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Plan Formulation Appendix

Shasta Lake Water Resources Investigation, California

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United States Department of the Interior
Bureau of Reclamation
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Abbreviations and Acronyms

2004 OCAP	*2004 Long-Term CVP Operations Criteria and Plan*
2004 OCAP BA	*2004 Long-Term CVP and SWP OCAP Biological Assessment*
AFS	anadromous fish survival
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
BDCP	Bay-Delta Conservation Plan
BLM	Bureau of Land Management
BO	Biological Opinion
CA	California Aqueduct
CALFED	CALFED Bay-Delta Program
cfs	cubic feet per second
CO	combined objectives
CP	Comprehensive Plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVPM	Central Valley Production Model
Delta	Sacramento-San Joaquin Delta
DEIS	Draft Environmental Impact Statement
DFG	California Department of Fish and Game
DHCCP	Delta Habitat Conservation and Conveyance Plan
DMC	Delta-Mendota Canal
DMC/CA	Delta Mendota Canal/California Aqueduct
DWR	California Department of Water Resources
EIS	Environmental Impact Statement
elevation xxx	elevation in feet above mean sea level
EQ	Environmental Quality
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
GIS	geographic information system
GWh	gigawatt-hour
I-5	Interstate 5
IDC	interest during construction
IMPLAN	IMpact analysis for PLANning
M&I	municipal and industrial

MAF	million acre-feet
MW	megawatt
NED	National Economic Development
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NODOS	North-of-the-Delta Offstream Storage
NRA	National Recreation Area
O&M	operations and maintenance
OCAP	Operations Criteria and Plan
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
PDEIS	Preliminary Draft Environmental Impact Statement
PG&E	Pacific Gas and Electric Company
PMF	Probable Maximum Flood
RBDD	Red Bluff Diversion Dam
RBPP	Red Bluff Pumping Plant
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RED	Regional Economic Development
ROD	Record of Decision
RPA	reasonable and prudent alternative
SCRB	separable costs-remaining benefits
SLWRI	Shasta Lake Water Resources Investigation
SRTTG	Sacramento River Temperature Task Group
STNF	Shasta-Trinity National Forest
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TCD	temperature control device
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WSR	water supply reliability

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Chapter 1 Introduction

This appendix describes the iterative plan formulation and evaluation process for the Shasta Lake Water Resources Investigation (SLWRI) by the U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region (Reclamation). This chapter defines planning objectives, constraints, and criteria. Subsequent chapters describe management measures, representative sets of concept plans, development of comprehensive plans, comparison of alternative plans, and an example preliminary cost allocation and apportionment for the plan identified as the most economically feasible at this stage in the planning process. Information presented in this appendix is used to support discussions in the Draft Feasibility Report and Preliminary Draft Environmental Impact Statement (PDEIS).

Plan Formulation Process

The plan formulation process for Federal water resources studies is identified in the *Principles and Guidelines for Evaluating Federal Water Projects* and consists of the following deliberate and iterative steps:

- Identifying existing and projected future resources conditions likely to occur in a study area.
- Defining water resources problems, needs, and opportunities to be addressed, and developing planning objectives, constraints, and criteria.
- Identifying potential management measures and formulating potential alternative plans to meet planning objectives within planning constraints.
- Comparing and evaluating alternative plans.
- Selecting a plan for recommendation to decision makers for implementation or no action.

For the SLWRI, this iterative process was separated into multiple phases as illustrated in Figure 1-1 and described below:

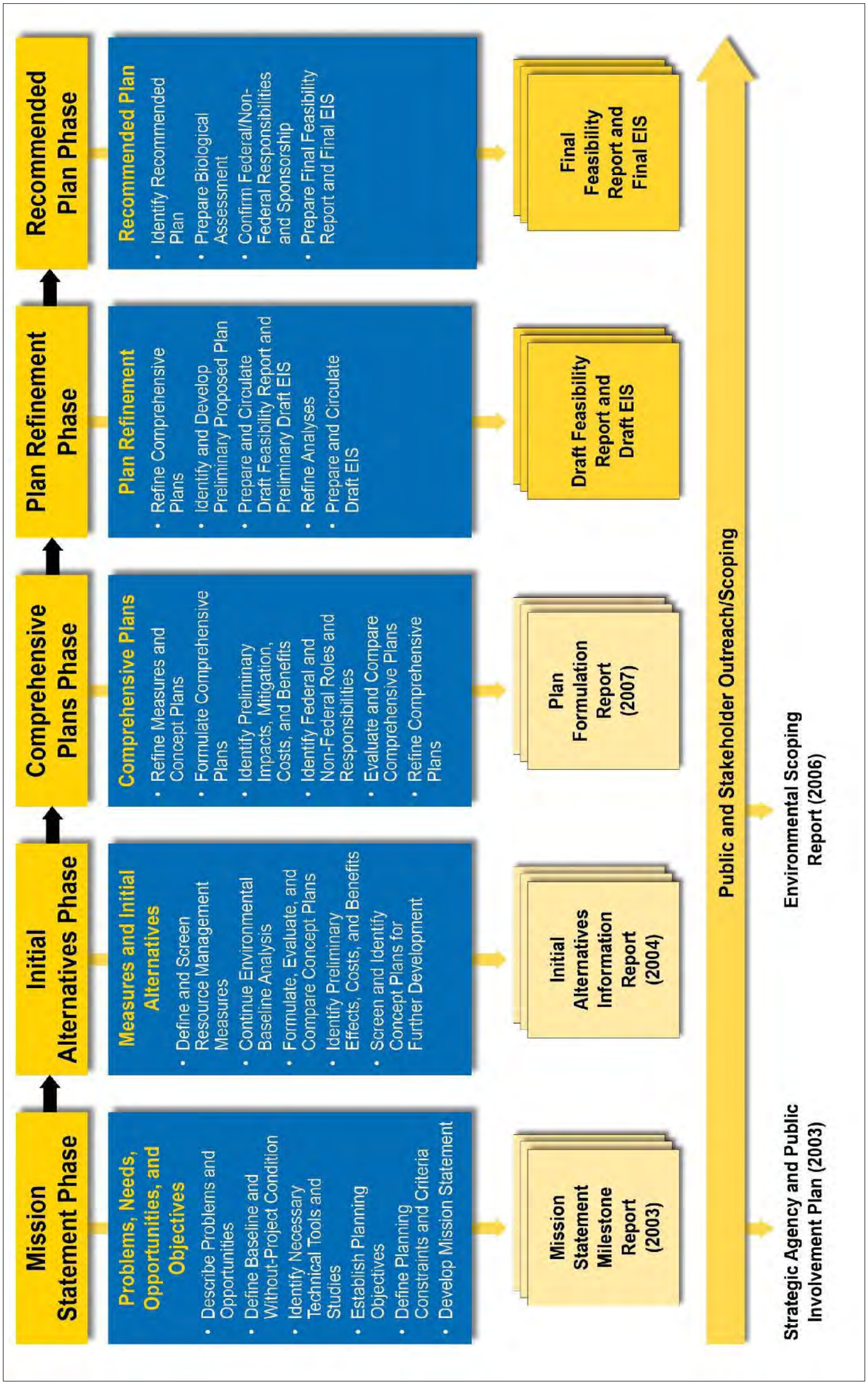


Figure 1-1. Plan Formulation Phases

- **Mission Statement Phase** – This study phase consisted of projecting without-project future conditions, defining resulting resource problems and needs, defining a specific set of planning objectives, and identifying constraints and criteria for addressing the planning objectives. The results of this phase of study were included in the *SLWRI Mission Statement Milestone Report* (Reclamation 2003a).

- **Initial Alternatives Phase –** This phase included developing a number of potential management measures, or project actions or features designed to address planning objectives. These measures were then used to formulate a set of plans that were conceptual in scope (concept plans). These initial plans were evaluated and compared to the planning objectives to identify the most suitable plans for further development. The results of this phase of study were included in the *SLWRI Initial Alternatives Information Report* (Reclamation 2004a).

- **Comprehensive Plans Phase –** The measures and concept plans carried forward were further refined and developed with more specificity to formulate comprehensive alternative plans to address the planning objectives. These plans were then evaluated and compared. The results of this phase of the study were included in the *SLWRI Plan Formulation Report* (Reclamation 2007).

- **Plan Refinement Phase –** This phase focuses on further refinement of the comprehensive plans to identify a plan suitable to be recommended for implementation. This phase includes preparing and circulating a Draft Feasibility Report and Draft EIS.

- **Recommended Plan Phase –** The next phase of the SLWRI planning process will focus on identifying a recommended plan, preparing a Biological Assessment, and confirming Federal and non-Federal responsibilities. This phase will conclude with the preparation and processing of a Final Feasibility Report to support a Federal decision, and a Final EIS.

Public and stakeholder outreach was performed concurrently with the above phases, as shown in Figure 1-1. Major reports include the *Strategic Agency Public Involvement Plan*, published in 2003 (Reclamation), and the *Environmental Scoping Report*, published in 2006 (Reclamation).

The first three phases have been completed. As shown in Figure 1-1, emphasis in these planning phases changes as the Feasibility Study proceeds. In the beginning, the emphasis is on defining problems, needs, and opportunities, and inventorying and forecasting conditions in the study area to help define a specific set of planning objectives. In time, however, emphasis shifts to defining water management measures and ways of combining the most appropriate of these measures into concept plans. Later, emphasis shifts to formulating, evaluating, and comparing complete and comprehensive alternatives. Still later in the study, emphasis is on defining and describing a recommended plan and preparing a Feasibility Report. During each study phase, it is important to review and revise, if necessary, previous decisions and future study planning objectives.

Water and Related Resources Problems, Needs, and Opportunities

Based on the overall feasibility study authority, and concerns expressed about existing and likely future water and related resources issues, following is a description of identified major water resources problems, needs, and opportunities in the primary SLWRI study area.

