time of the San Francisco Bay Area and is within 40 minutes travel time of the Sacramento metropolitan area.

Population growth has occurred at an average annual combined rate of 1.37 percent for the three counties (Placer, El Dorado, and Sacramento) over the period of 1960-2005 (from a population of 589,166 in 1960 to 1,857,351 in 2005). Population in the three counties is projected to grow at an average annual rate of 1.14 percent over the period of 2005 through 2050 (to a projected total of 3,798,143 in 2050). Continued population growth and urbanization in the demand area is expected to result in increased regional recreation demand over the period of analysis.

Existing Recreation Resource and Use

This section provides an overview of recreational opportunities at the ASRA and FLSRA as well as an overview of similar recreational opportunities within the region.

Table III - 17
ASRA Recreational Features, Activities, and Facilities

• Bike Trails	• Boat Mooring
• Family Campsites	• Boat Ramps
• Fishing and Hunting	• Boat-in Camps
• Hiking Trails	• Picnic Areas
• Horseback Trails	• Swimming
• Gold Panning	• Whitewater Rafting
• Off-Highway Vehicle Trails	• Annual Events

Auburn State Recreation Area (ASRA)

The ASRA is made up of the lands set aside for the Auburn Dam. DPR administers the area under contract with the U.S. Bureau of Reclamation. The current suite of recreational features, activities, and facilities provided at the ASRA are summarized in Table III - 17.

Visitation

Attendance estimates of the California Department of Parks and Recreation over the period of 1995-2005 for the ASRA are provided in Table III - 18.

Table III - 18
ASRA Visitation

Period	Visitation Estimation
10-year Total	7,334,204
10-year Average	733,420
5-year Total	4,896,486
5-year Average	979,297

Folsom Lake State Recreation Area (FLSRA)

The FLSRA includes both Folsom Lake and Lake Natoma. There are many access points and entrances. The primary recreation season coincides with the spring and summer months when temperatures are in the 80s, 90s, and 100s.

The water level at Folsom Lake dictates the type of recreation and length of the season. During years with normal precipitation, the main summer recreational season is June through September. During the remaining months of the year, use of Folsom Lake drops considerably. The desired reservoir elevation for recreation is approximately 435 feet to 455 feet.

Table III - 19
FLSRA Recreational Features, Activities, and Facilities

• Beach Wheelchair Access	• Wildlife Viewing
• Bike Trails	• Windsurfing
• Environmental Campsites	• Boat Ramps
• Exhibits and Programs	• Campers (Max. Lgth. - 31')
• Family Campsites	• Food Service
• Fishing	• Parking
• Group Campsites	• Picnic Areas
• Hiking Trails	• Restrooms
• Horseback Trails	• RV Dump Station
• Nature Trails	• Trailers (Max. Lgth. - 31')
• Swimming	• Visitor Center

FLSRA offers opportunities for hiking, biking, running, camping, picnicking, horseback riding, fishing, water-skiing and boating. The current suite of recreational features, activities, and facilities provided at the FLSRA are summarized in Table III - 19.

Visitation

Recreation visitation estimates of the California Department of Parks and Recreation over the period of 1995-2005 for the FLSRA are provided in Table III - 20.

Table III - 20
FLSRA Visitation

Period	Visitation Estimates
10-year Total	12,503,244
10-year Average	1,250,324
5-year Total	6,775,102
5-year Average	1,355,020

Without-Project and With-Project Conditions

The methodology applied for this recreational benefit update is based upon estimating the difference in the values of recreational benefits with and without the construction of Auburn Dam (referred to as “with-project” and “without-project” conditions and benefits) over the 100-year period of analysis.

Evaluation Methodology

The unit day value (UDV) method for estimating the value of recreation benefits was applied for this benefit update. When the UDV method is used for economic evaluations, planners select a specific value from the range of values provided in the most current published schedule. Application of the selected value to estimated annual use over the period of analysis, in the context of the with- and without-project framework of analysis, provides the estimate of recreation benefits. The UDV method relies on expert or informed opinion and judgment to develop point ratings for the alternative future conditions in the study area as they relate to recreation. For this study, DPR staff of the Auburn and Folsom State Recreation Areas developed the point ratings for with- and without-project conditions at both the SRAs.

The published point rating method in the P&G’s was applied to guide the selection of the appropriate recreation value from the published range. The factors in this point rating method along with the corresponding range of monetary values are described in Benefits Update technical memorandum. The resultant unit day monetary values are then multiplied by projected visitor use days at the two SRAs to estimate recreational benefits.

Key Assumptions

For this preliminary recreation benefits update, the without-project recreational features and facilities at the ASRA and FLSRA were assumed to remain similar to those provided under current conditions. It was also assumed that the projected population growth within the region would result in growth in the demand for recreation at the two SRAs over the 100-year period of analysis though at a lesser rate than the projected growth in population. Projected visitation was not allowed to exceed visitation capacity limits identified by DPR for each SRA under both with- and without-project conditions.

The evaluation of with-project conditions assumed the recreational features and facilities at the FLSRA would remain the same as those assumed for without-project conditions at the site. Estimated differences in the quantity and quality of recreational use at FLSRA under with-project conditions was assumed to be a function of the average annual days that the lake would be drawn below 430 feet impeding the use of recreational infrastructure around the lake.

For the evaluation of with-project conditions at ASRA, it was assumed that the existing recreational features and uses at the ASRA would be replaced with a new suite of recreational opportunities as identified in the 1978 General Plan for the Auburn Reservoir Project prepared by the California Department of Parks and Recreation.

Rating System Application

Table III - 21
Summary of Unit Day Point Ratings ASRA & FLSRA

Recreation Unit	Without-Project Point Ratings	With-Project Point Ratings	Change
ASRA	70	44	-26
FLSRA	42	42	0
Total	112	86	-26

Application of the unit day value method requires expert judgment to develop point ratings for with- and without-project conditions. The experts who developed the point ratings were planners/ recreation specialists from California Department of Parks and Recreation (DPR) representing the two SRAs with 30 years collective experience at the projects dating from 1977. The point ratings for each evaluation criteria are summed for the with- and without-project conditions to arrive at a total point rating for each site under each condition. Results of the point rating analysis are summarized in Table III - 21

Table III - 22
Point Ratings to Unit Day Values Conversions

Project Condition	Points	Recreation Category: General Unit Day Value	Hunting & Fishing Unit Day Value	Specialized Unit Day Value
ASRA Without	70	$7.78	$8.57	$25.52
ASRA With	44	$6.30	$7.02	$17.83
FLSRA Without	42	$6.14	$6.90	$17.39
FLSRA With	42	$6.14	$6.90	$17.39

The point values were converted to unit day dollar values using the FY06 table published by the U.S. Army Corps of Engineers as Economic Guidance Memorandum EGM-06, October 2005. Table III - 22 shows the unit day values associated with the point ratings in Table III - 21 Different values are provided for “general recreation”, “hunting and fishing”, and “specialized recreation”. For this study specialized recreation was defined as those activities of high quality that are not readily available at other sites within the region.

Table III - 23
Daily Visitation Estimates

Project Condition	Recreation Visitation		Percent by Category		
	Baseline (2006)	Optimum Capacity	General	Hunting & Fishing	Specialized
Auburn SRA Without-Project	979,297	1,500,000	84.5%	0.5%	15.0%
Auburn SRA With-Project	650,000	1,600,000	97.0%	3.0%	0.0%
Folsom Lake SRA Without-Project	1,355,020	2,000,000	74.0%	3.0%	23.0%
Folsom Lake SRA With-Project	1,140,250	2,000,000	74.0%	3.0%	23.0%

With- and Without-Project Recreation Visitation

The unit day values in Table III - 22 were multiplied by daily visitation estimates at the recreation units to derive an estimate of economic benefits of recreation at each site under each condition. Visitation estimates for the two state recreation areas were provided by the California Department of Parks and Recreation, Gold Fields District Office, and are presented in Table III - 23. The estimates include a breakout of recreation by recreation categories.

Results of Preliminary Update

To calculate the average annual benefits, recreation visitation in each year of the 100-year period of analysis was calculated based upon that year's visitation estimate; the percent participation in general recreation, hunting and fishing, and specialized recreation categories; and the unit day values for each condition. Calculations for each year were converted to their present value, summed, and converted to average annual equivalent value. The results of the benefit calculations are presented in Table III - 24.

Based on the updated analysis described above, the recreation benefits attributed to the project in the 1963 report do not appear to be reasonable based upon current conditions in the study area. The most significant change in conditions since the previous study is the highly valued recreational use that is currently taking place in the ASRA. Another key finding that caused results to shift from previous analysis was the reduction in visitation that results from the lower capacities at the recreation areas from those levels assumed in the 1963 analysis.

Table III - 24
Recreation Benefit Update (Current Conditions)

	Average Annual Benefits
Auburn State Recreation Area	
Without-Project	$11,402,300
With-Project	$6,378,400
Net Benefits	-$5,023,900
Folsom Lake State Recreation Area	
Without-Project	$13,216,500
With-Project	$13,437,700
Net Benefits	$221,200
Auburn and Folsom Lake State Recreation Areas	
Without-Project	$24,618,800
With-Project	$19,816,100
Net Benefits	-$4,802,700

Limitations of Update Approach

The unit day value methodology applied for this preliminary benefit update is appropriate for this reconnaissance level of analysis. If more detailed studies are conducted, it may be more appropriate to perform more detailed recreation valuation studies based upon similar or more detailed (contingent valuation or travel cost) methodologies for evaluating the recreation benefits or impacts of the project.

Sensitivity Analysis

A review of other studies on specific day use values indicates a wide range of values by activity, region, and agency. The USDA Forest Service completed a report in 2005, comparing average values per person per day for 30 different recreation activities from over 1,200 study estimates (Forest Service, 2005). Updated for 2006 price levels, the values ranged from a low of $6.43 (for visiting environmental education centers) to a high of $423.15 (for windsurfing) with an average of $51.02 per person per day across all listed activities. This average is higher than the values presented in Table III - 22 and used for benefit calculations in Table III - 24. USDA Forest Service values are flat values for types of activities; that is they do not vary for changes in quality as with the point rankings applied in the unit day value method used in this analysis.

To examine the sensitivity of the results of the recreation analysis to higher user day values, the unit day values from Table III - 22 were replaced with applicable values from the 2005 USDA Forest Service Study and net benefits were recalculated (using the same visitation estimates). The new use values were based on averages of the listed values for applicable activities found in the Forest Service study. The net annual recreation benefits using the user day values in are shown in Table III - 25.

Studies based on both Travel Cost Method (TCM) and Contingent Valuation Method (CVM) show that there can be a wide range of published unit day values depending on activities and regions. The Forest Service conducted a 1989 study that showed recreation user day values for Region 5, which would geographically include both ASRA and FSRA, ranging from $6 to $38 depending on activity (Forest Service, 2000). This range is close to the range of unit day values presented in Table III - 22, approximately $6 to $25.

Another recreation study provided aggregated river and reservoir recreation use values along the Snake River (Loomis, 1999). Although in a different region than the study area, this study involved the consideration of recreation conditions with and without dams/reservoirs on a river system. After selecting the types of activities from the Snake River study that were applicable to ASRA and FLSRA and averaging the corresponding day use values, the resultant day use values were similar for both river and reservoir activities at $86.95 and $86.88, respectively (updated for 2006 prices using Consumer Price Index).

Assumptions regarding future projected visitation also have an impact on the benefit estimates. Visitation projections used in the point ranking/unit day value model were based on past historical visitation, projected population growth and expert judgment. For sensitivity analysis, the following changes in the above visitation projection assumptions were incorporated in to the analysis as follows.

1. Visitation numbers for the new with-project Auburn facilities were allowed to grow at a rate equal to the population growth as opposed to the 25 percent of population growth rate used for without-project conditions. This change was based upon an assumption that it was possible that the additional opportunity provided with the new Auburn facilities (with more than adequate capacity to meet base year demands) could allow for faster growth than existing without-project facilities which have capacity limitations.
2. It was assumed that FLSRA would not see any of the transfer of use to ASRA (as projected by DPR and included in the methods resulting in the benefits shown Table VII - 18) in the first years that Auburn facilities become operational.
3. The initial loss of net visitation (new activity visitors minus loss of old activity visitors) from the without-project condition to the with-project condition at Auburn was assumed reduced to 25 percent.

Depending on the source of published day use values and visitation assumptions, the recreation benefit estimates from the construction of Auburn Dam vary significantly. Table III - 25 shows a summary of the range of possible benefits described in this section.

Table III - 25
Range of Net Annual Recreation Benefits

	Table III - 24	Forest Service Values	Snake River Values
Auburn State Recreation Area	-$5,023,900	-$22,730,200	$2,613,700
Folsom Lake State Recreation Area	$221,200	$1,020,300	$3,344,000
Auburn and Folsom Lake State Recreation Areas	-$4,802,700	-$21,709,900	$5,957,700

Fish and Wildlife Benefits

1963 Supplemental Report

Fish and Wildlife Benefits and Evaluation Methodology

In its summary of project accomplishments, the report stated the operation of Auburn Reservoir in conjunction with the existing Folsom Reservoir will make it possible to maintain a minimum pool of 600,000 acre-feet or more in all except the very critical dry years. Auburn Reservoir would assist in providing control over critical water temperature releases for downstream fish spawning and propagation. The Supplemental Report's summary of project benefits estimated fish and wildlife benefits amounting to $459,000 on an annual equivalent basis result from angling at Auburn Reservoir and improved downstream conditions, including those at Folsom Reservoir. Annual equivalent fish and wildlife benefits attributable to the Folsom South Canal are estimated at $19,000 annually for a total of $478,000.

Fish and wildlife benefits were documented in an accompanying U.S. Fish and Wildlife Service report for the following categories:

- Sport Fishing – resident fish and anadromous fish
- Commercial Fishing – anadromous fish
- Hunting – deer, upland game, and waterfowl

The benefits by category as listed in the 1963 report are included in Table III - 26.

Table III - 26
Annual Fish and Wildlife Benefits

Fish and Wildlife Benefits Claimed in 1963 (Econ Appendix)	Annual Benefits
Auburn Reservoir Fishery (non-native bass and trout)	$70,000.00
Folsom Reservoir Fishery (non-native bass and trout)	$156,000.00
Folsom South Stream Fishery (native trout sport)	$20,000.00
Folsom South Upland Game	$19,000.00
Fall Chinook (commercial)	$48,000.00
Spring Chinook (commercial)	$128,000.00
Winter Chinook (commercial)	$32,000.00
Steelhead (commercial)	$5,000.00
Totals	$478,000.00

Primary Changes Affecting Benefits

Significant changes have occurred affecting fish and wildlife benefit estimation since the analysis documented in the 1963 Supplemental Report. These include changes in fishing and hunting participation rates from assumed levels, changes to commercial fishing practices and fishery management (including Endangered Species Act (ESA) listings) along the Pacific Coast, and changes in the modeling of fish population productivity.