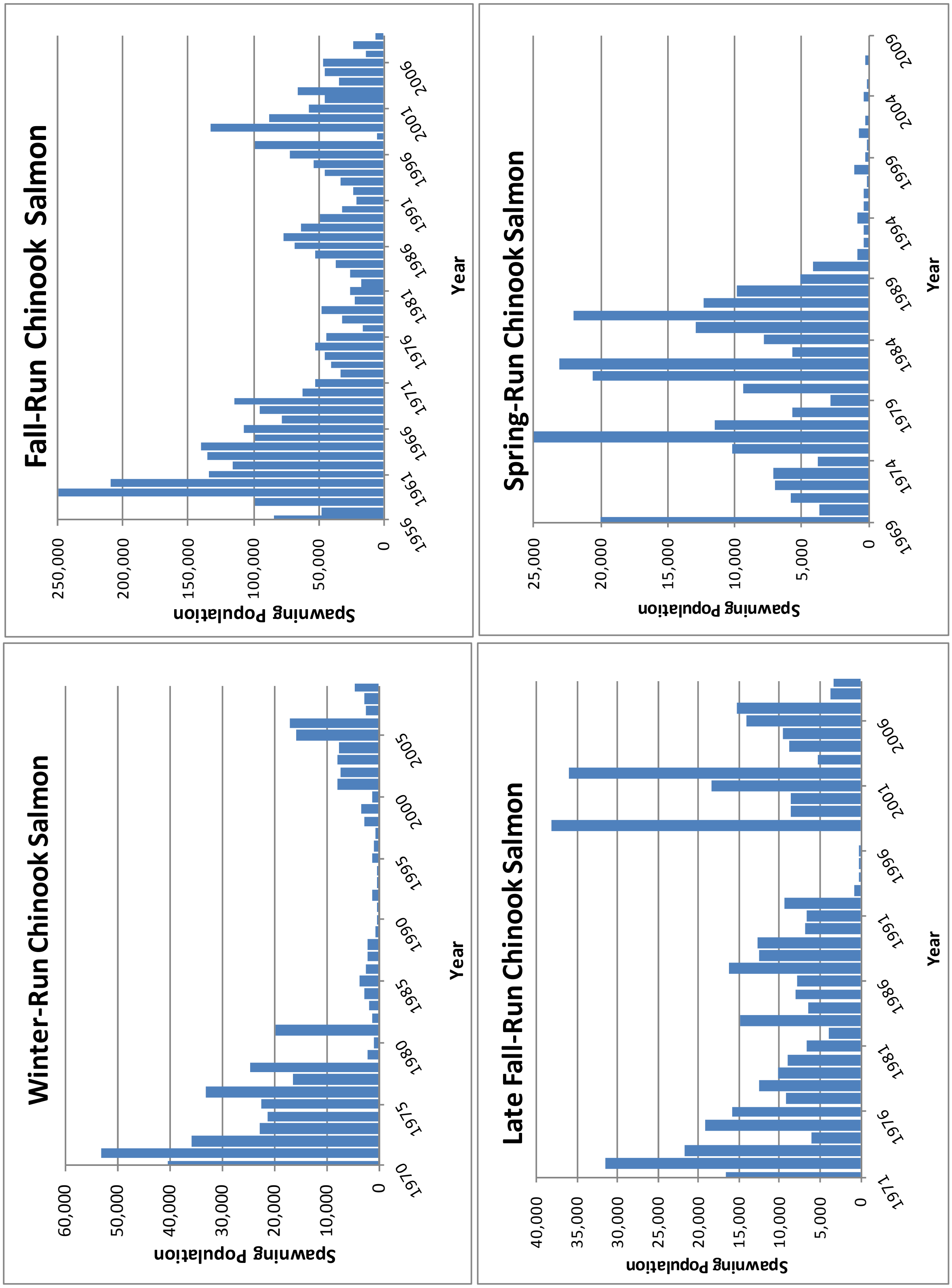
Anadromous Fish Survival

The population of Chinook salmon in the Sacramento River has significantly declined over the past 40 years (Figure 1-2) (DFG 2010). Numerous factors have contributed to the decline, including unstable water temperature, loss of historic spawning areas and suitable rearing habitat, water diversions from the Sacramento River, drought conditions, reduction in suitable spawning gravels, fluctuations in river flows, toxic acid mine drainage, high rates of predation, unsustainable fish harvests, and unsuitable ocean conditions.

One of the most significant environmental factors affecting Chinook salmon is unsuitable water temperature in the Sacramento River (NMFS 2009b). Water temperatures that are too high or, less commonly, too low, can be detrimental to the various life stages of Chinook salmon. Elevated water temperatures can negatively impact holding and spawning adults, egg viability and incubation, preemergent fry, and rearing juveniles and smolts, significantly diminishing the next generation of returning spawners. Stress caused by high water temperatures also may reduce the resistance of fish to parasites, disease, and pollutants. Releases of cold water stored behind Shasta Dam can significantly improve seasonal water temperatures in the Sacramento River for anadromous fish, particularly winter-run Chinook salmon, during critical periods.

The 2009 National Marine Fisheries Service (NMFS) *Public Draft Recovery Plan* states that prolonged droughts depleting the cold-water storage of Shasta Reservoir, or some related failure to manage cold-water storage, could extirpate the entire Sacramento River winter-run Chinook salmon population. The Recovery Plan emphasizes that under current conditions, even two consecutive years of drought could reduce Shasta Reservoir cold-water storage to levels insufficient to support the Sacramento River winter-run Chinook spawning and incubation season. This could result in complete year-class failure, virtually eliminating all of a single year's spawning and incubating winter-run Chinook in the Sacramento River (NMFS 2009b).

Conversely, water that is too cold is detrimental to the rapid growth of rearing juveniles. Following construction of Shasta Dam, water released in the spring was unusually cold and prevented the characteristic rapid growth of fall-run and late fall-run juvenile Chinook salmon. Reduced growth rates result in increased risk for predation and entrainment at unscreened and inadequately screened diversions.



Source: DFG, 2010

Figure 1-2. Chinook Salmon Historic Spawning Populations in the Sacramento River

Various Federal, State, and local projects are addressing each of the aforementioned factors contributing to anadromous fish population declines. Recovery actions range from changing the timing and magnitude of reservoir releases to changing the temperature of released water. In May 1990, State Water Resources Control Board (SWRCB) issued Order 90-5, which included temperature objectives for the Sacramento River to protect winter-run Chinook salmon. The 1993 NMFS Biological Opinion (BO) for winter-run Chinook salmon reinforced this order and established certain operating parameters for Shasta Reservoir. The BO established a reasonable and prudent alternative (RPA) comprising 13 separate actions that changed the patterns of water storage and withdrawal at Shasta, Trinity, and Whiskeytown reservoirs. This BO and SWRCB actions set surrogate or minimum flows in the river downstream from Keswick Dam primarily to affect water temperatures during key periods.

In addition to flow requirements, structural changes have been made at Shasta Dam to change the temperature of released water, such as construction of a temperature control device (TCD), which was completed in 1997. The TCD can selectively draw water from different depths within the lake, including the deepest, to help maintain river water temperatures beneficial to salmon. The TCD is effective in helping to reduce winter-run Chinook salmon mortality in some critically dry years[1], and for fall- and spring-run Chinook salmon in below-normal years.

However, implementing requirements in the Trinity River Record of Decision (ROD) (as amended) may reduce water temperature improvements provided by the TCD at Shasta Dam. One of the major elements of the Trinity River ROD is reducing the average annual export of Trinity River water from 74 percent to 52 percent of the flow (Reclamation 2000). This reduces flow from the Trinity River basin into Keswick Reservoir, and then into the Sacramento River. Because water diverted from the Trinity River is generally cooler than flows released from Shasta Dam, implementing the Trinity River ROD offsets some of the benefits derived from the TCD.

Although some fluctuations occur from year to year, the overall trend for the past 10 years has shown increases in Sacramento River winter-run Chinook salmon populations (DFG 2010). This increasing trend in salmon populations is likely due primarily to minimum release requirements at Shasta Dam, and to the TCD. In addition, Reclamation's construction of the Red Bluff Pumping Plant (RBPP) is expected to benefit Chinook Salmon populations in the Sacramento River. However, there is a residual need for generally cooler water in the Sacramento River, especially in dry and critically dry water years.

In the future, the effects of climate change on operations at Shasta Lake could potentially result in changes to water temperature, flow, and ultimately, fish survival. As described in the Climate Change Projection Appendix, climate change could result in increased inflows to Shasta Lake and higher reservoir

[1] Water year types are based on the Sacramento Valley Water Year Hydrologic Classification

releases due to an increase in winter and early spring inflow into the lake from high intensity storm events. The change in reservoir releases could be necessary to manage flood events resulting from these potentially larger storms. Climate change could also result in reduced end-of-September carryover storage volumes, resulting in lower lake levels for a portion of the year, and a smaller cold-water pool, resulting in warmer water temperature and reduced water quality within Shasta Reservoir.

Most importantly, it is expected that climate change may result in increased water temperatures downstream from Shasta Dam, particularly in summer months, and more frequent wet and drought (particularly extended drought) years. Increased water temperatures and extended drought periods may compound the threats to anadromous fish in the Sacramento River. Winter-run Chinook salmon are particularly vulnerable to potential climate warming, prolonged droughts, and catastrophic environmental events because they have only one remaining population that spawns during the summer months, when water temperature increases are expected to be the greatest (NMFS 2009b).

Water Supply Reliability

California’s water supply system faces critical challenges with demands exceeding supplies for urban, agricultural, and environmental water uses across the State. The 2009 *California Water Plan Update* (DWR) concludes that California is facing one of the most significant water crises in its history; drought impacts are growing, ecosystems are declining, water quality is diminishing, and climate change is affecting statewide hydrology. Compounding these issues, Reclamation’s *Water Supply and Yield Study* (2008) describes dramatic increases in population, land use changes, regulatory requirements, and limitations on storage and conveyance facilities, further straining available water supplies and infrastructure to meet water demands. Resulting unmet water demands have led to increases in competition for water supplies among urban, agricultural, and environmental uses.

The following subsections discuss identified key issues related to water supply reliability in California, including current and estimated water shortages, anticipated effects of population growth and climate change on water supply and demand, and limitations on system flexibility. The final subsection discusses strategies for meeting future statewide water supply needs.

Estimated Water Supply Shortages

Projecting accurate and quantified water supply and shortages in California is complex; there are numerous variables and, just as important, numerous opinions regarding these variables. Table 1-1 shows estimated water demands, available supplies, and shortages for the Central Valley and the State under existing conditions (Reclamation 2008). Current water supply shortages for the State are estimated at 2.3 and 4.2 million acre-feet (MAF) for average and dry years, respectively. As shown in Table 1-2, without further investment in water management and infrastructure, future shortages are expected to increase to approximately 4.9 and 6.1 MAF in average and dry years, respectively, by 2030. Representative demands for dry and average years were based on water use data from the 2005 *California Water Plan Update* (DWR), adjusted for population growth, increasing urban water use, and reductions in irrigated acreage and environmental flow due to insufficient water supplies. Shortages were determined on a regional basis, assuming that limitations on conveyance and storage would prevent surpluses from one region or use category from filling shortages in another.

Table 1-1. Estimated Water Demands, Supplies, and Shortages Under Existing Conditions[1]

Item	Hydrologic Basin						State of California	
	Sacramento		San Joaquin		Two-Basin Total			
	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]
Population (million)[3]	2.9		2.0		4.9		36.9	
Water Demand (MAF)								
Urban	0.9	0.9	0.6	0.6	1.5	1.5	8.9	9.0
Agricultural	8.7	8.7	7.0	7.0	15.7	15.7	34.2	34.2
Environmental	11.9	9.4	3.1	2.3	15.0	11.7	17.5	13.9
Total	***21.5***	***19.0***	***10.7***	***9.9***	***32.2***	***28.9***	***60.6***	***57.1***
Water Supply (MAF)								
Urban	0.9	0.9	0.6	0.6	1.5	1.5	8.8	8.4
Agricultural	8.7	8.6	6.9	7.0	15.6	15.6	33.2	32.0
Environmental	11.5	8.7	2.5	1.8	14.0	10.5	17.5	12.6
Total	***21.1***	***18.2***	***10.0***	***9.4***	***31.1***	***27.6***	***60.6***	***53.0***
Total Shortage (MAF)[4]	**0.4**	**0.8**	**0.7**	**0.5**	**1.1**	**1.3**	**2.3**	**4.1**

Notes:
1 Water demands, supplies, and shortages are from the 2008 Reclamation Water Supply and Yield Study
2 Representative dry and average year supplies and demands were based on adjusted water use and supply data from the 2005 California Water Plan Update (DWR 2005).
3 Population estimates are from the California Department of Finance (2010)
4 Total shortages are calculated as the sum of shortages for each category by region and, therefore, may not equal the difference between total demands and supplies. For categories where supply is greater than demand, the shortage is equal to zero.
Key:
MAF = million acre-feet

Table 1-2. Estimated Water Demands, Supplies, and Shortages for 2030[1]

Item	Sacramento and San Joaquin Hydrologic Basins		State of California	
	Two-Basin Total			
	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]
Population (million)[3]	10.5		49.2	
Water Demand (MAF)				
Urban	2.4	2.5	11.9	12.0
Agricultural	15.0	15.0	31.4	31.4
Environmental	14.9	11.7	17.5	14.0
Total	***32.3***	***29.2***	***60.8***	***57.4***
Water Supply (MAF)				
Urban	1.5	1.5	8.4	8.0
Agricultural	15.6	15.6	32.8	31.5
Environmental	14.0	10.5	16.3	12.6
Total	***31.1***	***27.6***	***57.5***	***52.1***
Total Shortage (MAF)[4]	**1.8**	**2.2**	**4.9**	**6.1**

Notes:
[1] Water demands, supplies, and shortages are from the 2008 Reclamation *Water Supply and Yield Study*
[2] Representative dry and average year supplies and demands were based on water use and supply data from the 2005 *California Water Plan Update* (DWR 2005) adjusted for population growth, increasing urban water use, and reductions in irrigated acreage and environmental flow due to insufficient water supplies.
[3] Population estimates are from the California Department of Finance (2010)
[4] Total shortages are calculated as the sum of shortages for each category by region and, therefore, may not equal the difference between demands and supplies. For categories where supply is greater than demand, the shortage is equal to zero.