Methodology and Data Needs for Benefit Update

Impacts or benefits associated with sport fishing for resident fish and hunting were captured in the recreational analysis for the preliminary update as documented in Section VII of the Benefits Update TM. Therefore those benefit categories are not addressed further in this Fish and Wildlife Benefits Update Section.

Potential benefits for commercial fishing and for sport fishing downstream of Nimbus Dam are discussed qualitatively below. In both cases, insufficient data exists to estimate potential benefits in quantitative terms at this time.

Potential Downstream Sport Fishing and Commercial Fishery Benefits

In the 1960 and 1963 economics analyses, a major benefit of the Auburn Reservoir was assumed to be in temperature benefits to the American River downstream from Nimbus Dam. Water stored in Auburn Reservoir would be released throughout the summer and fall and provide cold water flows into Folsom Reservoir, which could then be released downstream of Nimbus Dam. It is likely that a new analysis of potential fishery benefits from Auburn Reservoir would also identify cold water flows as a benefit to the overall American River system. However, the original calculations of benefits would likely be significantly revised.

Current populations of fall Chinook and steelhead trout in the American River are significantly reduced from the numbers in the 1950s and 1960s. Based upon available data, it is unclear to what extent a spring- or winter-run Chinook population could be established in the American River, or to what extent cold water flows would increase fall-run Chinook or steelhead trout populations. Hatchery populations have rarely, if ever, achieved the run sizes projected in the 1963 study.

Similarly, it is unlikely that commercial fishery benefits would reach the projected benefits calculated in 1963. A general decline in anadromous fishery stocks along the Pacific coastline has occurred since the 1963 analysis, resulting in a near closure of the Pacific salmon commercial fishery in California at the time of this report.

Development of reasonable estimates of benefits to sport and commercial fisheries would require more detailed modeling and evaluation of fish stocks and productivity under with and without-project conditions at Auburn Dam than is currently available. Such analysis would likely be required to address NEPA and ESA requirements.

Summary of Preliminary Benefit Update

Preliminary Results

Total benefits attributable to both Auburn Dam and the Folsom-South Unit as reported in the 1963 Report were just over $60 million. Assuming that all other existing conditions from the 1960s remained constant, inflationary price factors would raise these values to about $420 million in current 2006 dollars. But this limited price level update fails to address significant changes in the existing and projected future without-project conditions. Demands for water resources have changed along with changes in infrastructure, historical data, procedures, guidelines and model methodologies have had a great impact on these benefit estimates. These range from intended users finding alternate sources, such as irrigation for new farmers in the valley to underestimating recreational use in the existing without-project Auburn SRA. In addition, benefits that could be derived from the completion of the Folsom South Canal are not included in any of the preliminary results.

With this current analysis, benefits were very sensitive to some basic assumptions regarding operations and variable without-project conditions. Therefore, for many benefit categories a range of values were provided based on several scenarios. Table III - 27 shows the results of the current benefit update over a range of possibilities in terms of minimum and maximum benefits.

It is important to note that the benefits shown in the table do not reflect any reformulation or optimization of Auburn Dam. Re-allocation of storage capacity or resizing for optimization would have a significant effect on the benefits. Level of detail of model analysis was also limited, utilizing data from existing studies. In this Special Report, no plan formulation to consider various Auburn Dam alternatives has been completed. These details would require significant effort beyond the scope of the Special Report.

Observations

Based on this update, construction of a 2.326 MAF dam at Auburn would provide greater dollar benefits (unadjusted for price level) than the 2.5 MAF dam described in the 1963 study. Shifts in demands for water resources and changes in without-project conditions result in a change in the expected distribution of benefits of the dam. In the 1963 study, about 75 percent of the total benefits were from expected agricultural uses. Based on this preliminary evaluation there is a significant shift in benefits away from irrigation; while M&I, flood damage reduction, and hydropower are expected to exhibit benefit increases. With existing recreation visitation at Auburn being much greater than forecast in the 1960s, it is possible that the construction of Auburn Dam may lead to a reduction in recreational values in the study area. It is important to note that these observations are based on a preliminary reconnaissance level reevaluation with general broad based assumptions.

Table III - 27
Preliminary Estimate of Auburn Dam Benefits Under Current (2006) Conditions

Category	Range of Annual Equivalent Benefits from Auburn Dam
Irrigation [1]	\$25.4 to \$ 42.5
Municipal & Industrial [1]	\$ 3.9 to \$ 10.4
Hydropower	\$53.0 to \$113.0
Flood Damage Reduction [2]	\$ 9.6 to \$ 75.0
Recreation	-\$22.7 to \$ 6.0
Fish and Wildlife [3]	--
Total Benefits	**\$75.7 to \$240.4**

1. Water supply can be distributed between irrigation and M&I to provide a range of benefits. The trade-off is that for one to increase the other use decreases. The distribution shown in this table for the minimum is taken from Scenario 1 described in Section III and the maximum from Scenario 2.
2. The wide range of flood damage reduction benefits listed in the table reflects the uncertainty of operations. Due to changes in hydrology since the 1963 report, the flood control space would need to be increased or additional costs would have be included in the design to meet current PMF flow requirements. Without reformulation, it is hard to determine the accomplishments of Auburn Dam and account for dam safety.
3. Significant benefits are anticipated but most likely they would not be quantified in monetary units. Due to limited readily available data, time, and funding for this update, the updating of fish and wildlife benefits were considered beyond the scope of this report. In addition, methods used to value ecosystems and habitats have changed significantly since the analysis performed for the authorizing 1963 Supplemental Report.

Section IV
Engineering Design Review of Technical Standards

Sec. IV– Engineering Design Review of Technical Standards

For purposes of the Special Report, the CG-3 dam design at RM 20.1 was used as the basis for the engineering design technical review and cost update. This is not to say that if further studies were conducted regarding the Auburn Dam that a concrete curved gravity dam would be selected today as the most appropriate type of dam. Developments in dam design over the last 25 years may lead to a conclusion that another type of dam is more appropriate. The CG-3 design at RM 20.1 was documented in the "Feasibility Design Summary: Auburn Dam Concrete Curved Gravity Dam Alternative" (Interior, 1980). The basis for the selection of this design for this Special Report is associated primarily with the wealth of information readily available for the CG-3 design at RM 20.1, and a high degree of certainty that a dam of this design and location can safely be constructed.

Table IV - 1 summarizes the major features of the Auburn Dam and Reservoir serving as the basis for the engineering and technical review.

Table IV - 1

Auburn Dam and Reservoir – Summary of Features

Project Location: North and Middle Forks of American River, in Placer and El Dorado Counties, near Auburn, California

Project Purposes: Irrigation Water Supply, Municipal & Industrial Water Supply, Flood Control, Power, Recreation, Fish & Wildlife, Navigation

Drainage Areas		**Unimpaired Flows of Auburn Dam**	
Auburn Dam (RM 20.1)[1]	970 square miles	Mean annual runoff (WYs 1922-1994)[4]	1,363,000 acre-feet
North Fork American River at Auburn Dam[1]	355 square miles	Maximum annual runoff (1982 WY)[4]	3,256,000 acre-feet
N. Shirttail Cyn. Cr. at Sugar Pine Dam[2]	9 square miles	Minimum annual runoff (1977 WY)[4]	229,000 acre-feet
Middle Fork American R. at North Fork[1] (excluding Rubicon River)	300 square miles	Spillway Design Flood[5]	
MF American R. at Fr. Meadows Dam[2]	47 square miles	Peak inflow	500,000 cfs
Rubicon River at MF American River[1]	316 square miles	1-day volume	758,000 acre-feet
Rubicon River at Hell Hole Dam[2]	112 square miles	5-day volume	1,700,000 acre-feet
Pilot Creek at Stumpy Meadows Dam[2]	15 square miles	Standard Project Flood[2]	
Gerle Creek at Loon Lake Dam[2]	8 square miles	Peak Inflow	306,000 cfs
American River at Folsom Dam[3]	1,875 square miles	100-year flood	
American River at Fair Oaks[3]	1,921 square miles	Peak Inflow	202,000 cfs
American River at H Street Bridge[3]	1,969 square miles	5-day volume	783,000 acre-feet
Auburn Dam		**Auburn Reservoir**	
Dam Type	Conc. Curved Gravity (CG-3)	Elevations	
Location (North Fork American River)	River Mile 20.1	Top of dead storage	616.5 feet msl
Elevation, top of parapet	1,139.5 feet msl	Top of inactive	816.5 feet msl
Elevation, crest of dam	1,135.0 feet msl	Top of active conservation	1,083.1 feet msl
Structural height	685 feet	Top of joint use (gross pool)	1,131.4 feet msl
Total length of crest	4,150 feet	Area	
Width of crest at elevation 1135.0	40 feet	Gross pool	10,050 acres
Maximum base thickness	465 feet	Storage capacity	
Downstream face slope	0.68:1	Top of dead storage	29,000 acre-feet
Total concrete in dam	9,760,000 yd^3	Top of inactive	360,000 acre-feet
Diversion tunnel diameter (horseshoe)	33 feet	Top of active conservation	1,876,000 acre-feet
		Top of joint use (gross pool)	2,326,000 acre-feet
		Length of shoreline	140 mi
Spillway (service and auxiliary)		**Powerplant**	
Crest elevation	980 feet msl	Number and size of units	4 @ 200 MW
Discharge capacity at maximum water level	330,000 cfs	Type of turbines	Francis
Total orifice area	3,648 ft^2	Discharge at rated speed & head	5,760 cfs
Crest gates (top-seal radial)		Type of generators	vertical shaft
Number and size	8 @ 19x24 feet	Number and diameter of penstocks	4 @ 17 feet
Plunge pool basin elev (service / auxiliary)	410 / 430 feet msl	Penstock intake elevations	625 and 800 feet msl
Outlets		**Other Project Features**	
River outlets (72-in dia. w/ 72-in ring-follower gates & hollow jet valves)		Major relocations[7]	Highway 49, upstr. Access roads
Number and intake elevation		Takeline lands[8]	43,473 acres
Discharge elevation	485.5 feet msl		
Capacity at top of inactive	4,000 cfs		
Capacity at gross pool / restr. capacity[6]	5,540 cfs / 4,200 cfs		

Notes: All information presented in Table 1 was taken from *Feasibility Design Summary, Auburn Dam Concrete Curved Gravity Dam (CG-3)* (US Dept. of the Interior, Water and Power Resources Service, August 1980) unless otherwise noted.
[1] California Watershed Map, CALWATER Version 2.2, September 1999, http://gis.ca.gov/
[2] *Design and Analysis of Auburn Dam Volume One*, Reclamation, August 1977
[3] *Reservoir Regulation Manual for Flood Control, Folsom Dam and Reservoir, Appendix II*, U.S. Army District, Corps of Engineers, March 1959
[4] Auburn annual inflow data from CALSIM II (CVP OCAP Study 5, June 2004) per water year (WY)
[5] *Auburn Dam site Inflow Spillway Design Flood Study*, Reclamation, January 1967
[6] Restricted to a discharge of 4,200 cfs because of possible damages to the conduits caused by high-velocity flow
[7] *Final Report on the Evaluation of the Auburn Dam Project*, Bechtel National, Inc., November 1985
[8] Updated real estate assessment, Reclamation, February 2006

Auburn Dam was originally designed in the early 1970s and updated in the late 1970s. Design criteria for dams and other water control structures have changed in the roughly 30 years that have elapsed since the original design. The most crucial changes have occurred in hydrologic and seismic disciplines. Analysis methodologies in these technical areas rely in some measure on statistical data related to the frequency and magnitude of the occurrence of precipitation, runoff, and seismic activity. New data is always being collected in these areas, and the growing statistical population used in their methodologies ends up including larger, or smaller, events not sampled before.

When assessing the old CG-3 design in the context of today's design standards and methodologies the implications to any future design vary. Design criteria changes that have occurred since the late 1970s may not all result in cost increases. The evolution of knowledge of a physical process results in the application of more exact procedures that allow more efficient design resulting in reduced cost. The evolution of dam design over the last 30 years has certainly led to greater understanding of physical processes and technology has opened many possibilities in relation to materials and construction methodologies not available in the late 1970s.

Auburn Dam was designed following Reclamation and industry standards current in the 1970s. These design standards were presented in detail in several publications:

Auburn Dam Specific Publications

- Design and Analysis of Auburn Dam (1977)
- Auburn Reservoir Project – Preliminary General Plan (1978)
- Auburn Dam – Feasibility Design Summary – Curved Concrete Gravity Dam (CG-3) (with 800 MW Integral Powerplant) (1980)
- Auburn Dam – Feasibility Design Summary – Rockfill Dam (with 400 MW Underground Powerplant) (1980)

Reclamation Design Standards and Design Criteria

- Design Arch Dams 1977
- Design Gravity Dams 1976
- Monograph No. 19 Concrete Dams
- Monograph No. 20 Turbines
- Monograph No. 36 Arch Dams

Monograph No. 19 mentions Auburn Dam as one of the examples where those design standards are being implemented. The design standards or design criteria used by Reclamation aimed to provide safe, economical, functional, and durable structures. The criteria considered materials, including both the foundation, and the concrete and its components, loading conditions, methods of analysis and design data, and construction methodologies and quality.

Significant criteria used for the design of the concrete dam in 1978, relates to:

- Hydrologic Design
- Seismic Design
- Dam Site Selection
- Selection of Dam Type
- Selection of a Curved Gravity Dam
- Geometry of the Dam Cross-Section
- Location of the Powerhouse Inside the Gravity Structure
- Use of Conventional Mass Concrete Placed in Zones of Different Strengths
- Concrete Characteristics
- Thermal Analysis
- Foundation – Concrete Interface Characteristics
- Foundation Surface Treatment
- Foundation Seepage Control
- Loads and Loading Conditions
- Factors of Safety
- Methods of Analysis
- Spillway Design Considerations
- Plunge Pool Design Considerations
- Outlet Works and Diversion Considerations
- Powerplant and Related Features
- Major Relocations

Hydrologic Design

The early inflow design study results were reported in the "Auburn Damsite Inflow Spillway Design Flood Study" dated January 1967. This study was an extension of a previous study conducted in 1957, on the inflows to the proposed Auburn Dam reservoir. The hydrology was based on a rainfall volume calculated by the Denver Flood Hydrology Section of the Bureau of Reclamation in 1965. The distribution of the rainfall was based on an analysis of large storm events that occurred in 1955 and 1957.