Key:
MAF = million acre-feet

Potential Effects of Population Growth on Water Demands

A major factor in California's future water picture is population growth. California's population is expected to increase by just over 60 percent by 2050 (California Department of Finance 2010) and could force some of the existing water supplies currently identified for agricultural uses to be redirected to urban uses. Some portion of increased population in the Central Valley would occur on lands currently used for irrigated agriculture. Water that would have been needed for these lands for irrigation would instead be used to serve replaced urban demands. However, this would only partially offset the required agricultural-to-urban water conversion needed to sustain projected urban water demands, since much of the growth would occur on nonirrigated agricultural lands.

The 2009 *California Water Plan Update* (DWR) estimates changes in future water demands by 2050 considering three different population growth scenarios as well as climate change. Table 1-3 shows results of this study for an average water year (DWR 2009). The first scenario (Current Trends) assumes that recent population growth trends will continue until 2050. The second scenario (Slow and Strategic Growth) assumes that population growth will be slower than currently projected. The third scenario (Expansive Growth) assumes that population growth will be faster than currently projected, with nearly 70 million people living in California in 2050. Estimated reductions in agricultural water demands in Table 1-3 represent decreases in future agricultural water demands due to conversion from agricultural to urban land uses. Under the Current Trends and Expansive Growth scenarios, as much as 3 and 8 MAF, respectively, of increased demand is projected, adding to the current water shortages estimated in Table 1-1.

Table 1-3. Estimated Annual Change in Water Demand in California for 2050 Considering Different Population Growth Scenarios

Item	Current Trends	Slow and Strategic Growth	Expansive Growth
Population (million)	59.5	44.2	69.8
Irrigated Crop Acreage (million)	8.6	9	8.3
Water Demand Change[1] (MAF)			
Urban	7	2	11
Agricultural	-4.5	-5.5	-4
Environmental	1	2	1
Total	***3***	***-1.5***	***8***

Source: DWR 2009
Note:
[1] Water demand change is the difference between the average demands for 2043—2050 and 1998—2005.
Key:
MAF = million acre-feet

Potential Effects of Climate Change on Water Supply and Demand

Another potentially significant factor affecting water supply reliability is climate change. Potential impacts due to climate change are many and complex (DWR 2006), varying through time and geographic location across the State (Reclamation 2011). Changes in geographic distribution, timing, and intensity of precipitation are projected for the Central Valley (Reclamation 2011), which could broadly impact rainfall runoff relationships important for flood management as well as water supply. Additionally, when climate change is considered in projections of future water demand, annual water demand is higher than under a repeat of historical climate (DWR 2009). Other possible impacts range from potential sea level rise, which could impact coastal areas and water quality, to impacts to overall system storage for water supply.

A reduction in total system storage is widely predicted to occur with climate change. Precipitation held in snowpacks makes up a significant quantity of total annual supplies needed for urban, agricultural, and many environmental uses. It is expected that in the future, climate change may significantly reduce water held in snowpacks in the Sierra Nevada (Reclamation 2011, DWR 2009). Further potential for reductions in water conservation space in existing reservoirs in the Central Valley is anticipated because of increasing needs for additional space for flood management purposes. These potential reductions could significantly impact available water supplies, especially for reservoirs immediately upstream from large urban areas such as Folsom Lake on the American River, upstream from the greater Sacramento metropolitan area. During drought periods, supplies could be further reduced, and expected shortages would be significantly greater.

System Flexibility

In addition to concerns about future water supply and demand, California's Federal and State water systems lack flexibility in timing, location, and capacity to meet the multiple objectives of the projects. CVP and SWP flexibility has diminished with population growth and increased environmental and ecosystem commitments and requirements (Reclamation 2008a). Complicating this issue is the variability associated with water resources in California. Precipitation in California is seasonably, temporally, and spatially variable, and urban, agricultural, and environmental water users have variable needs for quantity, quality, timing, and place of use.

California's water systems face the threat of too much water during floods, and too little water to meet demands during dry and critical water years. Chronic water shortages have led to increases in groundwater usage, which has led to groundwater overdraft in many regions across the State. Groundwater overdraft can cause permanent declines in groundwater levels, long-term reductions in groundwater supplies, land subsidence, decreases in water quality, a greater potential for salt water intrusion, and lasting environmental impacts. Challenges are greatest during drought years, when water supplies are less available (DWR 2009). Increasing CVP/SWP operational constraints have led to growing competition for limited system resources between various users and uses. Urban and required environmental water uses have each increased, resulting in increased competition and conflicting demands for limited water supplies. For example, the Central Valley Project Improvement Act (CVPIA), implemented in 1993, dedicated 800 thousand acre-feet (TAF) of CVP water supplies to the environment as well as additional water supplies for the Trinity River and wildlife refuges. Table 1-4 illustrates the impacts of the CVPIA, modeled using CalSim-II, on urban and agricultural water deliveries to the north and south of the Sacramento-San Joaquin Delta (Delta). Dry year agricultural water deliveries were particularly impacted with deliveries to agricultural users, both north and south of the Delta, reduced by about 50 percent. Current BOs (2008 USFWS BO and 2009 NMFS BO), resulting in increased Delta pumping constraints and other operational restrictions, coupled with drought conditions, have even further decreased CVP deliveries. As competition for limited resources between various uses grows, water management flexibility and adaptability will be even more necessary in the future.

Table 1-4. Impact of CVPIA on CVP Deliveries

CVP Contract Deliveries	All Years			Driest Years		
	Pre-CVPIA Implementation (TAF)	Post-CVPIA Implementation (TAF)	Percent Change	Pre-CVPIA Implementation (TAF)	Post-CVPIA Implementation (TAF)	Percent Change
NOD Urban	176	167	-5%	166	145	-13%
NOD Agriculture	279	234	-16%	169	84	-50%
SOD Urban	134	122	-9%	114	96	-16%
SOD Agriculture	1,588	1,137	-28%	931	471	-49%
Total	**2,176**	**1,660**	**-24%**	**1,381**	**796**	**-42%**

Source: Reclamation 2008

Notes:
[1] Deliveries were modeled using CalSim-II.
Key:
CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
NOD = north of Delta
SOD = south of Delta
TAF= thousand acre-feet

Strategies to Address Water Supply Needs

As noted by Reclamation's *Water Supply and Yield Study* (Reclamation 2008), the *California Water Plan Update* (DWR 2009), and CALFED Bay-Delta Program (CALFED) (2000), an integrated portfolio of solutions, regional and statewide, is needed to meet future water supply needs. The *Water Supply and Yield Study* stated that a "variety of storage and conveyance projects and water management actions have the potential to help fill [the] gap" between water supply and demand in California. The 2009 *California Water Plan Update* concluded that California must invest in reliable, high quality, and affordable water conservation; efficient water management; and development of water supplies to protect public health, and improve California's economy, environment, and standard of living. However, even with major efforts by multiple agencies to address the complex water resources issues in the State, demands are expected to continue to exceed supplies in the future.

To avoid major impacts to the economy, overall environment, and standard of living in California, actions to conserve existing supplies and optimize the use of existing facilities will be needed. Additionally, development of additional water sources and increased storage and delivery capability are critical for providing reliable water supplies for expanding M&I uses and to maintain adequate supplies for agricultural and environmental purposes.

Ecosystem Resources

The health of the Sacramento River ecosystem, as elsewhere in the Central Valley, has been impacted in the last century by conflicts over the use of limited natural resources, particularly water resources. Humans have harnessed many of California's rivers and streams for beneficial uses such as hydropower, flood damage reduction, and water supply, contributing to a decline in habitat and native species populations, and a resulting increase in endangered or threatened species listings under the Federal Endangered Species Act (ESA) and California Endangered Species Act.

Construction of Shasta Dam has had both negative and positive effects on environmental resources in the region. Negative effects of Shasta Dam include blocking historic fish migration into the upper watersheds of the Sacramento River, modifying seasonal flow patterns and the natural riverine processes they support, and inundating fish and wildlife habitat.

While construction of the dam displaced valuable riverine and upland habitat, it also created shoreline and shallow water habitat for aquatic, terrestrial, and avian species in the reservoir area. For example, Shasta Lake is home to the largest concentration of nesting bald eagles in California, with 18 pairs nesting within 0.5 miles of the shoreline in any given year.

Shasta Lake Area

Various activities have impacted natural resources upstream from Shasta Dam, within the lake, on adjacent lands, and in and near tributary streams. The greatest impact in the area has probably come from historical mining, ore processing practices and resulting acid mine drainage, and fire suppression.

To guide management of the Shasta-Trinity National Forest (STNF), U.S. Forest Service (USFS) has prepared the *Shasta-Trinity National Forest Land and Resource Management Plan* (USFS 1995). Primary goals of the *Shasta-Trinity National Forest Land and Resource Management Plan*, which was implemented in 1995, are to integrate a mix of management activities that allows use and protection of forest resources; meets the needs of guiding legislation; and addresses local, regional, and national issues. The *Shasta-Trinity National Forest Land and Resource Management Plan* is intended to guide implementation of the *Aquatic Conservation Strategy of the Northwest Forest Plan* (USFS 1994) for protection and management of riparian and aquatic habitats adjacent to Shasta Lake.

Opportunities exist to further support ongoing USFS programs. These opportunities include improving and restoring environmental conditions by developing self-sustaining natural habitat in the area of Shasta Lake and its tributaries to benefit fish and wildlife resources.

Downstream from Shasta Dam

Land and water resources development has caused major resource problems and challenges in the Sacramento River basin, including decreases in anadromous fish and wildlife populations and losses of riparian, wetland, floodplain, and shaded riverine habitat. These decreases and losses have resulted in reduced populations of many plant and animal species.