The basis for the precipitation data used in the Auburn study is not referenced adequately in the information available for review, but it was assumed that the precipitation data were developed based on procedures similar to Hydrometeorological Report No. 36 (HMR 36) which was issued by the National Weather Service in 1961. HMR 36 was replaced in 1999, by Hydrometerological Report 59 (HMR 59). HMR 59 superceded the results of HMR 36, incorporating procedures and new data on extreme events that had occurred since publication of HMR 36.

Floods for designing the cofferdam, or in general floods of lower recurrence intervals, would potentially have more significant changes than the spillway design flood due to the recent hydrologic events recorded in the basin. These would need to be reviewed if the design process for the project advances to the next stage.

Seismic Design

Significant advances have been made in our understanding of seismic sources in the region surrounding the previously proposed Auburn Dam site since the Woodward-Clyde Consultants (WCC) and U.S. Bureau of Reclamation studies in the mid- to late-1970s. In addition, the approaches in evaluating seismic hazards and developing seismic design parameters have evolved significantly. Reclamation's approach to addressing seismic hazards and seismic design has kept abreast of these advances. There has also been a significant increase in the strong motion database, which forms the basis for both evaluating hazards and developing design motions. Hence, most of what is described in 1978 report is now outdated and in some cases, invalid.

Seismic Hazard Evaluation Approach

Up until about 1996-1997, Reclamation used a deterministic approach for evaluating seismic hazards to develop seismic design or earthquake safety evaluation ground motions. The most severe seismic loading was defined through the concept of a Maximum Credible Earthquake (MCE), which did not consider the recurrence rates of the source of the MCE. Two other design events, the Operating Basis Earthquake (OBE) and Design Basis Earthquake (DBE), were also considered for evaluating dam response. Both these events were assessed using recurrence relationships based on the historical earthquake record, a practice that for most regions has considerable uncertainties due to inadequate historical records. There are only two earthquake levels for agencies still using a deterministic approach: the DBE (or Maximum Design Earthquake [MDE]) and OBE. The U.S. Army Corps of Engineers stipulates that the MDE be equal to the MCE for high hazard dams.

Subsequent to 1996-1997, Reclamation has gone to a fully probabilistic approach employing the Probabilistic Seismic Hazard Analysis (PSHA) methodology of Cornell (1968) for evaluating their existing dams. The evaluation of dam safety and the design of any new dams must be performance-based requiring the evaluation of downstream risk and hence probabilistic hazard analysis (Reclamation, personal communication, April 2006). Hence the design of any new dam would be based on the results of a PSHA. That would be true for Auburn Dam (Reclamation, personal communication, April 2006). For example, the seismic safety of the nearby Mormon Island Auxiliary Dam was evaluated probabilistically by WCC (Wong et al., 1994) for Reclamation and by Reclamation itself in 1999 (LaForge and Ake, 1999). Other PSHAs include an evaluation of Folsom Dam by URS (URS, 2001) for the U.S. Army Corps of Engineers, although as previously stated, the U.S. Army Corps of Engineers still generally employs a deterministic approach.

Seismic Sources Significant to Auburn Dam

Considerable new information on seismic sources has emerged in the past three decades. This includes new data and information on the seismogenic potential of the Foothills fault system (Page and Sawyer, 2003) as well as all the faults shown on the 1978 report. In most cases, the MCEs presented are overestimated. The areal source zone approach is also outdated. The emphasis on seismic source characterization has evolved to characterizing discrete fault sources based on geologic and paleoseismic studies rather than areal sources, which rely on the often-deficient historical earthquake record. It should be noted that areal source zones are still used in PSHAs to account for background (random) earthquakes but these do not exceed moment magnitude (M) 6½ ± ¼ in this portion of California in contrast to what is shown in the 1978 report.

Based on current studies, strands within the Foothills fault system would need to be considered in any hazard analysis of a proposed Auburn Dam either deterministic or probabilistic (URS, 2001). Studies by PG&E along the Foothills fault system indicate that faults such as the Bear Mountains faults need to be incorporated into PSHAs (e.g., URS, 2001).

Reservoir Triggered Seismicity

Reservoir-induced seismicity or now termed reservoir-triggered seismicity (RTS) was overemphasized in the early Auburn studies due largely to the occurrence of the 1975 Oroville earthquake. Reclamation seismotectonic studies in the past 20 years have evaluated RTS at its dams in California and with the possible exception of Shasta Dam have not found it to be an issue. RTS will still need to be considered in the design of any new dam. The probability of RTS occurrence and maximum RTS earthquake is best addressed through a PSHA. The probabilistic approach for addressing RTS that was developed by Woodward-Clyde Consultants in the 1970s has also evolved considerably with a much expanded RTS database (Wong and Strandberg, 1996). An analysis using this approach could be performed.

Site Ground Motions

The whole approach to evaluating seismic hazards and developing design ground motions has evolved since the 1970s due in large part to the increase in the empirical strong motion database. In the 1970s, there were a limited number of strong motion records and these few records were used in techniques that required considerable judgment and often over-conservatism, which was used in lieu of adequate data. The technique used to develop deterministic design response spectra in the mid 1980s is no longer valid. For any new dam, a PSHA would be performed and Uniform Hazard Spectra (UHS) for specified annual exceedance probabilities would be defined. The annual exceedance probabilities would be based on Reclamation’s analysis of downstream risk. New attenuation relationships from PEER’s Next Generation of Attenuation (NGA) Project will soon be available to use in PSHAs. These relationships will become the state-of-the-practice based on an expanded and improved strong motion database. Relationships will be available for extensional tectonic regimes like the Sierran foothills. Preliminary review of these relationships show significant decreases in ground motions compared to earlier relationships. The hazard should be deaggregated to evaluate the controlling earthquakes at various spectral frequency bands and based on these results, one to two design earthquakes will be defined with their median response spectra scaled to the UHS. Time histories can be spectrally matched to the design spectra. Multiple time histories should be generated using the expanded strong motion database from the NGA Project.

The MCE ground motions from Reclamation's Auburn study were characterized by a peak horizontal acceleration of 0.50 g. The URS (2001) analysis of Folsom Dam, which is not very distant from Auburn, recommended an MDE peak horizontal acceleration of 0.28 g based on a PSHA with a return period of 10,000 years. The probabilistic peak horizontal acceleration for 35,000 years was 0.41 g. This would suggest that an MCE peak horizontal acceleration for Auburn of 0.50 g is conservative.

Fault Displacements

Since the first studies of the proposed Auburn Dam, a number of groups have looked at the issue of surface fault displacement in the dam foundation. The deterministic estimates of fault displacement for Auburn Dam ranged from no displacement to 91 cm (U.S. Geological Survey). Department of Water Resources (DWR) Consulting Board recommended that the proposed Auburn Dam be designed for a surface displacement of 13 cm. The displacement might occur on a single fault or distributed over a zone of faulting. In the final design specified by the Secretary of Interior, 23 cm of normal-oblique displacement was selected for selected foundation features. In the event of a new dam, investigations for active faulting in the dam foundation would be mandatory. New age-dating techniques have emerged in the past three decades and our understanding of faults in the Sierran Foothills have improved such that an assessment of the most recent displacements in bedrock faulting have a greater likelihood for success. Also the hazard of surface faulting displacement is now being addressed probabilistically for important facilities (e.g., Yucca Mountain) and given the uncertainties of characterizing faulting of the nature that would most likely be found in a potential dam foundation; a probabilistic fault displacement hazard analysis is recommended. If an Auburn Dam were to be built, it could be designed to withstand the most conservative design displacements appropriate for the Sierran Foothills seismotectonic setting assuming the proper type of dam and dam design.

Dam Design Considerations

Dam Site Selection

The selection of the dam site (RM 20.1) has been extensively debated. Significant geologic and geotechnical investigations have been carried out at the RM 20.1 and alternative sites. Despite the considerable investment in the RM 20.1 site, and the greater unknowns at alternative sites, it is likely that any future consideration of an Auburn Dam would include a review of the dam site selection.

Selection of Dam Type

The 1978 studies favored the selection of a concrete gravity dam instead of a rockfill dam. The technology of concrete-faced rockfill dams (CFRD) was not well developed at the time. Since the later 1970s, several dams using this technique have been built with heights that could be considered precedents for one of this type at the Auburn site. This type of dam is one of the dam types considered in most modern projects, as it is economical, and it is easy to adapt to diverse foundation conditions. Undoubtedly, this dam type would have to be considered along with a gravity dam built using roller-compacted concrete (RCC), as the probable two top contenders for the most appropriate dam type at this site.

Selection of a Curved Gravity Dam

The 1978 design selected a curved gravity dam, but documentation states that the dam was analyzed as a straight gravity dam. This analysis was likely done given the planning level of study, and the analysis methodologies available at the time. Given the available structural analysis methodologies more fully developed since the 1970s the earlier design may not be efficient, and one can probably save materials constructing a straight dam, or a curved dam with a larger radius. These potential design re-evaluations would affect the volume of concrete used in the dam. It should be mentioned that the 1978 CG-3 study implies arch action to re-distribute the stresses in the body of the dam, but the quantities calculated for the project do not include grouting of contraction joints to assure the arch behavior.

The use of any arch action to re-distribute the stresses would also need to be questioned considering the potential foundation fault displacement, and its unknown effect on the monolithic action of the dam blocks.

Geometry of the Dam Cross-Section

The geometry of the dam cross-section formed by a vertical upstream face and a 0.68H:1V downstream face, could be considered slender, and not particularly conservative, for a high dam in a seismic zone. Shasta, which is about the same height, has a heel block upstream, and its downstream slope is 0.8H:1V. Although comparisons of cross-section cannot be done directly, they do provide some guidance, and indicate that further analysis of the dam stability, particularly the foundation and concrete - foundation interface could result in a change of the cross section, to a heavier cross – section requiring additional volume of material. Again, the evolution of dam structural analysis and consideration of the planning level of design done in the late 1970s leads to the conclusion that further analysis is required.

Location of the Powerhouse inside the Gravity Structure

Construction of the powerhouse inside the dam was considered as a cost saving measure during the design process in the 1970s. However, the cost of formwork, and additional coordination of activities required to construct the powerhouse inside the dam probably would offset any potential cost saving. Additionally, the openings required for the powerhouse, access galleries and water conductors are located in the zone of highest stresses in the dam body, and would concentrate stresses to potentially unsafe levels. This is another design decision that would likely be reconsidered. An independent underground powerhouse and water conductors would probably be the preferred solution.

Use of Zoned Conventional Mass Concrete

A zoned dam would have many benefits, and it is a usual procedure successfully employed in many dams. However, conventional mass concrete has been almost completely displaced by RCC in the construction of dams. In the US, the highest dam constructed using RCC is Olivenhain Dam, with a height of 320 ft, but the world experience in RCC dams is at the 650-ft height, and volumes of up to ten million cubic yards. Any future studies for Auburn Dam would need to consider the use of RCC instead of conventional concrete.

Concrete Characteristics

Some of the zones used in the dam require concrete with very high compressive strength. To obtain those high compressive strengths the concrete mix would require very high cement contents resulting in high heat generation and thermal problems. This is another area that would require review. The use of RCC instead of using conventional mass concrete would provide a potential solution.

Thermal Analysis

This is another area that was not completely treated in the 1978 study. It would need to be one of the priorities in any further study of the Auburn Dam.

Spillway Design Considerations

The spillway would be located on two blocks near the center of the dam, and would consist of eight orifices. The four central gates would be the service spillway and used for normal flood operations. The outer two gates on each side of the service spillway would constitute the auxiliary spillway and would be opened only during extreme flood events. Each of the service spillway gates would have a capacity of 41,250 cfs at a maximum water surface elevation. Each auxiliary spillway would have a capacity of 82,500 cfs. At the maximum water surface elevation, the auxiliary spillways and the service spillway would have a maximum discharge capacity of 330,000 cfs.

It is highly likely that a new probable maximum flood (PMF) would need to be developed for Auburn Dam and Reservoir and that the new PMF would be greater than the current PMF. Accordingly, the Auburn spillway design likely would change.

Early designs for Auburn Dam spillway operations were based on criteria that limited discharges up to 115,000 cfs from Folsom Dam during passage of the Standard Project Flood through Auburn. These operations were based on a combined flood storage of 650,000 acre-feet for Auburn and Folsom Reservoirs, of which 125,000 acre-feet were interchangeable between the two reservoirs. Since the earlier studies, a new PMF has been developed for Folsom. Accordingly, reformulation would likely include a reconsideration of the maximum storage capacity at Auburn in conjunction with Folsom to achieve higher levels of flood protection and reconsideration of the overall design of the spillways at Auburn Dam.

Plunge Pool Design Considerations

The plunge pool was designed as a two-level basin to accommodate the discharge from the service spillway and auxiliary spillways. The flow from the service spillway would be dissipated in the farthest downstream basin. The auxiliary spillway discharges would follow a trajectory underneath the service spillway jets and dissipate in the upstream basin.

Outlet Works and Diversions

The outlet works would be located in a block near the center portion of the dam and consist of two bell-mouth circular intakes transitioning to two 72-inch diameter steel pipes, followed by two 72-inch ring-follower gates. The outlet pipes would drop from a centerline elevation of 625 feet above msl to elevation 485.5 feet and enter the powerplant outlet bay. The outlets would discharge horizontally through two 72-inch hollow-jet valves. The outlet works are designed to discharge 4,000 cfs providing releases for downstream requirements.

Direct diversion from Auburn Dam and Reservoir includes the PCWA Auburn Ravine (Ophir) Tunnel. The ¾ mile long, Ophir Tunnel extends from near the north (river right) abutment of the dam to an outlet in Auburn Ravine. The gated inlet would be inundated by about 200 feet at gross pool elevation in a 2.3 MAF Auburn Reservoir. PCWA intends to use the tunnel to divert some of its North Fork and Middle Fork American River water rights to western Placer County.

Two other features for possible consideration in future project designs include sacrificial bulkheads on the outlet works and potential additional temperature control device (TCD) facilities. The Special Report will not include these components in the cost update. Both of these elements will require additional study beyond the scope of this report and project reformulation.

Powerplant and Related Features

The 1965 authorization (PL-89-161) for the Auburn-Folsom South Unit included a hydro-electric power plant at Auburn Dam with initial installed capacity of approximately 240 megawatts (MW) with a provision for an ultimate development of up to approximately 400 MW. The authorization included necessary transmission for interconnection with the CVP power system. The August 1980 CG-3 Feasibility Design Summary (Interior) proposed an optimum powerplant size of 800 MW arranged as four 200 MW generating units. An additional 4 MW generating unit was located in the river outlet bay to generate the power needs of the dam.

Foundation Design

Foundation – Concrete Interface Characteristics

The foundation for Auburn Dam was studied exhaustively, using state of the art procedures at the time. The interpretation of the results of testing, and the corresponding parameters derived from the investigation, such as shear strength of the rock mass, strength of the concrete-foundation interface, deformation modulus of the rock mass and others, would be done different at this time, resulting in values that could affect the stability analyses performed. The rock mechanics studies would need to be reviewed and the test data re-evaluated based in the progress of the last 20 to 30 years.

Particularly important would be re-evaluations of the behavior of the rock mass, and of potential rock blocks, using state-of-the-art techniques.

Foundation Surface Treatment

The foundation surface treatment is not very well defined in the 1978 report. Considering the size of the dam, the foundation should not only be excavated to competent rock, but foundation shaping should be performed to avoid potential stress concentrations. Foundation concrete would be required in important quantities to obtain a regular surface for placement of the dam concrete. The existing foundation would have to be re-assessed given other considerations related above.

Foundation Seepage Control

The rock foundation apparently is tight, as implied by the selection of one row grout curtain, with holes spaced 12 feet on-center. No details are given about grout mixes or grouting technology. This area would need review. Currently design trends call for split spaced grout curtains with primary and secondary holes, and intermediate tertiary, and higher level, holes as required. Grouting would be performed using one stable thick grout mix, using super-plasticizers, and using real-time recording and computer controlled equipment. Closure would be evaluated using a volume-pressure control method developed after a thorough field test.

Loads and Loading Conditions

The loads and loading conditions used in the 1978 report are the usual loads for analysis of gravity dams; however, a thorough review would be required given the evolution of structural analysis methodologies of dams. The seismic loads are discussed under a separate paragraph below.

Particular attention would need to be given to foundation faulting and its movement, and the effect on the integrity of the dam. This problem was studied in 1978, and assumed to be amenable to be treated as a linear effect. However, the problem involves a complex interaction between the rock mass and the dam, and it is a highly non-linear problem. Some new approaches to fracture mechanics, start from the simplest smeared crack models to the more sophisticated models, such as cohesive crack modeling, and cracking-potential extension under static and dynamic stress fields.

Methods of Analysis and Factors of Safety

The 1978 studies and design were based on the traditional method of stability analysis called "shear friction factor" and corresponding factors of safety. This methodology has been replaced by the limit equilibrium method and its own factors of safety, but even this method is being replaced by risk-based design approaches and finite element analyses.

The feasibility level stability analyses performed used a two dimensional approach, but the curvature of the dam, plus the geometry of the canyon, require a three dimensional approach to the analysis.

Major Relocations

There are several remaining relocations required with the construction of Auburn Dam and Reservoir including roads, utilities, rails, and an equestrian bridge.

Construction of Auburn Dam and Reservoir would require relocation of several county roads and a portion of State Highway 49. Replacement of these roads is generally contained under provisions of Section 207 of the Flood Control Act of 1960, as amended by Section 208 of the River and Harbors Act of 1962 (PL 87-874), and Section 36 of the Water Resources Development Act of 1974 (WRDA). The Auburn-Foresthill Road and Bridge replacement was completed in 1973, and is now in operation. The two remaining major road relocations are State Highway 49 and the Placer/El Dorado county upstream route. Each roadway relocation will need to meet current Caltrans standards and will require significant additional analysis.

Highway 49 Relocation

The original relocation of State Highway 49 was to begin at the intersection of Lincoln and College Way in Auburn, run southerly to the intersection of the Auburn-Folsom and Shirland Tract roads, and then swing in a large arc toward the north (river right) abutment of Auburn Dam. This portion of the highway relocation has been completed and is in use. Highway 49 was to cross the North Fork American River canyon on a viaduct founded on the top of dam and continue easterly to an intersection with existing Highway 49 near Cool.

Current national security concerns would probably prohibit Highway 49 from crossing the American River Canyon on top of Auburn Dam. Much of the potential relocation route of Highway 49, especially on the Auburn side of the American River Canyon, is now in residential development. Other potential routes would need to be evaluated in any future studies.

Placer and El Dorado County Road Relocation

The Special Report is also including an earlier study's proposal to replace access in the eastern portion of Auburn Reservoir. This relocation includes a two-lane, all-weather, paved road extending from Old U.S. 40 between Colfax and Weimar to the El Dorado County road near Spanish Dry Diggings. Two major bridges will be required; the Colfax-Foresthill Bridge to cross the North Fork and the Greenwood Bridge to cross the Middle Fork.

Access Roads

To date, nearly 12 miles of construction access roads have been completed. They include Pacific Avenue, Indian Hill Road, Auburn-Folsom road intersection, left and right abutment access roads, a connecting road, powerplant access road, and railhead access road. Where appropriate, these access roads, especially within the construction area, would need to be replaced. Additional site access roads would be required to facilitate construction.

Other Roadways and Utilities

Various other minor roads, bridges, and utilities in the Auburn Reservoir area could be candidates for relocation. Examples include U. S. Forest Service facilities, the Ponderosa Way access road and bridge, power-lines, and radio towers. However, it is not clear at this time, if these and several other minor roads/bridges were included in the original project or should be considered for relocation. Future efforts are required to develop a detailed inventory of these facilities.

Trails and Equestrian Bridge

Numerous recreation trails used for hiking, running, biking, and equestrian purposes are located in the Auburn Reservoir area. New recreation facilities (described below) as part of the project would more than offset existing recreation uses in the American River Canyon. They would also offer an expanded array of recreation experience to a much broader population than under a no - action condition. Several specialty uses, however, may require separate relocation considerations. These include the Tevis Cup horse race and the Western States Run; both are 1-day, 100-mile events that use the Western States Trail from Auburn to Squaw Valley. These events draw entrants from around the world.

Cost estimates in the August 1980 CG-3 Feasibility Design Summary (Interior) included a trail and equestrian bridge. Further efforts are needed to identify the locations for these facilities. However, until the scope of this trail and bridge can be confirmed, it is believed that the previous cost be recalculated to current price levels for inclusion in the special report.

Recreation Considerations

The Auburn State Recreation Area, managed by California Department of Parks and Recreation (DPR), is located on Federal lands administered by Reclamation within the proposed Auburn Dam and Reservoir Project. Reclamation entered into an agreement with DPR in 1966 that governed the construction and operation of recreation and fish and wildlife enhancement facilities of the Auburn-Folsom South Unit. Under that agreement, DPR agreed to pay one-half of the separable costs for the recreation and fish and wildlife facilities that were to be constructed by Reclamation. The State also agreed to operate and maintain the completed facilities. In 1978, under this agreement, DPR developed a preliminary general plan for recreation facilities at Auburn and Folsom reservoirs and Lake Natoma. The 1978 General Plan assumed the construction of the dam and filling of the reservoir.

Table IV - 2 summarizes recreation facilities planned for the Auburn Reservoir. These facilities are sufficient to accommodate a maximum of 9,140 visitors at any one time and about 1.6 million visitors annually.

TABLE IV - 2
Summary – Recreation Facilities at Auburn Reservoir

Facility	Number	Capacity
Auto Campgrounds	2	280 Sites
Picnic Areas	10	245 Sites
Multi-use Areas	3	360 People
Bicycle Trails		12 Miles
Trail Staging Areas – Horseback Riding & Hiking	10	230 Cars
Riding & Hiking Trails		120 Miles
Trail Camps	5	50 People
Boat Launching Ramps	3	14 Lanes
Car Top Boat Launch Sites	5	95 Cars
Marina/Boat Rental	1	200 Cars
Boat Camps – On Shore (20 Sites Each)	3	60 Boats
Boat Camps – Off Shore (20 Boats Each)	3	60 Boats
Swimming Area – Floats	1	140 Cars
Motorcycle Trail Staging Areas (Plus Trails)	1	50 Cars
Four-Wheel Drive Route – Lake Access	1	4 Miles
Vista & Historic Sites	9	185 Cars
Interpretive, Orientation, & Administrative Areas	7	310 Cars

1. Source:
2. "Auburn Reservoir Project, Folsom Lake Site Recreation Area, Preliminary General Plan," DPR, October 1978.

Should Auburn Dam and Reservoir be selected for implementation, it is likely that the recreation facilities would change. However, for the purposes of the Special Report, it is estimated that the recreation facilities listed in Table IV - 2, as described in the 1978 Preliminary General Plan, would still be included in the project.

Environmental Considerations

The environmental impacts of this project have been addressed at various levels in the following reports:

- 1991 American River Watershed Investigation, Volume 6 - Appendix S
- 1978 Design and Analysis of Auburn Dam Report

Further Evaluation

In order to provide adequate information concerning the potential impacts and mitigation needs associated with the Auburn Dam project, the following will need to be completed:

1. An updated Environmental Impact Report (EIR) will need to be completed that addresses the current impacts to biological resources.
2. Impacts to special status species and their habitats, as well as other impacts to aquatic and upland habitat types need to be quantified.
3. A Mitigation Plan that describes the impacts, mitigation requirements, opportunities, and costs shall be prepared in order to adequately address the information provided in the updated Environmental Impact Report.

4. Additional studies may be needed in order to address impacts and potential mitigation from this project. Examples include:
    a) An Instream Flow Incremental Methodology (IFIM) study, resulting in habitat/flow relationships, may be required to determine the potential effect on aquatic species downstream of the dam.
    b) A stream temperature modeling study may be required to study the effect of the project on downstream water temperatures.

Review of Biological Information and Potential Mitigation Costs

The potential mitigation costs associated with impacts resulting from the construction of the Auburn Dam are estimated based upon information presented in Volume 6 - Appendix S, Part 1 of the December 1991 Feasibility Report (US ARMY CORPS OF ENGINEERS 1991). These costs are preliminary and are a rough estimate based upon potential impacts, estimated area of impacted habitat types and recent costs of similar mitigation lands.

Environmental Setting and Biotic Resources

Based upon a review of Volume 6 - Appendix S, Part 1 of the December 1991 Feasibility Report, the following existing conditions occur within the project area:

The project area occurs within a transition zone between the middle elevation foothill grassland, hardwood woodland-hardwood forest communities, and the higher montane, largely evergreen mixed- and conifer-dominated forest communities (US ARMY CORPS OF ENGINEERS 1991). To evaluate the anticipated impacts to fish and wildlife of the Auburn Dam project, through the U.S. Fish and Wildlife Service (USFWS) Habitat Evaluation Procedure (HEP) analysis, seven terrestrial vegetation cover types and one riverine cover type were identified, based upon Barbour's (1987) Terrestrial Plant Ecology designation.

Terrestrial Vegetation Cover Types:

1. Evergreen hardwood
    a) forest (north slope-black oak),
    b) woodland (south slope-oak woodland),
2. Conifer forest,
3. Chaparral
4. Grassland-savannah
5. Upland scrub
6. Rocky
7. Ruderal

Riverine Cover Type:

1. Riparian (Montane) - including riparian forest, freshwater marsh, palustrine scrub-shrub and other habitats located within the maximum high water mark.

In addition, rocky/ruderal upland habitat was identified to account for impacts to this habitat type, although it is not listed in Barbour's description. Table IV - 3 demonstrates the approximate acreages of each habitat type (based upon the US ARMY CORPS OF ENGINEERS 1991 data) within the project area.

Table IV - 3
Acreage by Habitat Type

Habitat Type	**Quantity (acres)**
Evergreen Hardwood Forest	8,300.0
Evergreen Hardwood Woodland	8,400.0
Conifer Forest	1,500.0
Chaparral	1,400.0
Grassland / Savannah	450.0
Freshwater Marsh	50.0
Montane Riparian	3,100.0
Total	**23,200.0**

Section V
Project Cost Estimate

Sec. V - Project Cost Estimate

A Total Project Cost Estimate for a water resources development project is a combination of construction contract costs (in general, those costs associated with actual physical construction) and other non-contract costs (costs primarily, but not exclusively, related to non-construction related costs) that are required to bring a water resources project to fruition. Project cost estimates are a measure of the expected cost of a project at a particular point in time. Project cost estimates can be developed at various stages or levels of a project. For this Special Report, the project cost estimates are developed at a appraisal, or order of magnitude level. This information is developed without detailed engineering data. The appraisal level estimate has a wide range of accuracy and is typically used to determine if a particular project is worth further investigation or to screen multiple alternatives. Typically, such an estimate compiles all of the costs of the categories, features, and items of a project.

It should be noted that the 1980 concrete-curved gravity dam, which formed the basis for this Special Report had, at the time, a fair level of detailed engineering data. The 1980 design took advantage of the detailed design data that had been available for the double curvature concrete-arch dam then under construction. The level of estimate for this Special Report is only considered appraisal because of the long time period that has transpired since the original project and because this evaluation was directed not to reformulate the old project. If further study were to be made of the Auburn Dam Project, the whole project would be re-formulated based upon current water demands, socio-economics, and design standards, methodologies, and technology. The cost estimate described here only represents an order of magnitude cost update of the 1980 design as formulated in 1980. Undoubtedly, if looked at in more detailed studies, the Auburn Dam Project would look much different today than in 1980.

The total project cost for the update of the costs associated with the Auburn Dam for this special study is $9,598,000,000. A breakdown of this estimated total project cost is found in Table V - 1. As an appraisal study cost estimate, this estimate has many risks and uncertainties associated with it. These risks and uncertainties are described in Section VI. These risks could lead to higher or lower estimates. During the course of reviewing the risk and uncertainties a low estimate of $6 billion was established as a lower range of estimated Total Project costs. Also, the total project cost referenced in this report cannot be equated to “Total Project Costs” referenced in historic documents. The foundational criteria when beginning this Special Study was that the project would not be reformulated. However, as the historic project and its design were reviewed, it became apparent that there were several conditions that have changed since the early 1980’s that potentially affect costs in a significant manner. It was found that preparing an updated cost estimate in strict adherence to the 1980 formulated project may not give the decision maker a true picture of current costs at an appraisal level. Consequently, when preparing this cost estimate engineering judgment was required to determine when the basis of the estimate would strictly adhere to the historic 1980 design and when the estimate would be based on more current knowledge and conditions. The professionals preparing this analysis had to balance the desire to present their best opinion of the order of magnitude appraisal level estimate for the Auburn Dam Project while meeting the institutional, time, and budget constraints that did not allow a reformulation of the project. A middle ground approach was used. For the most part, the basis of the design and cost estimate is related to the historic 1980 design. No redesign of the structure was made to account for changes in design standards or analysis methodologies. Some judgment was taken in relation to specific features however. For example, the historic design relocated Highway 49 over the top of the dam. For security reasons such an approach would not likely be allowed today. Consequently, a cost was developed for providing an alternative Highway 49 relocation. Similarly, historical costs associated with environmental mitigation were minimal. These costs have been substantially increased. The basis for the current updated cost estimate is detailed in the following pages. Other factors contributing to the risk and uncertainty associated with this cost estimate are delineated in Section 6.