The quantity, quality, diversity, and connectivity of riparian, wetland, floodplain, and shaded riverine habitat along the Sacramento River have been severely limited through confinement of the river system by levees, reclamation of adjacent lands for farming, bank protection, channel stabilization, and land development. Modification of seasonal flow patterns by dams and water diversions also has inhibited the natural channel-forming processes that drive riparian habitat succession. It is estimated that less than 5 percent of the historical acreage of riparian habitat within the Sacramento River basin remains today (Huber-Lee et al. 2003).

Decreases in quality and quantity of habitat have resulted in reduced populations of various fish and wildlife species. The low populations and questionable sustainability of these species have led to an increase in listings under the Federal ESA and California Endangered Species Act in recent years. Introduction of nonnative species has also contributed to the decline in native animal and plant species. In addition, lack of linear continuity of riparian habitat has impacted the movement of wildlife species among habitat areas, adversely affecting dispersal, migration, emigration, and immigration. For many species, this has resulted in reduced wildlife numbers and population viability.

Ecosystem restoration along the Sacramento River has been the focus of several ongoing programs, including the Senate Bill 1086 Program, CVPIA, CALFED, and Central Valley Habitat Joint Venture. These and numerous local programs have been established to address ongoing conflicts over the use of limited resources within the Central Valley. Much effort has been directed in the upper Sacramento River region above the Red Bluff Diversion Dam (RBDD) toward restoring or improving anadromous fisheries, which provide recreational and commercial values in addition to their environmental value. Despite these efforts, a significant need remains to conserve and restore ecosystem resources along the Sacramento River.

Endangered and threatened fish and wildlife populations, critical habitat, and sensitive Delta ecosystems are also declining. The decline is especially pronounced in the case of pelagic fish species in the Delta, including delta smelt, striped bass, threadfin shad, and longfin smelt. Recent monitoring results indicate that the threatened delta smelt population continues to remain at or near all-time lows and, as a result, delta smelt have been recommended for relisting as endangered. Observations of sharp declines in fish population have resulted in restrictions on Delta water operations to protect fish populations during environmentally sensitive periods. Legal actions concerning the impacts of CVP and SWP operations on fish populations, such as the December 2007 *Natural Resources Defense Council v. Kempthorne* (delta smelt), court decision and the May 2008 *Pacific Coast Federation of Fishermen's Associations vs. Gutierrez* (anadromous fish species) court decision, continue to shape water management in the Sacramento River basin and Delta.

In recognition of the challenges facing water management in California, and the need to develop new strategies for a sustainable Delta ecosystem that would continue to support its economic functions, various planning efforts are underway. Current planning efforts, such as the Bay Delta Conservation Plan/ Delta Habitat Conservation and Conveyance Program are focused on developing ecological solutions to protect Delta fisheries while providing a sustainable and reliable water conveyance system for the CVP and SWP. Greater operational flexibility within the CVP/SWP system is needed to address ecosystem concerns in the Sacramento River and Delta.

Flood Management

Large and small communities and agricultural lands in the Central Valley are subject to flooding along the Sacramento River. U.S. Army Corps of Engineers (USACE), in partnership with the California Department of Water Resources (DWR), has worked to assess basin-wide flood management issues and identify options in the Sacramento River basin to address these issues. Measures to reduce high flows in the Sacramento River include spilling floodwater into bypass areas through historical overflow areas, streams, conveyance canals, and weirs. The comprehensive flood control system in the Sacramento River basin includes river, canal, and stream channels, levees, flood relief bypasses, weirs, flood relief structures, a natural overflow area, outfall gates, and drainage pumping plants. USACE and DWR continue to develop improvements associated with the Sacramento River Bank Protection Project and to assist in local flood damage reduction projects along the Sacramento River. DWR is currently developing the Central Valley Flood Protection Plan, addressing flood issues throughout the Sacramento and San Joaquin valleys and the Delta.

Flooding poses risks to human life, health, and safety. Threats to the public from flooding are caused by many factors, including overtopping or sudden failures of levees, which can cause deep and rapid flooding with little warning, threatening lives and public safety. In addition, urban development in flood-prone areas has exposed the public to the risk of flooding.

Physical impacts from flooding occur to residential, agricultural, commercial, industrial, institutional, and public property. Damages occur to buildings, contents, automobiles, and outside property, including agricultural crops, equipment, and landscaping. Physical damages include cleanup costs and costs to repair roads, bridges, sewers, power lines, and other infrastructure components. Nonphysical flood losses include income losses and the cost of emergency services, such as flood fighting and disaster relief.

Even though a project to enlarge Shasta Dam and Reservoir has the potential to significantly reduce flood flows in the upper Sacramento River, influencing factors exist that can conflict with flood operation. Flood management operations at Shasta Dam, even with explicit rules provided in the Shasta Dam and Lake Flood Control Diagram (USACE 1977), are difficult to manage during a flood event. This is primarily due to the extreme inflow volumes to Shasta Reservoir that can occur over long periods, numerous points of inflow along the river downstream from Shasta Dam, and multiple points of operational interest downstream. The primary downstream control point along the Sacramento

River that determines reservoir releases under real-time operations is Bend Bridge.

Other unofficial factors enter into flood management decisions, such as peak flows at Hamilton City or other rural communities that are at risk of flooding. These factors, combined with the uncertainty of storm forecasting, could lead to a reduction in flood operation flexibility at Shasta Dam. Should this occur, it could cause a cascading impact on effective flood management downstream to the Delta. Accordingly, there is a need to review flood control operations at Shasta Dam.

Hydropower

Were California a nation, it would be the twelfth largest consumer of electricity worldwide (California Energy Commission 2002). Among the 50 States, California is the second largest consumer of electricity. Although California has 12 percent of the Nation's population, it uses only 7 percent of the Nation's electricity. This makes California the most energy-efficient State per capita in the Nation. Even so, demands for electricity are growing at a rapid pace.

As an example, over the next 10 years, California's peak demand for electricity is expected to increase 30 percent, from about 50,000 megawatts (MW) to about 65,000 MW. There are, and will continue to be, increasing demands for new electrical energy supplies, including clean energy sources, such as hydropower. Executive Orders S-14-08 and S-21-09, issued in 2008 and 2009 respectively, established a goal of using renewable energy sources, including hydropower, for 33 percent of the State's energy consumption by 2020 (California Public Utilities Commission 2011). Adding to the need for additional energy sources, existing nuclear power plants are nearing the end of their design lives and some may be offline within the next 10 to 20 years.

Recreation

As the population of the State of California continues to grow, demands will increase significantly for water-oriented recreation at and near the lakes, reservoirs, streams, and rivers of the Central Valley. This increase in demand will be especially pronounced at Shasta Lake. As mentioned, USFS manages recreation uses at Shasta Lake. USFS has expressed concern about seasonal capacity problems at existing marinas and USFS facilities. A significant and increasing need exists to improve recreation-related facilities and conditions at Shasta Lake. Any increase in the water surface area at the lake would be one element of a plan to help meet future recreation demands.

Water Quality

The Sacramento River and the Delta support fish and wildlife while providing water supplies for urban, agricultural, and environmental uses across the state. The Sacramento River downstream from Keswick Dam is critical habitat for the migration and reproduction of Chinook salmon (NMFS 2009b) and the Delta is one of the largest ecosystems for fish and wildlife habitat and production in the

United States (Cal Water Boards, SWRCB, and CalEPA 2006). However, saltwater intrusion, municipal discharges, agricultural drainage, and water project flows and diversions have led to water quality issues within the Delta, particularly related to salinity, that have resulted in significant declines in pelagic populations (Cal Water Boards, SWRCB, and CalEPA 2006). In the Sacramento River and its tributaries, water temperatures, which are vital for anadromous fish survival, are affected by variations in climate and rainfall as well as operating conditions of various Federal, State, and local water supply systems. Additionally, urban and agricultural runoff, and runoff and seepage from abandoned mining operations, have resulted in elevated levels of pesticides, phosphorous, mercury, and other metals in the Sacramento River.

Several environmental flow goals and objectives in the Central Valley, including the Delta, have been established through legal mandates to address the impacts of water operations and water quality deterioration on the Sacramento River basin and Delta ecosystems and on endangered and threatened fish populations. Planning efforts, such as the Bay-Delta Conservation Plan (BDCP), are intended to allow implementation of projects that restore and protect water supply and reliability, water quality, and ecosystem health in the Delta to proceed within a stable regulatory framework. Additional operational flexibility is needed to provide further opportunities to improve Sacramento River and Delta water quality conditions. Increasing storage in Shasta Reservoir could provide increased CVP operational flexibility to meet water quality goals in the Delta, as well as provide more cold-water storage in critical years to improve Sacramento River water temperatures.

Existing and Future Resources Conditions in Study Area

Shasta Dam and Reservoir are located on the upper Sacramento River in Northern California about 9 miles northwest of the City of Redding, within Shasta County. The SLWRI includes both a primary and extended study area because of the potential influence of the proposed modification of Shasta Dam and Reservoir, and subsequent water deliveries on resources over a rather large geographic area. The primary study area for the SLWRI encompasses Shasta Dam and Lake; lower reaches of three primary tributaries flowing into Shasta Lake (Sacramento River, McCloud River, and Pit River) and all smaller tributaries flowing into the lake; Trinity Lake and Lewiston Reservoir; and the Sacramento River downstream to about the RBDD facilities, including tributaries at their confluence. The RBDD facilities are directly adjacent to the Red Bluff Pumping Plant (RBPP), which is currently under construction. Figure 1-3 shows the geographic extent of the primary study area.