Table V - 1
Total Project Cost

Item	Description	Amount	Percentage of Total Cost
	Contract Costs		
1	Project General Requirements	$440,000,000	5%
2	Site Preparation	$79,000,000	<1%
3	Concrete Curved Gravity Dam	$2,092,000,000	22%
4	Hydro-Electric Power Plant	$578,000,000	6%
5	Electric Power Transmission, Switchyard, and Substation	$76,000,000	<1%
6	Highway and Road Relocation	$469,000,000	5%
7	Public Access and Recreation	$32,000,000	<1%
	Subtotal	$3,766,000,000	39%
	Unlisted Items (@ 20% ±)	$753,000,000	8%
	Contract Cost	$4,519,000,000	47%
	Contingencies (@ 20% ±)	$904,000,000	10%
	Field Cost	$5,423,000,000	57%
	Non-Contract Costs		
	Lands and Rights	$2,380,000,000	25%
	Environmental Mitigation	$1,480,000,000	15%
	Environmental Compliance & Planning	$15,000,000	<1%
	Engineering and Design	$100,000,000	1%
	Construction Management	$200,000,000	2%
	Non-Contract Subtotal	$4,175,000,000.00	43%
	Total Project Cost*	**$9,598,000,000**	**100%**

*An estimated $315,500,000 in "sunk costs" has not been incorporated into the above total project cost.

A descriptive discussion of cost estimating terminology and the specific line item costs listed above in Table V - 1 are explained in more detail below.

Definitions

It is critical that managers and decision makers have a basic understanding of cost estimating terminology in order that estimates, and what they represent, are properly understood and used. The cost estimates developed for this Special Report are at an appraisal level, and are characterized as an order of magnitude estimate. An inappropriate use of a cost estimate is using it for purposes it was not intended for. The use of an appraisal cost estimate for establishing authorization or funding limits to build a project is not appropriate. This type of estimate has a high order of uncertainty and using it to authorize a project could lead to substantial funding shortfalls. The following definitions and discussion are provided to give a basic understanding of the technical discipline of cost estimating and provides a foundation for the cost estimates presented in this Special Report for the Auburn Dam.

Contract and Field Costs

The contract cost estimate is intended to represent the cost of a construction contract at the time of bid or award. It normally includes allowances for unlisted items and for procurement strategies but does not include contingencies. At the appraisal level this estimate has a wide range of accuracy.

The field cost line item is intended to represent the total construction contract dollars needed for this feature or project from award to construction closeout. This line item will also include dollars for contingencies. The field cost does not include non-contract costs such as legal, lands and damages, environmental permitting and mitigation, and other costs. Some industry standards call this cost the Opinion of Probable Construction Cost.

Non-Contract Costs

Non-contract costs refer to work or services provided in support of the project. These costs include, but are not limited to investigations, designs and specifications, construction management, environmental compliance, archeological considerations, and lands and rights.

Contingencies and Unlisted Items

Contingencies and unlisted items are shown as separate line items.

The estimated construction cost was based on an appraisal level design. During preparation of the estimated construction cost some constructability issues involving surface and ground water management, borrow area location, material processing and haul lengths, foundation conditions and extent of grout curtain construction were examined and discussed. Contingencies are included in the cost estimate to account for unknowns in these types of constructability and site conditions.

A factor was applied to direct and indirect costs for all features as an allowance for pricing, quantities and features not yet identified and designed. These are called unlisted items.

Depending on the level of study, and especially in regards to conceptual level estimates, it is often not practical to identify all items associated with a project. Generally these are items of work, which in and of themselves, do not add significantly to the cost of the project but when added up in aggregate potentially represent a more significant percentage of total costs. Typically a percentage will be applied to appraisal level estimates to account for these minor items.

Discussion of Specific Line Items

Contract Costs

Project General Requirements

Component costs included under Project General Requirements fall under several major categories. These are project administration and management, quality assurance and management, temporary facilities and construction, execution, operations, and decommissioning. These costs are associated with the construction contractor, and are not associated with construction management by the overseeing owner or agency. Construction management costs by the overseeing owner or agency are included in the non-contract costs under construction management.

Project management costs incurred by the construction contractor include coordination, meetings, contract administration, progress monitoring, procurement documentation, and submittals. Quality assurance and management includes activities necessary to meet regulatory and contract requirements, testing and qualifications, field quality control, testing and inspection services and laboratory testing. Temporary facilities and construction may include temporary utilities to field and administrative offices, maintenance and repair facilities for equipment, parking and staging areas, access roads, dust control, fences, noise barriers, and erosion and sediment protection. Execution includes construction layout, field engineering, surveying, security, and closeout documentation. Operations include operation and maintenance costs of all associated facilities and equipment necessary under the general requirements. Decommissioning includes all activities necessary to demobilize upon completion of the project.

Site Preparation

This item includes construction and improvement of existing access roads, layout and construction of haul roads, environmental protection erosion and sediment control, demolition and removal of existing structures, abandonment and sealing existing structures, stripping of excavation, foundation and borrow areas, drying and processing borrow areas, pre-wetting borrow and excavation areas, as needed, diverting and de-watering surface and ground water. Quantities have been calculated for some of these activities where there is design and detail. They are identified by units of measure in the estimated construction cost and have been priced using historical and database unit prices. Other activities not having adequate design and detail have been priced as lump sum allowances in the estimated construction cost based on an experience factor of the total estimated construction cost.

For purposes of this study it was assumed that the reservoir area would be cleared of heavy timber and brush. This extensive clearing was common engineering practice in the 1970s. The need for such extensive clearing would be reassessed based upon current engineering practice and environmental considerations.

This cost item also considers removal of the Placer County Water Agency American River Pump Station currently under construction. The estimate includes total removal, although future studies would have to assess the need for total removal of all concrete structures.

This section includes construction of the upstream and downstream cofferdams. Much of the old upstream and downstream cofferdams were washed away in the floods of 1986 and 1997. This study assumes a total reconstruction of these structures. The estimate also includes costs for the diversion of the river. While the old diversion tunnel is still functional it is unclear what diversion requirements may be deemed necessary should any new project move forward. As a conservative cost estimating measure these costs were retained in the estimate.

Concrete Curved Gravity Dam

Dam

After original authorization a double-curvature concrete arch dam at RM 20.1 was selected. Construction was initiated on this design, until the controversy created by the earthquake event centered near Oroville resulted in cessation of activities. Following cessation of major construction activities, various studies of alternative dam types and alignments were conducted. One study, by Reclamation in 1977-1978, focused on two options: a rock-fill embankment with central impervious core slightly downstream from the RM 20.1 site, and a concrete curved gravity dam (CG-3) at the RM 20.1 site. That study resulted in selection of the concrete curved gravity dam for further consideration. In the mid-1980s, Bechtel National, Inc. evaluated a number of dam types and locations (Bechtel, 1985). These studies concluded that a roller-compacted concrete (RCC) dam at RM 19.0 would be less costly than other dam types and locations.

This Special Report is based on the CG-3 dam design at RM 20.1, as documented in the "Feasibility Design Summary: Auburn Dam Concrete Curved Gravity Dam Alternative" (Reclamation, 1980).

The dam would be founded on slightly weathered rock. Treatment of faults, shears, and weaker zones would be performed as necessary. Grout and drainage curtains would be drilled from the upstream drainage gallery to control seepage.

Spillway and Appurtenant Features

The spillway would be located on two blocks near the center of the dam and would consist of eight orifices. Each orifice would be approximately 456 square feet in area and extend from about elevation 980 to about elevation 1,004 above feet msl. Flow through the orifices would be controlled by a 19-foot by 24-foot top-seal radial gates, which would discharge into two chutes and terminate with a ski jump flip bucket on each chute. The four central gates would be the service spillway and used for normal flood operations. The outer two gates on each side of the service spillway would constitute the auxiliary spillway and would be opened only during extreme flood events. Each of the service spillway gates would have a capacity of 41,250 cfs at a maximum water surface elevation of 1,135.0 feet. Each auxiliary spillway would have a capacity of 82,500 cfs. At the maximum water surface elevation, the auxiliary spillways and the service spillway would have a maximum discharge capacity of 330,000 cfs.

Early designs for Auburn Dam spillway operations were based on criteria that limited discharges up to 115,000 cfs from Folsom Dam during passage of the Standard Project Flood through Auburn, and protected Auburn Dam during passage of the Inflow Design Flood. These operations were based on combined flood storage of 650,000 acre-feet for Auburn and Folsom reservoirs, of which 125,000 acre-feet were interchangeable between the two reservoirs.

The plunge pool would be a two level basin to accommodate the discharge from the service spillway and auxiliary spillways. The flow from the service spillway would be dissipated in the farthest downstream basin. This basin would be placed at elevation 410 feet above msl and concrete lined to withstand impact loading at low discharges. The auxiliary spillway discharges would follow a trajectory underneath the service spillway jets and dissipate in the upstream basin. Accordingly, this basin would be placed at elevation 430.0 feet above msl and be unlined.

Outlet Works

The outlet works would be located in a block near the center portion of the dam and consist of two bell-mouth circular intakes transitioning to two 72-inch diameter steel pipes, followed by two 72-inch ring follower gates. The outlet pipes would drop from a centerline elevation of 625 feet above msl to elevation 485.5 feet to enter the powerplant outlet bay. The outlets would discharge horizontally at a centerline elevation of 485.5 feet above msl through two 72-inch hollow jet valves.

The outlet works were designed for a discharge of 4,000 cfs at a water surface elevation of 816.5 feet above msl to provide releases for downstream requirements. The river outlets would have a capacity of 5,540 cfs at gross pool (reservoir water surface elevation of 1,131.4 feet above msl) but would be restricted to a discharge of 4,200 cfs because of possible damages to the conduits caused by high velocity flow.

Diversions from Auburn Dam and Reservoir would primarily include the PCWA Auburn Ravine (Ophir) Tunnel. The ¾ mile long Ophir Tunnel extends from near the north abutment of the dam to an outlet in Auburn Ravine. Its entrance would be inundated by about 200 feet at gross pool elevation in a 2.3 MAF Auburn Reservoir. The intent was for PCWA to use the tunnel to divert some of its North Fork and Middle Fork American River water rights to western Placer County. The project would include a gated structure at the entrance to the tunnel. This would be needed for PCWA to effectively manage the diversion of its water from Auburn Reservoir and for Reclamation to be able to store water above the inlet elevation to the Ophir Tunnel.

Although not initially included in the project, during construction, provisions were made for the potential future addition of a pipeline to extend from the dam to near Cool by Georgetown Divide Public Utility District (GDPUD). To allow for a cost effective future attachment of the pipeline, a small portion was constructed near (downstream) the south abutment of the dam. Lift stations and any other pipeline and related facilities would be the responsibility of GDPUD.

Borrow Areas

A primary source for aggregate production is the area on the Middle Fork American River that would be inundated by the reservoir. Approximately 8 to 9 million cubic yards of tested concrete aggregate materials exist from Mammoth Bar upstream to Cherokee Bar. Additional materials could be available from development of a rock quarry near the possible site of the aggregate processing plant, or from river gravels located in the Middle Fork American River above the potential Ruck-A-Chucky Bridge site, extending to PCWA's Ralston Afterbay Dam (Reclamation, 1977). Other potential borrow sites include Lake Clementine and the Knickerbocker Creek area (which could impact potential recreation). Material for the original cofferdam came from the Salt Creek Boat ramp and foundation excavation

Constructability and Schedule

A critical component in the development of a cost estimate for a significant project such as Auburn Dam is recognition of the duration of construction. For purposes of this Special Report, a construction duration of 10 years was established. This was established based upon past studies. In the 1980 feasibility evaluation of the CG-3 dam a construction duration of eight years was identified. Other supporting documents suggested that construction could take as long as 12 years. A reduction in the timeframe could lead to substantial cost savings. Several factors influence the construction schedule. Such factors availability of materials and size and quality of workforce, production rates, types and availability of equipment, the number of contracts and contractors on site at any one time, time constraints on work done in the river, limitations on work hours or shifts, funding stream limitations, environmental constraints, weather conditions, and security requirements may all influence the construction period. Construction scheduling issues will be an important component.

In any project of significant size, it is appropriate to evaluate the constructability of the proposed project prior to initiating construction. In the case of Auburn Dam, with a price tag in the billions, it is critical to determine in advance that the ability exists to complete the project. General contractors exist within the United States that have the expertise to complete a project of this magnitude, although it is likely that many of the bidders would be joint ventures in order to compile sufficient resources in both labor force and equipment. Although no contractors have built a dam of this magnitude in the United

States since Glen Canyon Dam in the 1960s, many other types of projects, including dam construction, which include the same types of construction functions have been built during the last 40 years. Design and construction management capabilities exist within Reclamation to successfully complete a project of the size of Auburn Dam. Technical resources within Reclamation, combined with private sector resources, are available to design and construct a project of this magnitude.

Hydro-Electric Power Plant

Power Plant and Switching Facilities

The 1965 authorization (PL-89-161) for the Auburn-Folsom South Unit included a hydro-electric power plant at Auburn Dam with initial installed capacity of approximately 240 megawatts (MW) and transmission for interconnection with the CVP power system. Provision also was made for a potential ultimate development of up to approximately 400 MW. Other power configurations have been evaluated since the authorization. According to the August 1980 Feasibility Design Summary (Reclamation), the optimum size of the CG-3 powerplant was an installed capacity of 800 MW. An arrangement of four 200 MW generating units was selected due to the electrical design flexibility of having an even number of units. Each of the generating units has a minimum head of 356.5 feet, a maximum head of 626.0 feet, a rated head of 500.0 feet, and a design head of 548.5 feet. Each vertical shaft generator has a rotor diameter of about 31 feet and is directly connected to a Francis-type turbine with a spiral case width of about 44 feet. Water, from each turbine, flows through a concrete draft tube with an exit opening of 20 feet wide by 35 feet high. At rated speed and head, the discharge through each turbine is 5,760 cfs. An additional 4 MW generating unit located in the river outlet bay would be used to generate power needed in the dam itself.

The penstocks and their intakes would be located in the center portion of the dam. Each of the four 17-foot diameter penstocks would have two intakes, one with a centerline at elevation 800 feet above msl and one with a centerline at elevation 625 feet above msl. This provides multilevel intake capability for each powerplant unit.

The tailrace would consist of the excavated river channel currently flowing through the floor of the canyon. Tailrace channel slopes would be protected with riprap to prevent erosion and slides.

Electric Power Transmission Switchyard and Substation

Distribution of the electric power generated by the powerplant requires the construction of an appropriately sized switchyard and substation. Generally, these facilities will include steel lattice or tube transmission towers, transformers, switches, surge protection, circuit breakers, substations, fire protection, instrumentation, and the necessary cables and wire and grounding.

Highway and Road Relocation

Highway 49 Relocation

The original replacement of State Highway 49 was to begin at the intersection of Lincoln and College Way in Auburn and run in a southerly direction generally parallel to and slightly west of Sacramento Street to the intersection of the Auburn-Folsom and Shirland Tract roads. This portion of the highway relocation has been completed and is in use. From this intersection, Highway 49 replacement was to swing in a large arc toward the north (right) abutment of Auburn Dam. Maidu Drive, a part of the right abutment access road system, has been constructed in part on the eventual location for Highway 49 in this area. Highway 49 was to cross the North Fork American River canyon on the viaduct founded on the crest of Auburn Dam. From the south (left) abutment of the dam, the route was to continue in an easterly direction through the Salt Creek-Knickerbocker Recreation Area to an intersection with existing Highway 49 near Cool. The total length of the relocation would have been 6.5 miles, of which 1.9 miles has been completed.

Primarily on the basis of National security concerns, the current project plan would not include Highway 49 crossing the American River Canyon on top of Auburn Dam. In the mid-1980s, alternative relocations were considered by the State of California. For purposes of this Special Report an alternative alignment was assumed downstream of the existing dam alignment. The plan also would include an access road from the relocated Highway 49 alignment to the south and north abutments and across the dam. Much of the potential relocation route of Highway 49, especially on the Auburn side of the American River Canyon, is now in residential development.

Other Road Relocations

Construction of Auburn Dam and Reservoir would also require relocation of several county roads. Replacement of these roads is generally contained under provisions of Section 207 of the Flood Control Act of 1960, as amended by Section 208 of the River and Harbors Act of 1962 (PL 87-874) and Section 36 of WRDA. The Auburn-Foresthill Road and Bridge replacement was completed in 1973 and is now in operation. Other remaining major road relocation is the Placer/El Dorado county upstream route. This relocation would need to be made to current State of California standards. Each of these and other minor road relocations would require significant additional evaluation.

The Special Report also is adopting the plan recommended in earlier studies to replace access in the eastern portion of Auburn Reservoir. This relocation includes a two-lane, all-weather, paved road extending from Old U.S. 40 between Colfax and Weimar to the El Dorado County road near Spanish Dry Diggings. Two major bridges would be required: a 1,840-foot long bridge crossing the North Fork (Colfax-Foresthill Bridge) and a 1,900-foot long bridge crossing the Middle Fork (Greenwood Bridge).

Access Roads

To date, nearly 12 miles of construction access roads have been completed. They include Pacific Avenue, Indian Hill Road, Auburn-Folsom Road intersection, left and right abutment access roads, a connecting road, powerplant access road, and railhead access road. Where appropriate, these access roads, especially within the construction area, would need to be replaced. In addition, to facilitate construction, various additional site access roads would be required to facilitate construction.

Utilities and Other Facilities Relocations

Various other minor roads, bridges, and utilities in the Auburn Reservoir area could be candidates for relocation. Examples include U.S. Forest Service facilities, the Ponderosa Way access road and bridge, powerlines, and radio towers. It is not clear at this time, however, if these and several other minor roads/bridges were included in the original project or should be considered for relocation. Therefore, they are not identified for this report. Future efforts would be needed to develop a detailed inventory of these facilities.

Public Access and Recreation

Numerous recreation trails used for hiking, running, biking, and equestrian purposes are located in the Auburn Reservoir area and would need to be replaced.

All cost estimates in the August 1980 Feasibility Design Summary (Interior) included a trail and equestrian bridge. Further, efforts are needed to identify the locations for these facilities. However, until the scope of this trail and bridge can be confirmed, it is believed that the previous cost adjusted to current price levels should be included in the Special Report.

Reclamation entered into an agreement with DPR in 1966 that governed the construction and operation of recreation and fish and wildlife enhancement facilities at the Auburn-Folsom South Unit. Under that agreement, DPR agreed to pay one-half of the separable costs for the recreation and fish and wildlife facilities that were to be constructed by Reclamation. The State also agreed to operate and maintain the completed facilities. In 1978, under this agreement, DPR developed a preliminary general plan for recreation facilities at Auburn and Folsom Reservoirs and Lake Natoma.

As mentioned, many of the lands acquired to date by Reclamation for the Auburn Project are being managed by DPR, which is in the process of developing the Auburn SRA Resource Management Plan/General Development Plan EIS/EIR.

Non-Contract Costs

Lands and Rights

It was originally estimated that total land requirements to implement the Auburn Dam Project would be 49,265 acres. Of lands needed in the Auburn Reservoir area, 12,820 acres would be acquired from private landowners and the remaining 36,431 acres would be withdrawn from public sources, respectively. The anticipated takeline for Auburn Reservoir and areas remaining to be acquired is shown in supporting documentation. However, future studies may identify that some of these remaining lands may not be required. However, additional lands not now identified may be needed. This is especially the case if additional lands are required for environmental mitigation purposes.

For purposes of this Special Report a cursory analysis of the potential cost of acquiring the non-federal property within Reclamation's Auburn Project Lands (in-holdings) was made. Lands affected include in-holdings within both Placer and El Dorado Counties. El Dorado and Placer counties zoned some of these in-holdings as residential or business so many in-holdings now have improvements.

Other lands that may be required include mitigation lands and lands associated with the Highway 49 and other road relocations. For this effort, 23,200 acres of mitigation land were estimated based upon earlier studies done for the U.S. Army Corps of Engineers. Also, since the alignment of any new proposed Highway 49 bridge is very conceptual at this time, a general assumption was made that up to 50 homes may be required to accommodate any new alignment. This estimate was not based on any actual survey of an alignment but was intended to provide a place holder which recognizes this cost item. The uncertainty in the real estate acreage requirements for mitigation lands and their associated cost per acre introduces a significant unknown variable into the estimated total project costs. This uncertainty could introduce either higher or lower costs. A value of $100,000 per acre was used for this estimate but this value could be lower if large blocks of land can be acquired.

Table V - 2
Non-Federal Lands within Project Boundary

	Number of parcels	Total Acres
Placer County	281	8,679.59
El Dorado County (flood)	66	4,142.19
Total	347	12,821.78

Significant additional effort will be required. Surveys are needed for most of the in-holdings. The lack of surveys seems to be one of the most significant data gaps.

Environmental Mitigation

Significant efforts went into the National Environmental Policy Act (NEPA) compliance process and documentation as part of the original project and it is recognized that much more work will be required should this Special Report proceed to another phase of development or the reformulation of the AFSU. As described in Reclamation's 1987 Auburn Dam Report (Auburn Dam Alternative Study), wildlife mitigation measures would be necessary to compensate for adverse effects on wildlife resources of the impoundment area. Through September 1986, about $400,000 of Federal funds were spent to acquire lands in the Auburn Reservoir area to mitigate for impacts to wildlife resources. These lands are located on the Middle Fork American River near Volcanoville. It was stated that the U.S. Fish and Wildlife Service would use funds appropriated to protect the habitat in these wildlife areas and restore plantings used by the wildlife for food and shelter.

It is believed, based on the review of detailed resources evaluations by U.S. Army Corps of Engineers in its studies regarding a flood detention dam at the Auburn Dam site, that the magnitude of mitigation requirements due to direct inundation impacts alone would be significantly larger than anticipated in the authorized project. A multiple propose reservoir at the Auburn site would result in the total loss of over 10,000 acres of wildlife habitat. Impacts would occur to endangered species, primarily the valley elderberry beetle, resident fish species, and cultural resources. Further, surrounding recreation faculties and activities also could adversely impact the resources.

The Auburn Reservoir inundation area and lands required for roads and relocations and recreation facilities contain numerous sites of cultural significance. Many of these sites would be adversely impacted by construction and operation of the project. Surveys of historic and archaeological sites in the project area have been accomplished as part of previous studies and an archaeology recovery plan has been developed. It is believed that based on this information, estimates of costs to implement a recovery and mitigation project element of the impacted sites has been developed in previous studies. These costs are to be updated for the Special Report and no new surveys are planned as part of current efforts.

The uncertainty in the mitigation requirements also introduces a large amount of uncertainty in the total project cost estimate. Actual mitigation requirements could be higher or lower. For the basis of this estimate extensive plantings and restoration activities are assumed as being required to mitigate project impacts. An estimate of over $50,000 per acre was assumed as being required to mitigate adverse impacts. Depending on approaches to project mitigation, there may be some possibility of achieving the required mitigation at a lesser cost per acre.

Environmental Compliance

Environmental compliance requirements are substantially different today than they were in the original project formulation and subsequent studies in the 1970s and 1980s. Environmental compliance requirements include, but are not limited to the National Environmental Protection Act, Historic Preservation Act, Clean Water Act, Clean Air Act, and the Endangered Species Act. In addition there are several State of California requirements administered by the California State Water Resources Control Board and the California Department of Fish and Game.

Planning

Very extensive planning efforts would be required to move the Auburn Dam Project forward. Planning efforts would include identification of water needs and demands, a complete reformulation of the project, identification of potential benefits, new engineering analyses, real estate studies, environmental activities, water rights evaluations, and many other disciplines.

Engineering and Design

As indicated earlier, design and engineering activities would essentially start with a complete engineering re-evaluation of the total project. Many standard and criteria changes since the original authorization along with advances in engineering and construction technology and design methodologies would likely lead to the formulation of a much different looking project today.

Construction Management

Construction management includes all of the staff and facilities necessary to administer a large construction contract. Requirements include administrative personnel and buildings to house them, materials laboratories and field engineering staff and facilities.

Costing Process

This section provides more general background on the development of the cost estimates. The following steps were used to develop the Opinion of Most Probable Construction Cost (OPCC):

Review of Documentation

The available documentation, including drawings, reports, and design criteria, were reviewed to allow the estimator to obtain an initial understanding of the project. Discussions with personnel involved in the design studies are also part of the information process. The review of documentation also includes visits to the project site in order to assess the logistics of the particular location, and discussions with potential contractors, subcontractors, suppliers, and vendors, to evaluate methodologies, and project execution processes.

Quantities Take-Off

This is the measuring and cataloging the quantities of work derived from the scope of work documents. The quantities for this particular case were taken from the 1978 design as presented in the CG-3 feasibility report. The major quantity is the volume of mass concrete, and this was one of the few quantities checked in detail, and modified. Development of an accurate take-off estimate of quantities is fundamental in any costing procedure.

- Classifying the work into features and a work break down
- Describing each of the items of work
- Determining the geometry of the work
- Calculating volumes or other quantities that can be priced

The installed quantities are further defined before being priced by calculating the necessary man-hours, equipment, and productivity rates necessary to install the materials. The estimator also works closely with sub-contractors, suppliers, and equipment vendors to obtain pricing from them for their defined portions of the work.

Costing

Using the take-off and the information presented in the scope documents to assign cost values to the items and features of work cataloged. The quantities determined above are translated into necessary man-hours, equipment hours, materials, and sub-contractors required to complete the work. Accounting of these inputs at the expected pricing will result in the estimated contract price to perform the work.

Pricing

Determines the amount the contractor would charge to the owner including direct and indirect costs as well as contingency and markups.

Unit Pricing

Unit Pricing is accomplished with the use of cost indexes from published and internally developed and maintained historical databases factored for location, contractor markups, and other project specific criteria. All logic, methods, and procedures for developing cost are typical for the construction industry.

Accuracy is not guaranteed and the use of unit pricing should not be deemed as an offering or proposal with respect to the outcome of the cost of an activity or project. Unit price opinions are subject to change with proper notice. Any estimate of unit prices is not intended to predict the outcome of hard dollar results from open and competitive bidding.

Cost indexes include the following:

- General Purpose Cost Indices including Engineering News Record, the Department of Commerce, and the Bureau of Reclamation.
- Contractor Pricing Indices including those received and maintained from previous and current similar project.
- Special Purpose Indices including RS Means, the Bureau of Labor Statistics, and various State Departments of Transportation.

Indices are gathered monthly, or as available, and maintained as current and historic databases. Unit prices calculated from the indices reflect average pricing for the various unit of work incorporated into heavy and civil construction.

Various limitations are built into the use of unit prices calculated from indices. These limitations include the potential for changes in technology, methods and construction applications, the impact of short-term economic cycles, the ever present time-lag of reporting databases and that cost index databases are a composite average, and therefore, have a range of acceptability.

Direct and Indirect Costs

The Opinion of Probable Construction Cost is segregated into direct and indirect costs. Direct and indirect unit pricing is accomplished with the use of cost indexes from published and internally developed and maintained historical databases factored for location, contractor markups and other project specific criteria. All logic, methods, and procedures for developing cost are typical for the construction industry. Direct costs include labor, equipment, material, and subcontracts. Indirect costs include taxes, risk, accommodation for risk analysis and escalation.

Sources of Cost Data and Level of Detail

Construction Pricing Methodology

Construction pricing used in the development of the estimated construction cost includes all direct labor, equipment, materials, and other costs. Several sources were used to obtain unit prices. Unit prices bid for current projects of a similar nature were taken from bid tabulations analyzed for balance. Historical unit price databases maintained by URS were also used along with current RS Means electronic unit price databases. Any unit pricing used was factored for location and work specific criteria. It is assumed that unit prices include, as part of the direct cost, burdened labor hour rates (health, welfare and pension, taxes and insurance), loaded equipment hour rates (depreciation or rent, insurance, taxes, repairs, maintenance and fuel), materials and supplies (allowance for freight, taxes, tariffs and waste) and subcontractors (incorporating all the above). Indirect cost is also assumed to be included in the unit prices. These costs involve all the terms and conditions of the General Conditions and General Requirements, as well as, contractor overheads, profit and bond cost. For major project features involving large quantities unit prices were developed from production calculations based on historical production rates of similar work. Labor and equipment hour rates described above were applied along with allowances for indirect costs. Vendors were contacted and pricing was obtained and factored to include freight, taxes, and waste for project features requiring difficult to locate or large volumes of material.

Quantities

The level of detail associated with this conceptual estimated construction cost was based on the accuracy of the available topographic maps available and provided at the time. Quantities are identified and shown in industry standard units of measure. Calculated quantities were calculated from the level of detail and design developed and based on in-place volumes that do not reflect any possible quantity reductions that can be achieved through material management and balancing of cut and fill volumes.

Bidding Assumptions

All pricing assumes that contractors are qualified and experienced in the construction of large concrete dams. That the contractors will calculate and offer construction pricing from an open and competitive approach to equipment production and material pricing and will not include allowances for changes, extra work, unforeseen conditions, or other unplanned costs.

Escalation

It is also assumed that because of the multi-year construction duration contractors will accommodate for escalation in their pricing. However, for the purposes of this conceptual estimate costs and pricing are in current U.S. dollars with no allowance for escalation or inflation. Costs associated with escalation or inflation are generally accounted for in the project authorization process. In subsequent planning phases, cost estimates will also likely account for inflation during the estimate development process through adjustments of unit pricing based upon the anticipated extended construction period.