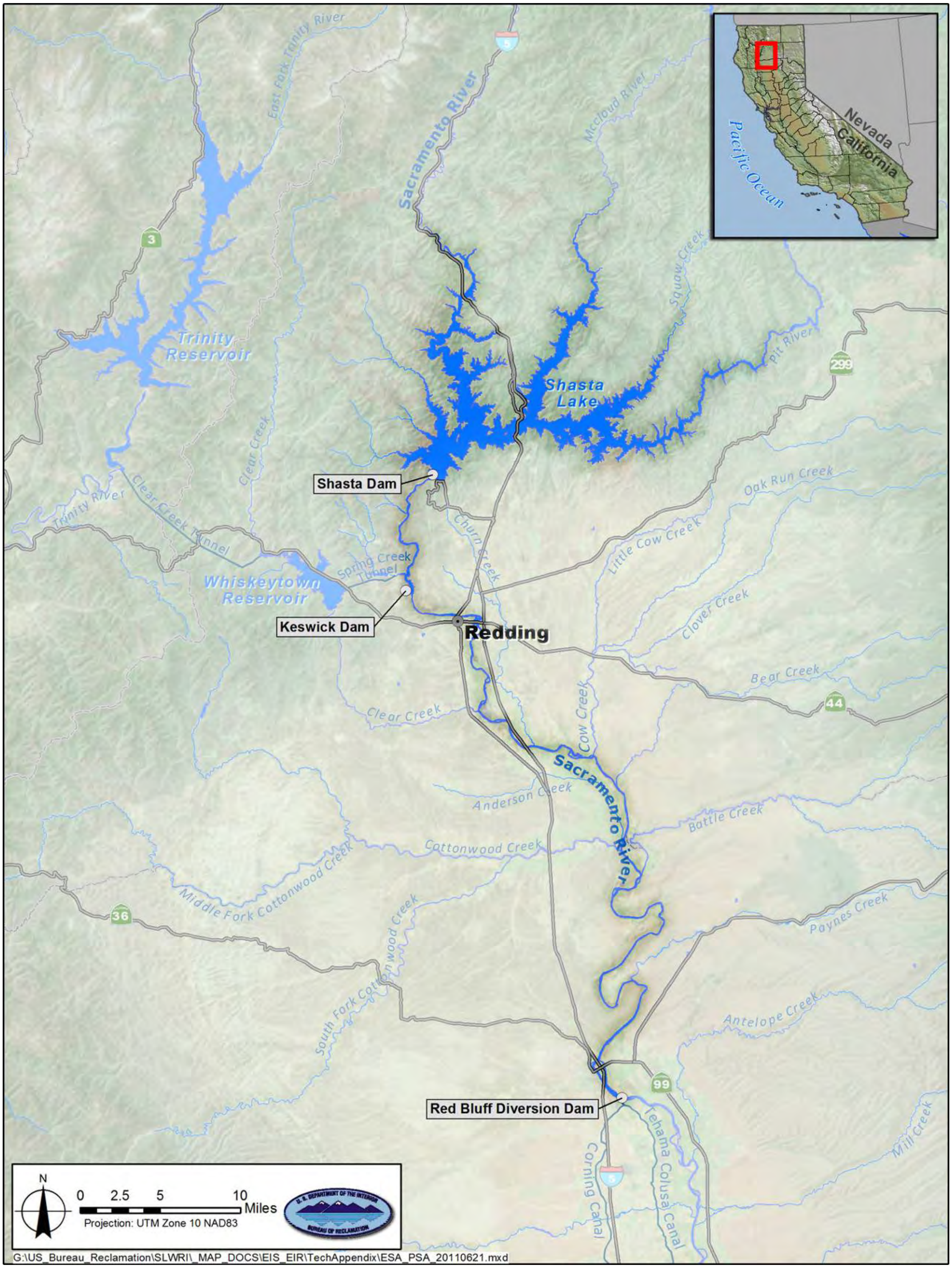


Figure 1-3. Shasta Lake Water Resources Investigation Primary Study Area – Shasta Lake Area and Sacramento River from Shasta Dam to Red Bluff Diversion Dam

The extended study area includes other areas of California with resource programs or projects that could potentially be indirectly influenced by modifying Shasta Dam and Reservoir. The extended study area encompasses the Sacramento River downstream from the Red Bluff Diversion Dam, the Delta, portions of major tributaries, namely the lower Feather and American Rivers, parts of the lower San Joaquin River, and facilities and water service areas of the CVP and SWP. Detailed descriptions of the study area and existing conditions for physical, biological, cultural, and socioeconomic resources within the SLWRI study area is included in the accompanying PDEIS and the Physical Resources Appendix, Biological Resources Appendix, Cultural Resources Appendix, and Socioeconomics Appendix. Following is a brief description of the likely future resources conditions in the study area.

Likely Future Conditions

Identification of the magnitude of potential water resources and related problems, needs, and opportunities in the study area is based not only on the existing conditions, but also on an estimate of how these conditions may change in the future. Predicting future changes to the physical, biological, cultural, and socioeconomic environments in the primary and extended study areas is complicated by ongoing programs and projects and potential changes in regulatory requirements. Several ecosystem restoration, water quality, water supply, and levee improvement projects are likely to be implemented in the future. Collectively, these efforts may improve ecosystem resources, Delta water quality, water supply, and levees. Much of this improvement would be based on separate opportunities that are not integrated in a single plan or part of an approved and funded program.

The following sections summarize likely future conditions for physical, biological, cultural, and socioeconomic resources within the SLWRI study area, as described in the accompanying PDEIS.

Physical Resources Environment

Basic physical conditions in the primary and extended study areas are expected to remain relatively unchanged in the future. Continued development in urban and suburban areas is expected. Ongoing restoration efforts along rivers are expected to marginally improve natural riverine processes. Without major physical changes to the river systems, hydrologic conditions may remain unchanged. However, the region’s hydrology could be altered should there be significant changes in global climatic conditions; scientific work in this field of study is continuing. Without major changes in hydrology, topography, or geology, sedimentation and erosion are also likely to remain unchanged.

Much effort has been expended to control the levels and types of herbicides, fungicides, and pesticides that can be used in the environment. Further, efforts are underway to better manage the quality of runoff from urban environments to the major stream systems. However, water quality conditions are expected to remain unchanged and similar to existing conditions.

It is unclear to what extent potential changes to the region's climate could occur in association with global climate change. As the population continues to grow and agricultural lands are converted to urban and industrial uses, a general degradation of air quality conditions could occur. However, because of technological innovation and stringent regulations, air quality could improve over time. While similar types and sources of hazardous materials and waste are likely to be present in the future, increasing population will likely increase the potential for hazardous waste issues. Similarly, increasing population will likely affect increases in environmental noise and vibration.

Biological Resources Environment

Efforts are underway by numerous agencies and groups to restore various biological conditions throughout the primary and extended study areas. Accordingly, major areas of wildlife habitat, including wetlands and riparian vegetation areas, are expected to be protected and restored. However, as population and urban growth continues, and land uses are converted to urban centers, many wildlife and plant species especially dependent on woodland, oak woodland, and grassland habitats may be adversely affected.

Through the significant efforts of Federal and State wildlife agencies, populations of special-status species in the riverine and nearby areas are estimated to generally remain as under existing conditions. Although increases in anadromous and resident fish populations in the Sacramento River could continue through implementation of projects such as the Battle Creek Salmon and Steelhead Restoration Project, some degradation will likely occur through actions that reduce Sacramento River flows or elevate water temperatures such as implementation of the Trinity River ROD. Accordingly, populations of anadromous fish are expected to remain generally similar to existing conditions.

No rivers or streams in the primary study area are expected to be added to the list of Federal and/or State wild and scenic resources. The wild and scenic status of the McCloud River is expected to remain as under existing conditions.

Cultural Resources Environment

In the vicinity of Shasta Lake, any archaeological, historic, or ethnographic resources currently affected by erosion due to reservoir fluctuations would continue to be impacted. Artifacts located around the perimeter of the existing reservoir will continue to be subject to collection by recreationalists. Similarly, conditions related to the cultural environment downstream from Shasta Dam are unlikely to change significantly.

Socioeconomic Resources Environment

The State's population is estimated to increase from approximately 37 million in 2005 to about 44 million by 2020, and to approximately 60 million by 2050. Between now and 2050, Shasta and Tehama counties are expected to continue their historic growth trends. According to the California Department of Finance (2007, 2010), Shasta County's population is expected to increase by approximately 86 percent by 2050 to a total of approximately 332,000 residents (2005 population was 179,000). This represents an expected increase in population that is almost 20 percent greater than for the State as a whole. The population of Tehama County is expected to more than double by 2050, with population increasing from approximately 60,000 (in 2005) to 124,000 (California Department of Finance 2007, 2010).

To support these expected increases in population, some conversion of agricultural and other rural land to urban uses is anticipated. More transportation routes are likely to be constructed to connect the anticipated population increase in the Central Valley to transportation infrastructure. Anticipated increases in population growth will also impact visual resources as areas of open space on the valley floor are converted to urban uses.

Increases in population will increase demands for electric, natural gas, and wastewater utilities; public services such as fire, police protection, and emergency services; and water-related and communication infrastructure. The increase in population and aging "baby boomer" generation will increase the need for health services. The region's superior outdoor recreational opportunities and moderate housing cost opportunities are expected to attract increasing numbers of retirees from outside the region and State. An increasing population will produce employment gains, particularly in retail sales, personal services, finance, insurance, and real estate. Recreation is expected to remain an important element of the community and economy in the region.

Anticipated increases in population growth in the Central Valley will also significantly increase demands on water resources systems for additional and reliable Central Valley water supplies, energy supplies, water-related facilities, recreational facilities, and flood management facilities.

Planning Objectives

This section discusses the national planning objectives and objectives, constraints, and other considerations specific to the SLWRI.

National Planning Objectives

The Federal objective is defined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) (WRC 1983):

> *The Federal objective of water and related resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.*

Contributions to national economic development (NED) are further defined as "increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are direct net benefits that accrue in the planning area and the rest of the Nation." (WRC 1983).

The National Water Resources Policy specified in the Water Resources Development Act of 2007 (Public Law 110-114, Section 2031), is that Federal water resources investments should reflect national priorities, encourage economic development, and protect the environment by doing the following:

- Seek to maximize sustainable economic development
- Seek to avoid the unwise use of floodplains and flood-prone areas and minimize adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used
- Protect and restore the functions of natural systems and mitigate any unavoidable damage to natural systems

In consideration of the many complex water management challenges and competing demands for limited Federal resources, Federal agencies investing in water resources should strive to maximize public benefits, particularly compared to costs. Public benefits encompass environmental, economic, and social goals, including monetary and nonmonetary benefits, and allow for the inclusion of quantified and unquantified benefits. Stakeholders and decision makers expect the formulation and evaluation of a diverse range of alternative solutions. Such solutions may produce varying degrees of benefits and/or impacts relative to the three goals specified above. As a result, trade-offs among potential solutions will need to be assessed and properly communicated during the decision making process.

SLWRI-Specific Planning Objectives

On the basis of the problems, needs, and opportunities identified and defined previously, study authorities and other pertinent direction, including information contained in the August 2000 CALFED ROD, primary and secondary planning objectives were developed. Primary planning objectives are those which specific alternatives are formulated to address. The primary objectives are considered to have coequal priority, with each pursued to the maximum practicable extent without adversely affecting the other. Secondary planning objectives are actions, operations, or features that should be considered in the plan formulation process, but only to the extent possible through pursuit of the primary planning objectives.

- **Primary Planning Objective**s:
  - Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream from the Red Bluff Diversion Dam.

- Increase water supply and water supply reliability for agricultural, M&I, and environmental purposes to help meet current and future water demands, with a focus on enlarging Shasta Dam and Reservoir.

- **Secondary Planning Objectives**:
  - Conserve, restore, and enhance ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
  - Reduce flood damage along the Sacramento River.
  - Develop additional hydropower generation capabilities at Shasta Dam.
  - Maintain and increase recreation opportunities at Shasta Lake.
  - Maintain or improve water quality conditions in the Sacramento River downstream from Shasta Dam and in the Delta.

Planning Constraints and Other Considerations

The P&G provide fundamental guidance for the formulation of Federal water resources projects. In addition, basic constraints and other considerations specific to this investigation must be developed and identified. Following is a summary of the constraints and considerations being used for the SLWRI.

Planning Constraints

Fundamental to the plan formulation process is identifying and developing basic constraints specific to this investigation. Some planning constraints are more rigid than others. Examples of more rigid constraints include congressional direction in study authorizations; other current applicable laws, regulations, and policies; and physical conditions (e.g., topography, hydrology). Other planning constraints are less restrictive but are still influential in guiding the process. Examples include water resource planning efforts such as the CALFED ROD. Several key constraints identified for the SLWRI are as follows:

- **Study Authorizations –** On August 30, 1935, in the Rivers and Harbors Bill, an initial amount of Federal funds was authorized for constructing Kennett (now Shasta) Dam. Initial authorization for the SLWRI derives from Public Law 96-375 of 1980. This law authorized the Secretary of the Interior to engage in feasibility studies relating to (1) enlarging Shasta Dam and Reservoir, or constructing a replacement dam on the Sacramento River and (2) using the Sacramento River to convey water from an enlarged dam. Additional guidance is contained in Public Law 108-361 of 2004, which authorized the Secretary of the Interior to carry out "…planning and feasibility studies for projects to be pursued with project-specific study for enlargement of the Shasta Dam in Shasta County…" The CVPIA of 1992 (Public Law 102-575) is pertinent because of its influence on water supply deliveries, river flows, and related environmental conditions in the primary and extended study areas.