Section VI
Risk and Uncertainty Analysis

Sec. VI – Risk and Uncertainty Analysis

The intent of this section is to describe factors which provide uncertainty to the cost analysis and hence pose risks for decision makers as they make use of the cost information provided in this report. The uncertainty being considered in this analysis is based on that of the cost estimate, not on what happens during actual construction. Risks and uncertainty related to activities during construction are addressed through contingencies identified as a line item in the cost estimate. This analysis investigates impact of the risk factors and the associated scenarios on the cost estimate and it was developed based on the top level work breakdown structure (WBS) developed for the individual project features.

Methodology

The procedure followed to conduct this risk and uncertainty analysis consisted of five steps:

1. Conducting a qualitative risk assessment.
2. Using a semi-quantitative analysis.
3. Ranking risk factors in order of decreasing importance.
4. Identifying those risk factors which have the greatest potential for impacting the whole project.
5. Identifying those project features which are greatest risk.

This five-step process involved eight considerations:

- Assessment of base cost
- Development of work breakdown structure
- Identification of relevant risk factors
- Identification of risk scenarios
- Criteria for identifying how to include risk factors in the analysis
- Probability of encountering risk factors
- Cost impact of risk factors
- Calculation of risk scores

Assessment of Base Cost

The appraisal level field cost was developed according to the available level of detail. The field cost is developed with an allowance for the risk that a prudent, experienced contractor would expect to incur. The field cost was prepared on the basis of calculated quantities and unit pricing that are commensurate with the degree of design detail known and assumed. Construction was separated into incremental parts. These parts were defined as a work breakdown of construction tasks. If significant design assumptions were necessary, pricing was developed from historical databases and from similar current and completed projects. As the details of the design become better known in the future, construction task pricing will be developed utilizing crews made up of equipment and labor and an estimated productivity.

Breakdown of Construction Tasks

For the risk analysis, the project was broken down into eight features as follows

- Project General Requirements
- Site Preparation
- Concrete Curved Gravity Dam
- Hydro-electric Power Plant
- Electric Power Transmission, Switchyards and Substations
- Highway and Road Relocation
- Public Access and Recreation Facilities
- Environmental Mitigation

For each item above, it was possible to adjust quantities and unit prices in response to the perceived uncertainty or risk factor.

Identification of Relevant Risk Factors

Assessing the project risk required the use of risk factors. A risk factor is defined as an unplanned condition or event that can significantly impact the project cost. These are unplanned in that they are not included in the contingencies developed for the project. They do however identify issues of particular concern for an owner or agency specific to this project. These can include anything from changes in design requirements due to improved understanding of physical process, (e.g., floods or earthquakes), to changes in environmental regulatory requirements, to changes in real estate costs, to a change in the economy in general.

Nine risk factors were used for the risk analysis.

- Hydrology
- Seismicity
- Borrow Sources
- Quantities
- Environmental Uncertainty

- Real Estate
- Inflation
- Market Conditions
- Legal

Identification of Risk Scenarios

The risk factor identifies unexpected and hence unplanned adverse condition or events. Risk factors, however, may have several conditions we wish to evaluate. To address this issue, we use the risk scenario. The risk scenario sets conditions on the risk factor. It provides an opportunity to perform a more refined assessment of a risk factor's impact on the project's estimated cost. For example, with regard to the potential impact of market conditions on the cost estimate, two conditions were identified which may apply for this risk factor: changes in the availability of critical building materials, and changes in the availability of skilled labor necessary for the project. Each has the potential to impact the cost, but each reflects different aspects or conditions of the risk factor. Under the Material Availability scenario, for example, the impacts to the project can be assessed under the conditions of increased competition for construction and building materials separately from that of labor availability, although both reflect market conditions. This differentiation of the market availability impact from provides an owner or agency with a better understanding of how potential shortages of critical construction materials can affect the estimated project costs.

Criteria for Identifying How to Include Risk Factors in the Analysis

As defined above, a risk factor should identify an unexpected and hence unplanned adverse condition or event. It needs to meet the following criteria to be considered for this analysis:

1. If an adverse condition is known or anticipated with a high probability (greater than 50 percent), its cost impact should be included in the base cost.
2. The risk factor should not be associated with a condition or event whose chance of occurrence is remote (defined as less than 1 in 100 for this analysis). For example, a catastrophic earthquake that could cause extensive damage in the project area was not included as a risk factor, because its chance of occurrence was judged to be less than 1 in 100. This level of exposure is usually taken care of in the design of the project.
3. The cost impact of the risk factor should be significant. For this analysis, the impact is defined as a cost impact of at least three million dollars (estimated at the beginning of the study to roughly correspond to one tenth of one percent of the cost). Risk factors with cost impacts less than this threshold would be included as part of the normal variation in the base cost and are captured in the contingency.

Probability for Encountering Risk Factors

To be considered in this analysis, a risk factor should fall within a specified range of probabilities. Commonly encountered risk factors are not considered in this analysis as they should be included in the contingency costs. At this stage of design, the lower threshold probability for the common risk factors is 50 percent. At a more mature phase, the threshold would be higher. Risk factors whose probability of encountering is small, less than 1:100 in this analysis, are considered too rare to significantly impact the project, or are considered and mitigated using other procedures (design flood, Operating Basis Earthquake). Risk factors which lie within the range between these two extremes are the ones considered in this analysis.

The probability range for considering whether a risk factor was significant was between 1:100 or 1 percent chance to 1:2 or 50 percent chance. Due to the qualitative nature of this analysis, the probabilities were broken down into five categories. They are as follows:

- Category “1” = 1:100 – 1:50 Rare events
- Category “2” = 1:50 – 1:10
- Category “3” = 1:10 – 1:5
- Category “4” = 1:5 – 1:3
- Category “5” = 1:3 – 1:2 Likely events

Thus, a risk factor where the probability of encountering was considered to be 15 percent was given a “3”. The probability of encountering each risk factor was assessed using expert judgment based on experience with similar projects.

Cost Impact of Risk Factors

The risk score was calculated by multiplying the probability and cost scores for each risk factor/scenario and dividing by five (Eq 1). This provided a semi-quantitative five point scale with which to compare the impact of the various risk factors/scenarios on individual project and the project as a whole.

(Eq 1) $$\text{Risk Score} = \frac{(\text{Probability} * \text{Risk Cost Scores})}{5}$$

To assess the impact of the risk factors on the estimated cost of the project, the Risk factors were then ranked in descending order of the scores. Thus a risk factor with a score of “4” is identified as having a greater potential to adversely impact the project than a risk factor with a lower score (e.g., “2.4”).

The range of potential risk scores is presented in Table VI - 1.

Table VI - 1
Matrix of Potential Risk Scores

Probability of Occurrence		Consequence (Millions of Dollars)				
		$3 - $10	$10 - $20	$20-$50	$50-$100	> $100
	Ranking	1	2	3	4	5
1:100 – 1:50	1	.2	.4	.6	.8	1.0
1:50 – 1:10	2	.4	.8	1.2	1.6	2.0
1:10 – 1:5	3	.6	1.2	1.8	2.4	3.0
1:5 – 1:3	4	.8	1.6	2.4	3.2	4.0
1:3 – 1:2	5	1.0	2.0	3.0	4.0	5.0

Detailed Discussion of Risk Factors/Scenarios

The following discussion presents the risk factors and scenarios employed for this analysis. All are considered to have the potential to impact the estimated cost of the dam.

Hydrologic Uncertainty

This purpose of this risk factor is to capture potential cost increases due to changes in design required to accommodate changes in flood flow. Collection of additional hydrologic data usually results on larger flood flows. This has happened with the flood hydrology of the American River at Auburn. There is also the potential that the acquisition of new hydrology data could result in additional revisions to hydrologic design criteria. Such changes have the potential to increase the estimated cost of the dam. To assess the potential impact of such changes, two hydrologic scenarios were employed: Hydrologic Design and Hydrologic Source.

Risk Scenario - Design

New or updated models result in change in the period of return for floods; this may result in design changes for the facility. It is possible that new data could result in an increase of the Probable Maximum Flood (PMF) at the dam site, thereby requiring a larger design flood for the spillway and appurtenant works. This scenario assesses the potential impact to the project costs from a larger design flood.

Risk Scenario - Source

New models or information could also result in changes in predicted flood levels for given flood events. The impact from such changes could be exhibited in design changes for the facility. This scenario assesses the potential impact to the project costs from changes in flood levels.

Seismic Uncertainty

Seismic design criteria for dams have changed since the dam was originally designed. The changes can be attributed to a number of different reasons, such as changes due to improved methodologies due to better seismic data in other areas, and changes due to better seismic data in the neighborhood of the project. There is the potential that the acquisition of new seismic data could result in additional revisions to seismic design criteria. Such changes have the potential to impact the estimated cost of the dam. To assess the potential impact of such changes, two seismic scenarios were employed: seismic design and seismic source.

Risk Scenario - Design

There is the potential that new or modified seismic models could result in change in the period of return for earthquakes or earthquakes at this location of this facility. Such changes have the potential to impact the design criteria of the dam as well as the costs of construction. This scenario assesses the potential impact to the project costs from the need to make design and construction changes in order to meet new seismic requirements.

Risk Scenario - Source

New seismic models result in change in predicted earthquake severity, which may results in design changes for the facility. This scenario assesses the potential impact to the project costs from such changes.

Borrow Sources

Construction of the dam and associated structures necessitates that borrow sources be identified to meet the aggregate requirements for construction. This risk factor assesses the impact to the estimated cost of construction should the identified borrow sources not meet these requirements. Two scenarios were developed to assess the impact of this risk factor: Borrow Source Quantity and Borrow Source Quality.

Risk Scenario - Quantity

For this scenario, the quantity of material available at the identified borrow sources is inadequate for the project. This requires acquiring/purchasing additional aggregate from other locations and potentially increasing project costs.

Risk Scenario - Quality

For this scenario, the quality of material from the identified borrow sources does not meet the design requirements for the project. This requires acquiring/purchasing higher quality aggregate from other locations and potentially increasing project costs, or modifying mix designs that could impact the cost.

Quantities

This risk factor reflects the impacts of modifications to the quantities due to potential changes on the site conditions related to the dam foundation. In this case, two quantities have major impacts on the cost of the project: excavation and concrete. Although the foundation has been excavated already, the excavation was performed before the design had been finalized. The long exposure to the elements may have had deleterious effects on the foundation requiring additional excavation and correspondingly more concrete. Alternatively, in the intervening years since the foundation was originally excavated, changes in design specifications may require additional excavation in order to meet current building standards.

Environmental Uncertainty

This risk factor reflects the impact of environmental issues on the estimated construction costs. The dam and its associated features will impact a fairly large area in the Sierra foothills. Potential environmental impacts encompass things such some of the loss of woodland, loss of riparian habitat, impacts to endangered plant and animal species, etc. Prior to construction of the dam and the subsequent impact to the local environment, environmental permits will be required, and mitigation to reduce the significance of the impacts will be initiated. However, in the years between the time when the dam is designed and when it is built there is some uncertainty with regard to what the final environmental permit and mitigation requirements might be. To assess the potential cost impact, two scenarios are employed: Environmental Permitting and Environmental Mitigation.

Risk Scenario – Environmental Permitting

Acquisition of environmental permits from both the State of California and the Federal Government will be required prior to the construction of the dam and its associated features. These permits specify certain requirements and conditions for the operation of the dam and its associated features. There is the potential that conditions and requirements may change or additional permits may be needed. The impact could result in delay of construction and/or possible changes to facility and thus, increased costs.

Risk Scenario – Environmental Mitigation

For this scenario, additional mitigation will be required. The change may be related to changes in dam design and the associate features, i.e., the dam footprint, the high water line, additional roads and associated rights of way, etc; it might be changes in species status within the area of the dam; or the addition of a new endangered species. The net outcome would be the need for additional lands and/or funds to implement the mitigation changes.

Real Estate

Real estate was identified as a risk factor with the potential to significantly impact the estimated cost of the project. The area in the vicinity of the dam has seen a significant increase in population in the years since the dam was originally designed. This has resulted in an increased demand for land and increase in real estate value. Over the past several years, the pressures have increased with the Central Valley in general, and the Sacramento Metropolitan area in particular, exhibiting significant population growth. The potential impact of these changes can be reflected in two scenarios: Real Estate Land Costs and Increased Land Needed for the project.

Risk Scenario - Cost

For this scenario, land costs have increased and are higher than planned in contingency. Additional funds will be required to purchase the land necessary for the project and its associated features.

Risk Scenario - Quantity

For this scenario, a change in design has resulted in the need for more land to complete the project. The change may be related to a number of issues including the dam footprint, the high water line, additional roads and associated rights of way, etc. Additional funds will be required to purchase the land necessary for the project and its associated features.

Inflation

This risk factor reflects the impact of inflation on the estimated construction costs. Reclamation requirements specify that the project be considered at an inflation rate of x percent. For this risk factor, the impact is considered for an inflation rate greater than 6 percent. Inflation is considered a global risk factor because its impact applies to all elements or features of the project, not just the individual features. Thus, the cost impact will be applied to the total project cost.

Market Conditions

This risk factor reflects changes in market conditions not related to general inflation. The purpose of including this risk factor is to capture the effect of a robust economy and subsequent reduced availability of resources on the cost estimate of the dam. Such changes in market conditions can be reflected in two scenarios: Changes in the Availability of Building Materials and Changes in the Availability of Labor.

Risk Scenario – Material Availability

There is limited availability of building materials due to the fact that economic conditions are different from those used in the initial costing process. The causes could be that the local economy has picked up and thus there is more competition for the same materials or that there is competition from outside the local area for the same materials. The effect could be an upward pressure on the unit pricing for the required construction materials and thus an increase in costs for the whole project. It is important to note that the aggregate costs captured in the Borrow Sources risk factor are not counted here.

Risk Scenario – Labor Availability

During times when the economy is robust, there is the potential of increased competition for labor, particularly skilled labor for complex projects such as the dam and its associated features. The effect could be an upward pressure on the labor costs for the required construction and thus resulting in an increase in costs for the whole project. This scenario assesses the impact of such competition on the estimated cost of construction.

Impact of Risk Analysis on Cost Table Line Items

For the purpose of this analysis, four categories of work breakdown were excluded from the risk analysis: Site Preparation, Electric Power Transmission, Switchyards and Substations, and Public Access and Recreation Facilities. While the estimated cost of these four features was approximately $225 million, they accounted for only five percent of the total estimate. The potential impact to the project cost from risks associated with these features is small compared to the potential impacts from the higher cost features. The risks posed by each remaining work breakdown categories are described below.

Project General Requirements

The results of the Project General Requirements risk analysis are presented in Table VI - 2. Only two risk factor/scenario combinations are considered to have significant impact on the cost of this feature: Market Conditions/Labor Availability and Market Conditions/Material Availability. The issues of concern for the Labor Availability scenario have to do with project administration and management, quality assurance and control, temporary facilities and construction with a cost impact assessment of “3”. The Material Availability issues affected the quality assurance and control, temporary facilities and construction costs with a cost impact assessment of “3”. The risk scores for these two risk factors/scenarios are low at 1.2. The potential increase to project cost from the combined impact of Market Conditions risk factors/scenarios is approximately $36 million, or 7 percent of the feature cost.

Table VI - 2
Ranked Risk Scores for Project General Requirements

Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Market Conditions	Labor availability	2	3	1.2	$ 20,416
Market Conditions	Material availability	3	2	1.2	$ 15,330

Concrete Curved Gravity Dam

The results of the Concrete Curved Gravity Dam risk analysis are presented in Table VI - 3. Out of thirteen risk factor/scenarios, eight had risk scores greater than zero. These ranged from a risk score of “5” for Seismic Uncertainty/Design to “0.8” for Hydrologic Uncertainty/Design. Of the five highest ranked risk factors/scenarios, the first was concerned with seismic design standards related to construction of the dam based on current design standards compared to those of the 1970s. This is most significant because it has of five and a potential cost impact of approximately $750 million. Three were concerned with the availability construction materials, i.e., concrete, aggregate, and steel. The fifth ranked risk factor/scenario concerned labor availability. The potential cost impact was greatest for those risk factors/scenarios that were concerned with building materials. Of the eight with risk scores greater than zero, six had potential costs that were categorized as a “5.” The total potential increase to project cost from the risk factors/scenarios related to the concrete curved gravity dam if several were to occur simultaneously would be above one billion dollars

Table VI - 3
Ranked Risk Scores for the Concrete Curved Gravity Dam Risk Analysis

Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Seismic Uncertainty	Design	5	5	5	$ 752,616
Market Conditions	Material availability	3	4	2.4	$ 83,086
Seismic Uncertainty	Source	2	5	2	$ 800,215
Quantities	Quantity	2	5	2	$ 139,732
Market Conditions	Labor availability	2	5	2	$ 104,601
Borrow Sources	Quality	2	5	2	$ 101,110
Borrow Sources	Quantity	1	5	1	$ 101,110
Hydrologic Uncertainty	Design	2	2	0.8	$ 13,312

Hydro-Electric Power Plant

The results of the Hydro-Electric Power Plant risk analysis are presented in Table VI - 4. Risk scores for four risk factors/scenarios were greater than zero. Of these, only one, Market Conditions/Material Availability had a moderately high-risk score of three. This scenario exhibited a potential cost increase of $130 million, an approximately 19 percent increase in costs for this feature because of potential increases in unit prices in almost all line items identified in this WBS feature. The other risk factors/scenarios had to do with seismic uncertainty and labor availability. These had low risk scores of 1.2 and a total potential cost impact of approximately $74 million from all three scenarios combined. The total potential increase to project cost from all the risk factors/scenarios for this feature is approximately $204 million, 30 percent of the base cost for this feature.

Table VI - 4
Ranked Risk Scores for the Hydro-Electric Power Plant Risk Analysis

Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Market Conditions	Material availability	3	5	3	$ 130,740
Seismic Uncertainty	Design	2	3	1.2	$ 22,584
Seismic Uncertainty	Source	2	3	1.2	$ 22,584
Market Conditions	Labor availability	2	3	1.2	$ 28,898

Highway and Road Relocation

All of the thirteen risk factor/scenarios for the Highway and Road Relocation risk analysis had risk scores greater than zero (Table VI - 5). These ranged from a risk score of “5” for Real Estate/Costs to “0.2” for Borrow Sources/Quantity. Two risk factors/scenarios had risk scores greater than “2”: Real Estate/Costs and Quantities. The potential increase in land costs for roads is the significant issue for this feature. At approximately $234 million, it accounts for 43 percent of the total potential cost impact for this feature. It should be noted that Real Estate is used as a proxy of cost impacts due to changes to the alignment of the road. The potential cost of the Quantities risk factor is significantly lower at $70 million or 12 percent of the total for this feature. Environmental uncertainty, both permitting and mitigation, are also identified as significant risk factor/scenarios, albeit with cost impacts 20 percent that of the real estate costs. Finally, what is probably the most surprising issue with this category is the potential total cost impact of all the risk factor/scenarios. The potential cost increase to this feature if several risk factors were to occur is above $ 250 million. This potential cost increase corresponds with the level of detail that went into the design of the structures in this feature, as all of them are only identified at a conceptual level.

Table VI - 5
Ranked Risk Scores for the Highway and Road Relocation Risk Analysis

Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Real Estate	Cost	5	5	5	$ 234,512
Quantities	Quantity	4	4	3.2	$ 70,353
Environmental Uncertainty	Permits	3	3	1.8	$ 23,451
Environmental Uncertainty	Mitigation	3	3	1.8	$ 23,451
Market Conditions	Material availability	3	3	1.8	$ 46,902
Seismic Uncertainty	Design	2	3	1.2	$ 32,535
Real Estate	Quantity	2	3	1.2	$ 46,902
Market Conditions	Labor availability	2	3	1.2	$ 23,451
Hydrologic Uncertainty	Design	2	1	0.4	$ 9,380
Hydrologic Uncertainty	Source	2	1	0.4	$ 9,380
Seismic Uncertainty	Source	2	1	0.4	$ 9,380
Borrow Sources	Quality	2	1	0.4	$ 9,380
Borrow Sources	Quantity	1	1	0.2	$ 9,380

Inflation – Dam Costs

The results of the Inflation risk analysis are presented in Table VI - 6. Of the two scenarios under consideration, both have a potential to significantly impact the dam costs as they were evaluated in terms of the total project costs. Of the two scenarios, the six percent scenario has the highest probability of impacting the dam costs with a risk score of four. This is probably not surprising considering the design phase being evaluated in this analysis. If the project were to go forward, the potential effects of inflation would most likely be mitigated as the project moves closer to actual construction.

Table VI - 6
Ranked Risk Scores for the Dam Inflation Risk Analysis

Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Inflation	6 percent	4	5	4	$ 271,180
Inflation	10 percent	2	5	2	$ 451,967

Environmental Mitigation

The OPCC for environmental mitigation is $1.48 billion. Real Estate is identified as the primary feature potentially affected by environmental mitigation costs. See Table VI - 7.

Table VI - 7
Ranked Risk Scores for the Environmental Mitigation Risk Analysis

Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Real Estate	Cost	5	5	5	$ 123,339
Real Estate	Quantity	4	5	4	$ 308,347

The high risk scores for both scenarios reflects the high level of uncertainty with respect to what mitigation would be required for the dam impacts, both in terms of the degree to which the land costs may change and the amount of land that may be required for mitigation. The fact that this analysis is being performed on conceptual OPCC estimates, which at a very early phase in the design process, is a significant contributor to the potential increase in costs for mitigation. The total potential cost increase to this feature is $548 million, an increase of 29 percent over the estimated cost of $1.48 billion.

Inflation – Environmental Mitigation

The results of the Inflation risk analysis are presented in Table VI - 8. As with the inflation analysis of the dam costs, both scenarios have a potential to significantly impact the environmental mitigation costs as they were evaluated in terms of the total project costs. Of the two scenarios, the six percent scenario has the highest probability of impacting the dam costs with a risk score of “3.2.” This suggests that inflation associated environmental mitigation land costs will continue to be a major component in cost uncertainty.

Table VI - 8
Ranked Risk Scores for the Environmental Mitigation Inflation Risk Analysis

Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Inflation	6 percent	4	4	3.2	$88,804
Inflation	10 percent	2	5	2	$148,006

Summary of Significant Risk Factors

Using a risk score of three as a cutoff with which to identify the significant risk factors/scenarios, five risk factors are identified as having a high probability of significantly impacting the project cost:

- Seismic design
- Real estate

- Quantities
- Market conditions
- Inflation

A risk score of three was selected as the cutoff because at this value, the minimum ranking that either the probability of occurrence or cost impact can get is a “3” or higher. For the purposes of this analysis, it was considered a reasonable threshold for identifying those risk factors with high potential to affect the estimated project cost. The total potential cost impacts of four risk factors on the individual work breakdown elements are presented in Table VI - 9.

Seismic design issues dominate the uncertainty costs with respect to dam construction. At a potential high-risk cost of approximately $750 million, seismic issues clearly affect potential dam construction costs. Better understanding of seismic design resulted in changes to quantities of materials necessary to build the dam to modern earthquake standards.

With respect to the highway relocation, real estate risk cost accounting for 42 percent of the high probability risk costs at $234 million. Not surprisingly, the real estate impact affects highway relocation; a land intensive feature. The design uncertainty for the highway is much larger than that of the dam and is thus reflected in the high-risk scores and potential costs increases. Land costs have a high potential to continue to significantly impact costs if the trend in the recent growth rate in real estate prices continues.

The issue of Quantities also affects the highway relocation feature. The Quantities risk factor addresses the issues of excavation, steel and concrete and the potential impact on costs. As stated above, the highway feature, as currently defined, was not an original feature of the dam. The current relocation alignment is being considered now because of changes in regional land use and national security issues since the dam was originally designed. Highway construction will require significant excavation and fill. Until such time as the alignment is identified and finalized, excavation costs will continue to have the potential to significantly increase costs.

Market conditions, in particular material availability, is a fourth major issue potentially affecting project costs. As analyzed, market conditions have the potential to impact costs for all construction features, but it is especially important for the hydro-electric power plant construction. Unit pricing is identified as the key the issue. With regard to the hydro-electric power plant, unit pricing uncertainty shows an average total potential impact of 19 percent. For a number of items, the potential impact on unit pricing is 25 percent; concrete reinforcement, cast-in-place concrete, steel fabrications, hydraulic gates and valves, special construction, conveying systems, mechanical, electrical. Given the recent trends in unit pricing, the volatility in pricing may not change in the near term. The potential impact may continue until such time as the dam would be built.

With respect to environmental mitigation, the real estate risk issues, both in terms of cost and land dominate the uncertainty, accounting for all the high probability risk costs.

Environmental mitigation is a land intensive feature. At this stage of design, uncertainty with regard to what and how much mitigation will be required is the dominant consideration. This uncertainty will only be reduced at such time as when the design is at a more mature phase and environmental impacts from the dam are more fully characterized and the affiliated regulatory agencies have time to rule.

As discussed, for the purpose of this analysis inflation is considered a global risk factor, in that it affects the estimated cost of the entire project, not just individual line items. In this analysis, the six percent scenario was given a rank of "4" for the dam and "5" for environmental mitigation signifying that this inflation level is an issue has a high potential to impact the total project costs. The potential impact applies to both the dam and environmental mitigation costs.

Table VI - 9
Potentially Significant Risk Factors/Scenarios

WBS	Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Dam						
3	Seismic Uncertainty	Design	5	5	5	$ 752,616
6	Real Estate	Cost	5	5	5	$ 234,512
6	Quantities	Quantity	4	4	3.2	$ 70,353
4	Market Conditions	Material availability	3	5	3	$ 130,740
All	Inflation	6 percent	4	5	4	$ 271,180
Environmental Mitigation						
8	Real Estate	Cost	5	5	5	$ 123,339
8	Real Estate	Quantity	4	5	4	$ 308,347
8	Inflation	6 Percent	4	4	3.2	$ 88,803

There are a number of risk factor/scenarios that do not meet the risk score cut-off of "3," but are of potential importance because of their potential high cost impacts. All of these scenarios have a cost impact ranking of "5" (> $100 million) (Table VI - 10). These six risk factors/scenarios can be characterized as low-probability, high-consequences events. That is, these risk factors have a small likelihood of occurrence (less than 10 percent), but they could cause very high cost impacts if they occur. They apply to both the dam and environmental mitigation.

With regard to the dam, the five risk factor/scenarios range in potential total cost impact from $800 million for Seismic Uncertainty/Source to $101 million for Borrow Source issues. A significant characteristic of these risk factors/scenarios is the fact that they apply to only one WBS feature, the dam construction. The dam is the single largest feature of the project, accounting for 56 percent of the estimated costs and consequently requires the largest amount construction materials and resources. Inflation has the potential to add an approximately $450 million to the construction costs.

Pertaining to environmental mitigation, inflation is the only risk factor of consequence with a potential total cost impact of approximately $150 million.

Table VI - 10
Low Probability - High Cost Risk Factors/Scenarios

WBS	Risk Factor	Risk Scenario	Probability Ranking	Cost Impact Ranking	Risk Score	Costs (1000s)
Dam						
3	Seismic Uncertainty	Source	2	5	2	$ 800,215
3	Quantities	Quantity	2	5	2	$ 139,732
3	Market Conditions	Labor availability	2	5	2	$ 104,601
3	Borrow Sources	Quality	2	5	2	$ 101,110
3	Borrow Sources	Quantity	1	5	1	$ 101,110
All	Inflation	10 Percent	2	5	2	$ 451,967
Environmental Mitigation						
8	Inflation	10 Percent	2	5	2	$ 148,006

All of these identified costs in the risk tables above represent a judgment of potential effects of these factors on the project. It is inappropriate to add all of these costs identified above to identify a total risk cost. This analysis does not attempt to predict the probability of one, more than one, or all of these risks occurring at the same time and the consequent statistical effect on the project cost estimate. Such an effort is beyond the scope of this appraisal effort. It should be noted also, that the tables above focus on adverse consequences of risk and uncertainty. At this level of study, as one expects, the risks and uncertainties identified are high. However, there are other possibilities that may also lead to cost savings.

As identified earlier the Auburn-Folsom South Unit was designed according to the design standards that were followed in the 1970s. As discussed earlier, many of these criteria are outdated and they will be replaced by state-of-the-art criteria. Changing criteria in many of these areas will result in changes to quantities of materials and construction methodologies, and will have an important impact on costs. Fundamental impacts to the costs are expected from changes to the dam site location, dam type selection, dam cross-section geometry, use of materials in the dam, and others as listed above or discussed previously. Some of these impacts will increase the cost of the project, while others will reduce this cost. Among those factors potentially reducing the cost of the project, the use of RCC is probably the easiest to identify. RCC has become the preferred methodology to construct concrete gravity dams, and in a dam like Auburn, can result in important savings in the cost of concrete, although there would be additional costs related to relocating the powerplant outside of the body of the dam. This combination of effects would need to be studied.

The risks and uncertainties associated with costs, along with the uncertainties associated with the benefits analysis, all point to the following needs:

1. A more accurate reformulation of the current and projected future conditions.
2. An optimization of the size and use of those features.
3. Modification of designs to current standards.
4. A reallocation of benefits and costs of the AFSU.

A “reformulation” would review and determine the required features to accomplish the project purposes under current and projected future conditions.

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