- **CALFED Record of Decision –** CALFED was established to "develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system." The 2000 CALFED ROD (CALFED 2000) includes program goals, objectives, and projects primarily to benefit the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) system. The objectives for the SLWRI are consistent with the CALFED ROD (CALFED 2000) for Shasta enlargement, as follows:

  > *Expand CVP storage in Shasta Lake by approximately 300 TAF. Such an expansion will increase the pool of cold water available to maintain lower Sacramento River temperatures needed by certain fish and provide other water management benefits, such as water supply reliability.*

  The ROD has been adopted by various Federal and State agencies as a framework for further consideration. In addition to objectives for potential enlargement of Shasta Dam and Reservoir, the Preferred Program Alternative in the CALFED ROD includes four other potential surface water and various groundwater storage projects to help reduce the gap between water supplies and projected demands. Expanding water storage capacity is critical to the successful implementation of all aspects of the program. Water supply reliability rests on capturing peak flows, especially during wet years. New storage must be strategically located to provide the needed flexibility in the current water system to improve water quality, support fish restoration goals, and meet the needs of a growing population. CALFED ROD also includes numerous other projects to help improve the ecosystem functions of the Bay-Delta system. Developed plans should address the goals, objectives, and programs and projects of the CALFED ROD (2000).

- **Laws, Regulations, and Policies –** Numerous laws, regulations, executive orders, and policies need to be considered, among them: the P&G, NEPA, Fish and Wildlife Coordination Act, Clean Air Act, Clean Water Act, National Historic Preservation Act, California Public Resources Code, Federal and State ESA, California Environmental Quality Act, and CVPIA. Table 1-5 summarizes many of the applicable laws, policies, plans, and permits potentially affecting the project.

Table 1-5. Summary of Applicable Laws, Policies, Plans, and Permits Potentially Affecting Project

Level	Laws, Policies, Plans, and Permits
Federal	Federal Endangered Species Act
	Section 404 of the Clean Water Act
	Rivers and Harbors Act Section 10
	National Historic Preservation Act, Section 106 (1966)
	Migratory Bird Treaty Act
	Fish and Wildlife Coordination Act
	Executive Orders 11990 (Wetlands Policy), 11988 (Flood Hazard Policy), and 12898 (Environmental Justice Policy)
	Indian Trust Assets
	Americans with Disabilities Act
	Rehabilitation Act
	Farmland Protection Policy
	Federal Transit Administration Activities and Programs
	Essential Fish Habitat
	Architectural Barriers Act
	Federal Cave Resources Protection Act (1988)
	Executive Order 11312 (National Invasive Species Management Plan)
	Magnuson-Stevens Fishery Conservation and Management Act
	National Wild and Scenic Rivers System
	Federal Land Use Policies
	Federal Water Project Recreation Act
	Whiskeytown-Shasta-Trinity National Recreation Area Management Guide
	Whiskeytown-Shasta-Trinity National Recreation Act
	Shasta-Trinity National Forest Management Plan
	Federal Energy Regulatory Commission Permitting Requirements
	U.S. Army Corps of Engineers – Shasta Dam and Reservoir Regulation Requirements
	U.S. Coast Guard Activities and Programs
	Uniform Relocations Assistance and Real Properties Acquisition Act of 1970, as amended (Public Law 91-646 and Public Law 100-17)
State	California Public Resources Code
	Clean Water Act Section 401
	California Endangered Species Act
	California Fish and Game Code – Fully Protected Species
	California Fish and Game Code Section 1600 – Streambed Alteration
	Porter-Cologne Water Quality Control Act
	California Native Plant Society Species Designations
	Reclamation Board Encroachment Permit
	California Water Rights
	State Lands Commission Land Use Lease
	State of California General Plan Guidelines
	California Department of Transportation Encroachment Permit and Activities, Programs
	California Land Conservation Act of 1965 (Williamson Act)
	California Native Plant Protection Act
	California Department of Boating Activities and Programs
	California Scenic Highway Program
	California Wild and Scenic Rivers Act

Table 1-5. Summary of Applicable Laws, Policies, Plans, and Permits Potentially Affecting Project (contd.)

Level	Laws, Policies, and Plans
Local	Shasta County Air Quality Management District Authority to Construct and Permit to Operate
	Shasta County Building Division Grading Permit
	Shasta County Zone Plan
	Shasta County Department of Public Works Encroachment Permit
	Shasta County General Plan
	Other Local Permits and Requirements

Statewide Water Operation Considerations

Planning assumptions and information on water operations used to develop comprehensive plans for the SLWRI were developed in 2006, and reflect the integrated CVP and SWP operations described in Reclamation's 2004 *Long-Term CVP Operations Criteria and Plan* (2004 OCAP). Since formulation and evaluation of SLWRI plans, new BOs have been issued on integrated CVP and SWP operations. In December 2008, U.S. Fish and Wildlife Service (USFWS) issued a new BO, finding that the 2004 *Long-Term CVP and SWP OCAP Biological Assessment* (2004 OCAP BA), developed by DWR and Reclamation, would jeopardize the continued existence of the delta smelt. In July 2009, NMFS issued a new BO finding that the same operations would jeopardize populations of listed salmonids, steelhead, green sturgeon, and orcas. Because both agencies made jeopardy determinations, both agencies included an RPA in their BOs.

Several lawsuits were filed challenging the validity of the 2008 USFWS BO and 2009 NMFS BO and Reclamation's acceptance of the RPA included with each BO (*Consolidated Salmonid Cases*, *Delta Smelt Consolidated Cases*). On November 13, 2009, and March 5, 2010, the District Court for the Eastern District of California (District Court) concluded that Reclamation had violated NEPA by failing to perform any NEPA analysis before provisionally adopting the 2008 USFWS RPA and 2009 NMFS RPA. On December 14, 2010, the District Court found the 2008 USFWS BO to be unlawful and remanded the BO to USFWS. The District Court issued a similar ruling for the 2009 NMFS BO on September 20, 2011. On May 4, 2011, in the *Delta Smelt Consolidated Cases*, the District Court ordered USFWS to prepare a draft BO by October 1, 2011, which was subsequently extended to an unspecified date to be agreed upon by involved parties. Reclamation and USFWS must prepare a final BO and final NEPA document by November 1, 2013, and December 1, 2013, respectively.

Reclamation and DWR use CalSim-II to study operations, benefits, and effects of new facilities and operational parameters for the CVP and SWP. A set of operational assumptions was developed in 2006 based on water operations described in the 2004 OCAP BA and the Coordinated Operations Agreement between Reclamation and DWR for the CVP and SWP, as ratified by Congress.

These assumptions were used to guide development, modeling, and evaluation of potential effects of the No-Action Alternative and comprehensive plans included in the Draft Feasibility Report and accompanying Preliminary Draft EIS.

The legal challenges and changing environmental conditions result in uncertainty with regard to both current and future operations. These operational uncertainties are likely to continue, and current and future water operation conditions may be different because operational constraints governing water operations are likely to change with release of revised USFWS and NMFS BOs. Modeling studies will be updated to reflect changes in water operations resulting from ongoing Operations Criteria and Plan (OCAP) reconsultation and other relevant water resources projects and programs, including, potentially, BDCP/Delta Habitat Conservation and Conveyance Plan (DHCCP) efforts. The results of these updated studies will be incorporated into future SLWRI documents.

Other Planning Considerations

In addition to the planning constraints, a series of other planning considerations helps guide plan formulation, not only in formulating the initial set of concept plans, but also in determining which alternatives best address the planning objectives. Planning considerations relate to economic justification, environmental compliance, technical standards, etc., and may result from local policies, practices, and conditions. Examples of these planning considerations, used in the SLWRI for formulating, evaluating, and comparing concept plans, and later, detailed comprehensive alternatives, include the following:

- Alternative plans should incorporate results of coordination with other Federal and State agencies such as the USFWS, NMFS, USFS, Bureau of Indian Affairs, Bureau of Land Management (BLM), DWR, and California Department of Fish and Game (DFG).

- A direct and significant geographical, operational, and/or physical dependency must exist between major components of alternatives.

- Alternative plans should address, at a minimum, each of the identified primary planning objectives and, to the extent possible, the secondary planning objectives.

- Measures to address secondary planning objectives should be either directly or indirectly related to the primary planning objectives (i.e., plan features should not be independent increments).

- Alternatives should avoid any increases in flood damage or other significant, adverse hydraulic effects to areas downstream along the Sacramento River.

- Alternatives should strive to first avoid potential adverse effects to environmental resources, or then should include features to mitigate for unavoidable adverse effects through enhanced designs, construction methods, and/or facilities operations.

- Alternatives should strive to first avoid potential adverse effects to present or historical cultural resources, or then include features to mitigate unavoidable adverse effects.

- Alternatives should not result in significant adverse effects to existing and future water supplies, hydropower generation, or related water resources conditions.

- Alternatives should not result in a reduction in existing recreation capacity at Shasta Lake.

- Alternatives are to consider the purposes, operations, and limitations of existing projects and programs and be formulated to not adversely impact those projects and programs.

- Alternatives are to be formulated and evaluated based on a 100-year period of analysis.

- Construction costs for alternatives are to reflect current prices and price levels, and annual costs are to include the current Federal discount rate and an allowance for interest during construction (IDC).

- Alternatives are to be formulated to neither preclude nor enhance development and implementation of other elements included in the CALFED ROD or other water resources programs and projects in the Central Valley.

- Alternatives should have a high certainty for achieving intended benefits and not significantly depend on long-term actions (past the initial construction period) for success. Alternatives that require future and ongoing action specific for success have a higher uncertainty than other plans.

The additional planning considerations listed above are useful for comparing concept and comprehensive plans, and are expanded upon in Chapters 4 and 6 of this appendix.

Criteria

The Federal planning process in the P&G also includes four specific criteria for consideration in formulating and evaluating alternatives: completeness, effectiveness, efficiency, and acceptability (WRC 1983).

- Completeness is a determination of whether a plan includes all elements necessary to realize planned effects, and the degree that intended benefits of the plan depend on the actions of others.
- Effectiveness is the extent to which an alternative alleviates problems and achieves objectives.
- Efficiency is the measure of how efficiently an alternative alleviates identified problems while realizing specified objectives consistent with protecting the Nation's environment.
- Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals.

These criteria, and how they apply in helping to compare comprehensive alternative plans, are described in Chapter 6 of this appendix.

Chapter 2
Management Measures

After development of the planning objectives, constraints, and criteria, the next major step in formulating concept plans was to identify and evaluate potential management measures. A management measure is any structural or nonstructural project action or feature that could address the planning objectives and satisfies the other applicable planning considerations. Concept plans are formulated (see Chapter 4) by combining retained management measures that address the primary planning objectives.

More than 60 potential management measures were identified as part of previous studies, programs, and projects to address the primary and secondary planning objectives and satisfy the other applicable planning constraints, considerations, and criteria. These measures were developed through study team meetings, field inspections, public outreach, and environmental scoping for the SLWRI and Environmental Impact Statement (EIS). Management measures were reviewed by SLWRI study team and stakeholders for their ability to address the primary and secondary planning objectives. Following is a general description of the measures considered, reasons for retaining or deleting the measures from further development, and information on how retained measures could fit into potential concept plans.

In the discussion of SLWRI management measures, the term “enhancement” specifically refers to restoration actions that improve environmental conditions above the baseline (without-project condition). Correspondingly, the term “mitigation” refers to restoration actions that improve environmental conditions toward the baseline to compensate for project impacts. The relationship between restoration, enhancement, and mitigation is illustrated in Figure 2-1.

Identified management measures were analyzed in the *Mission Statement Milestone Report* (Reclamation 2003a), and summarized herein, to determine whether they would be retained for further consideration. One important factor was the potential for a measure to directly address a planning objective without adversely impacting other objectives. Measures were rated on a scale of high to low based on their relative ability to address the planning objectives. In most cases, measures that were rated as moderately addressing a planning objective, or less than moderately, were deleted from further consideration, while measures rating higher were retained. This is primarily because measures that could only marginally address an objective were generally found inconsistent with study constraints or other principles and criteria. Other major factors and rationale in retaining or deleting a measure are included in the following descriptions of the individual management measures.

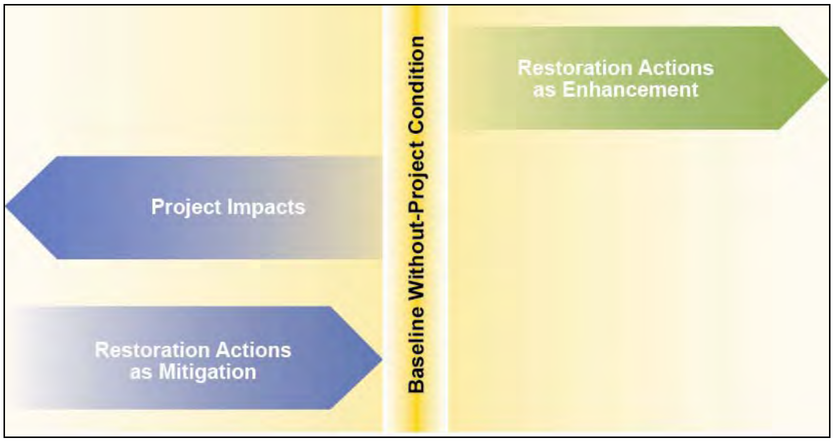


Figure 2-1. Conceptual Schematic of Restoration Actions as Enhancement Versus Restoration Actions as Mitigation

It should be noted that measures that did not directly address the planning objectives, or were otherwise dropped from consideration and further development as alternative plan components under certain circumstances, may be incorporated into alternative plans as mitigation measures. This is primarily because some measures may be found potentially effective in mitigating adverse impacts.

Measures to Address Primary Planning Objectives

Various management measures were identified to address the primary planning objectives of increasing anadromous fish survival and increasing water supply reliably. For each planning objective, measures were identified and separated into categories. In the following sections, rationale is discussed for retaining or deleting each measure.

Increase Anadromous Fish Survival

A number of potential management measures to address increasing anadromous fish restoration opportunities were identified. Most are listed in the November 2003 *Ecosystem Restoration Office Report* (Reclamation 2003b). Of more than 20 measures identified specifically to address the primary objective of increasing anadromous fish survival on the Sacramento River (see Table 2-1), six were retained for possible inclusion in concept plans during the initial plans phase.

Measures Considered

Following is a brief discussion of the array of measures considered, which are separated into three broad categories: (1) improve fish habitat, (2) improve water flows and quality, and (3) improve fish migration. This section summarizes rationale for deleting measures or retaining measures for further consideration, as presented in Table 2-1.

Improve Fish Habitat The six measures described below were identified to improve fish habitat.

- **Restore abandoned gravel mines along the Sacramento River –** Instream gravel mining has resulted, in many instances, in the degradation of aquatic and floodplain habitat. This is primarily because these activities have often created large artificial pits at various locations in the primary study area that disrupt natural geomorphic processes and riparian regeneration. Aquatic conditions at former gravel mining sites are typically unsuitable for spawning and rearing. High fish mortality due to stranding and unnatural predation occurs in many abandoned pits that either lose their connections with the river during low-flow periods or otherwise discourage effective transmission of fish passage between the river and mine area. The river cannot refill and restore many of these pits naturally because of changes in flow regime and reductions in coarse sediment input. This measure consists of acquiring, restoring, and reclaiming several inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Gravel pit restoration would involve filling deep depressions and recontouring the stream channel and floodplain within the gravel mine area, if possible and practical, to mimic more natural conditions. Side channels and other features could be created to encourage spawning and rearing and prevent stranding. Soil may need to be imported to replenish areas where gravel mining has resulted in a considerable loss of fine sediments. Revegetation using native riparian plants would be performed on restored floodplain lands.

  This measure was retained for potential further development as part of the SLWRI because it may have potential to successfully address the first primary planning objective. Furthermore, it may combine favorably with other potential measures related to Shasta Dam and Lake and their operation. This measure would not be expected to conflict with other known programs or projects on the upper Sacramento River.

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Table 2-1. Management Measures Addressing the Primary Planning Objective of Increasing Anadromous Fish Survival

Management Measure	Potential to Address Planning Objective	Status/Rationale
Improve Fish Habitat		
Restore abandoned gravel mines along the Sacramento River	**Moderate** – Addresses primary planning objective.	**Deleted –** Consistent with other anadromous fish programs and with secondary planning objectives and constraints. This measure was initially retained, then deleted from further consideration during the comprehensive plans phase due to subsequent modeling results indicating marginal benefits to anadromous fish and a general lack of interest from the public and stakeholders.
Construct instream aquatic habitat downstream from Keswick Dam	**Moderate –** Addresses primary planning objective.	**Retained –** This measure was retained for potential further development due to its potential to successfully address the first primary planning objective, potential to combine favorably with other potential measures, and a high interest from fisheries agencies
Replenish spawning gravel in the Sacramento River	**Moderate –** Addresses primary planning objective.	**Retained –** High potential for combining with other measures. Demonstrated benefits that continue as gravel moves downstream. Low initial cost. Concerns over induced downstream impacts to agricultural facilities. Consistent with Federal planning objectives and principles.
Construct instream fish habitat on tributaries to the Sacramento River	**Low to Moderate** – Indirectly benefits planning objective.	**Deleted –** Considerable benefit to tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Remove instream sediment along Middle Creek	**Low** – Indirectly benefits planning objective.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. High uncertainty due to increased need for long-term remediation.
Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks	**Low** – Indirectly benefits planning objective.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Improve Water Flows and Quality		
Make additional modifications to Shasta Dam for temperature control	**Moderate to High** – Potential to contribute to planning objective by improving temperatures for anadromous fish.	**Retained –** High likelihood of combining with measures involving increasing Shasta storage. Although existing TCD at Shasta effectively meets objectives, potential may exist to further modify the device to benefit anadromous fish with increased storage at Shasta.
Enlarge Shasta Lake cold-water pool	**Moderate to High** – Directly contributes to planning objective by improving water temperature conditions for anadromous fish.	**Retained –** High potential for combining with other measures. Consistent with other primary planning objective and secondary planning objectives. Consistent with goals of CALFED.
Modify storage and release operations at Shasta Dam	**Moderate to High** – Directly contributes to planning objective by improving flow conditions for anadromous fish.	**Retained –** This measure was retained because it is consistent with goals of CALFED and other programs/projects to benefit anadromous fish and has potential to combine with other measures, including raising Shasta Dam and Shasta Reservoir.
Modify Anderson-Cottonwood Irrigation District diversions to reduce flow fluctuations	**Moderate** – Reduced flow fluctuations would benefit anadromous fish, directly contributing to the planning objective.	**Deleted –** Conflicts with other primary planning objective of water supply reliability.
Increase instream flows on Clear, Cow, and Bear creeks	**Low** – Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Independent of hydraulic/hydrologic conditions in upper Sacramento River.
Construct a storage facility on Cottonwood Creek to augment spring instream flows	**Very Low** – Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Independent of hydraulic/hydrologic conditions in upper Sacramento River. Adverse environmental impacts expected to exceed benefits.

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Table 2-1. Management Measures Addressing the Primary Planning Objective of Increasing Anadromous Fish Survival (contd.)

Management Measure	Potential to Address Planning Objective	Status/Rationale
Improve Water Flows and Quality (contd).		
Transfer existing Shasta Reservoir storage from water supply to cold-water releases	**Low** – Potential to benefit anadromous fish but at a considerable disbenefit to water supply reliability.	**Deleted –** Violates basic plan formulation criteria – causes considerable reduction in water supply reliability without development of a replacement supply.
Remove Shasta Dam and Reservoir	**Very Low** – Relatively low potential benefit to anadromous fish with major adverse impacts to all other planning objectives.	**Deleted –** Violates basic plan formulation criteria and no known project or projects could replace the lost benefits provided by Shasta and Keswick dams, reservoirs, and appurtenant facilities, at any price.
Improve Fish Migration		
Improve fish trap below Keswick Dam	**Low to Moderate –** Directly contributes to planning objective by reducing mortality and supplying more fish to hatcheries.	**Deleted –** Although helps fish populations, would not contribute to favorable conditions for sustained spawning and rearing of anadromous fish along mainstem Sacramento River.
Screen diversions on Old Cow and South Cow creeks	**Moderate –** Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River.
Remove or screen diversions on Battle Creek	**Moderate –** Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River.
Construct a migration corridor from the Sacramento River to the Pit River	**Low –** High uncertainty as to the potential to successfully benefit area resources.	**Deleted –** Extremely high cost. Multiple physical obstructions of effective fish passage even after implementation. Very low certainty of success.
Cease operating or remove the Red Bluff Diversion Dam	**Moderate –** Potential to improve fish migration along upper Sacramento River.	**Deleted –** As the result of another Federal investigation **–** Red Bluff Diversion Dam Fish Passage Improvement Project. Reclamation subsequently ceased operation of Red Bluff Diversion Dam.
Reoperate the CVP to improve overall fish management	**Low –** Limited potential to improve anadromous fish survival along the upper Sacramento River.	**Deleted –** See above measure regarding the Red Bluff Diversion Dam. Issues regarding reoperating facilities on the Trinity River were addressed in the Trinity River Record of Decision in 2000. Any further modification within that system would violate planning criteria for SLWRI.
Construct a fish ladder on Shasta Dam	**Very Low –** Very low potential for marginal benefit to anadromous fish on the upper Sacramento River.	**Deleted –** Extremely high cost, relatively small benefit on limited stream system, and very low potential for physically implementing a workable ladder.
Reintroduce anadromous fish to areas upstream from Shasta Dam	**Low –** Low potential for marginal benefit to anadromous fish on the upper Sacramento River.	**Deleted –** Likely high cost, low potential for successful recapture of out-migrants, and potential for major impacts to existing warm- and cold-water species in the upper river.

Key:
CALFED = CALFED Bay-Delta Program
cfs = cubic feet per second
CVP = Central Valley Project
TCD = temperature control device

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- **Construct instream aquatic habitat downstream from Keswick Dam –** Keswick Dam is the uppermost barrier to anadromous fish migration on the Sacramento River. Releases from the dam have scoured the channel, and the dam blocks passage of gravels, bed sediments, and woody debris that were replenished historically by upstream tributaries. As a result, aquatic habitat is poor for spawning and rearing of anadromous fish, and predation can be high because of the lack of instream cover. Despite these unfavorable channel conditions, cold-water releases from Keswick Dam attract large numbers of spawners to this reach. This measure consists of constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam to encourage use of this reach by anadromous fish for reproduction. Habitat restoration would involve acquiring lands adjacent to the Sacramento River; earthwork along the riverbank to construct side channels for spawning; and strategic placement of instream cover structures within the river channel, including large boulders, anchored root wads, and other natural materials. Side channels and other features could also be created to encourage spawning and rearing. Restored floodplain lands could be revegetated with native riparian plants.

  This measure was retained for potential further development as part of the SLWRI, because it may have potential to successfully address the first primary planning objective and due to high interest from fisheries agencies. Furthermore, this measure will likely combine favorably with other potential measures related to Shasta Dam and Reservoir and their operation. This measure would not be expected to conflict with other known programs or projects on the upper Sacramento River.

- **Replenish spawning gravel in the Sacramento River –** Historically, tributary watersheds upstream from Keswick and Shasta Dams provided a continuous source of high-quality gravel and other coarse sediments to the Sacramento River. Dams, river diversions, gravel mining, and other obstructions have blocked or reduced natural gravel sources. Gravel suitable for spawning has been identified as a considerable influencing factor in the recovery of anadromous fish populations in the Sacramento River. Several programs, including CALFED and the Anadromous Fish Restoration Program, have provided gravel replenishment in selected locations. With the exception of the CVPIA(b)(13) program, these programs represent single applications at discrete locations. Similarly, this measure consists of a single application of spawning-sized gravel at a discrete location in the Sacramento River between Keswick and Red Bluff. Gravel would be transported and placed into the Sacramento River downstream from Keswick Dam. This measure was retained for potential further development as part of the SLWRI because it may have potential to successfully address the first primary planning objective. Furthermore, it may combine favorably with other potential measures related to Shasta Dam and Reservoir and their operation.

- **Construct instream fish habitat on tributaries to the Sacramento River –** This measure consists of improving instream aquatic habitat along the lower reaches of tributaries to the Sacramento River. Various structural techniques would be employed to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Both perennial and intermittent streams would be potential candidates for structural habitat improvements. Candidates for aquatic habitat improvement include Middle, Olney, Churn, and Cow creeks. However, this measure would not directly contribute to improved ecological conditions or fish habitat along the mainstem Sacramento River. Although this measure would have considerable benefits for tributaries, it was deleted from further development as part of the SLWRI primarily because it is a separate and independent action. It would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area.

- **Remove instream sediment along Middle Creek –** This measure consists of implementing a sediment removal and control program along Middle Creek, an intermittent tributary to the Sacramento River between Keswick Dam and Redding. Lower Middle Creek supports spawning runs of rainbow trout, steelhead, and salmon. Spawning gravels have been degraded by fine granitic sediment eroding from streambanks and adjacent land. Sediment from the creek also negatively impacts spawning habitat in the Sacramento River around the Middle Creek confluence. This measure was deleted from further development primarily because it is a separate and independent action. It would not considerably contribute to increasing anadromous fish survival within the primary Sacramento River study area.

- **Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks –** This measure consists of rehabilitating ecological conditions in former instream gravel mining sites along Stillwater Creek. Seven inactive gravel pits on Stillwater and/or Cottonwood creeks historically contributed to depletion of nearly all instream gravel resources along various reaches, leaving the channel scoured to bedrock. Restoring these gravel mines could help Stillwater Creek provide additional seasonal habitat for various anadromous and resident fish. This measure was deleted from further development primarily because it is a separate and independent action. It would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

Improve Water Flows and Quality The following section describes the measures considered for improving water flows and quality.

- **Make additional modifications to Shasta Dam for temperature control –** The TCD installed at Shasta Dam allows operators to make selective releases from various reservoir depths to regulate water temperatures to benefit anadromous fish in the upper Sacramento River. This measure consists of determining if making additional structural modifications to the outlets and existing TCD for temperature control is possible and feasible and, if so, implementing those modifications.

  This measure was retained for further development primarily because it could (1) improve the performance of the existing facility, (2) complement other measures under consideration to raise Shasta Dam, and (3) complement measures to improve aquatic spawning habitat in the Sacramento River. This measure would not conflict with other ecosystem restoration measures preliminarily retained herein, or other known programs or projects on the upper Sacramento River.

- **Enlarge Shasta Lake cold-water pool –** Cold water released from Shasta Dam considerably influences water temperature conditions on the Sacramento River between Keswick Dam and the RBDD facilities. This measure consists of enlarging the cold-water pool by either raising Shasta Dam and enlarging the minimum operating pool, or increasing the seasonal carryover storage in Shasta Lake. Each action would help provide greater flexibility in meeting water temperature targets throughout the year and extending suitable spawning habitat downstream. This measure also would be consistent with the goals of CALFED.

  This measure was retained for further development primarily because it would (1) directly contribute to both primary planning objectives for the SLWRI, (2) combine favorably with other measures, and (3) have a high certainty of providing the intended benefits once implemented. This measure would not conflict with any other ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects on the upper Sacramento River.

- **Modify storage and release operations at Shasta Dam –** In addition to water temperature, flow conditions in the upper Sacramento River are also important in addressing anadromous fish needs. This measure consists of enlarging Shasta Dam and modifying seasonal storage and releases to benefit anadromous fisheries. Although this measure could help provide greater flexibility in meeting water temperature targets, it would be aimed primarily at improving flows and influencing physical channel conditions for anadromous fish. Changes would be made to the timing and magnitude of releases performed to maintain target flows in spawning areas and to improve the quality of aquatic habitat. The quality of aquatic habitat could be further improved by cleaning spawning gravels. These changes would be at the discretion of Reclamation based on recommendations by the Sacramento River Temperature Task Group (SRTTG). This measure would contribute to the goals of the Anadromous Fish Restoration Program included as part of the CVPIA. This measure also could include release changes during the flood season to permit "pulse flows" and other releases that could improve aquatic habitat conditions. Further, this measure could provide additional control and dilution of acid mine drainage from Spring Creek.

This measure was initially deleted from consideration because analyses indicated a decreased fisheries benefit with increasing Sacramento River flows compared to increasing the cold-water pool. However, this measure was retained for further development when combined with additional storage space in Shasta Reservoir, as part of an adaptive management plan, primarily because it could directly contribute to both primary objectives of the SLWRI and combine favorably with other measures.

- **Modify Anderson-Cottonwood Irrigation District diversions to reduce flow fluctuations –** This measure consists of modifying operations at the Anderson-Cottonwood Irrigation District diversion dam near Anderson to reduce extreme flow fluctuations and their resulting impacts on anadromous fish. Extreme fluctuations in Sacramento River flows result in fish stranding and juvenile fish mortality. This measure was deleted from further development, however, primarily because of potential impacts to water supply reliability. Negative impacts on water deliveries from the Anderson-Cottonwood Irrigation District diversion dam would conflict with the second primary planning objective of increasing water supply reliability.

- **Increase instream flows on Clear, Cow, and Bear creeks –** This measure consists of increasing instream flows on Clear, Cow, and Bear Creeks during critical periods to support anadromous fish that spawn in the creek. Increasing flows would improve the quality of spawning habitat and help reduce water temperatures, thereby increasing the amount of suitable tributary spawning habitat available in the creeks. This measure was deleted from further development primarily because it would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. In addition, this measure could impact hydropower production.

- **Construct a storage facility on Cottonwood Creek to augment spring instream flows –** This measure consists of constructing a dry dam or offstream storage facility on upper Cottonwood Creek to support flows for spring-run Chinook salmon. A storage facility would allow late-spring and summer releases for spring-run Chinook salmon, and improve overall seasonal aquatic conditions. This measure was deleted from further development primarily because it is an independent action. It would not considerably or directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. In addition, it is highly likely that this measure would have considerable and overriding adverse environmental impacts in the Cottonwood Creek watershed.

- **Transfer existing Shasta Reservoir storage from water supply to cold-water releases –** This measure consists of reoperating the existing Shasta Dam and Reservoir for anadromous fishery resources. This measure was requested as part of the environmental scoping process. For this measure, it was assumed that storage space in Shasta could be reoperated to provide flows similar to those identified in the January 2001 *Final Restoration Plan* for the Anadromous Fish Restoration Program. This would require an optimal minimum flow along the upper Sacramento River of about 5,500 cubic feet per second (cfs) during certain periods of time. Operational considerations of the increased flows would be given to managing the existing cold-water pool in Shasta Reservoir. A cursory estimate was made of the potential water supply yield reduction through increasing the minimum flows from the existing 3,250 cfs to 5,500 cfs. It showed that the loss in drought period yield would amount to about 50,000 acre-feet per year. Additional fishery modeling studies and water supply related analysis would be necessary to both confirm the magnitude of yield loss and potential benefit to the anadromous fishery. A potential least-cost replacement water source for the yield reduction would likely be in excess of $250 million. This measure was deleted from further consideration primarily because it violates at least one of the planning criteria concerning the potential to adversely impact existing project purposes. In addition, it is believed that existing CVP water contractors would not be willing to pay for the water loss, and no other entities willing to pay have been identified.

- **Remove Shasta Dam and Reservoir –** This measure consists of removing the existing Shasta Dam and Reservoir to benefit anadromous fishery resources. This measure was requested as part of the environmental scoping process. It is believed that this measure would also include removing Keswick Dam and Reservoir to allow anadromous fish to access upstream river areas. Removing Keswick and Shasta Dams and Reservoirs would allow anadromous fish access to spawning areas that are now within the lake areas and passage to the headwaters of the upper Sacramento River, several smaller streams, and about 24 miles of river area along the lower McCloud River. A number of additional dams and reservoirs on the Pit and upper McCloud rivers would block access along those water courses.

The Shasta Division of the CVP provides supplemental irrigation service to nearly 1 half-million acres of land in the Central Valley of California. It also provides water for M&I purposes and power generation amounting to about 680,000 kilowatts. In addition, Shasta Dam helps reduce flooding over a large area along the Sacramento River. Estimates of flood damages prevented by Shasta Dam and Reservoir during the major storms of 1995 and 1997 were about $3.5 billion and 4.3 billion, respectively. Much of the economy of the Central Valley, and the entire State, has greatly benefited from Shasta Dam and Reservoir. It is believed that the cost of Shasta Dam and Reservoir and its associated facilities have been paid multiple times over since they were constructed in the early 1940s. Although the potential benefit to anadromous fish resources along the upper Sacramento River may be sizeable (substantial studies would be required to define potential benefits and disadvantages to the fisheries), these benefits by no means begin to approach the monetary benefit associated with the existing project. No known project or projects could replace the benefits provided by Shasta and Keswick dams, reservoirs, and appurtenant facilities at any price. This measure was deleted from further consideration primarily because it violates at least one of the planning criteria concerning the potential to adversely impact existing project purposes.

Improve Fish Migration The measures identified to improve migration are described in the subsequent section.

- **Improve fish trap below Keswick Dam** – Keswick Dam is an upstream barrier to fish migration on the Sacramento River. As part of mitigation actions associated with the construction of Shasta and Keswick dams, a fish trap facility was constructed at Keswick Dam to capture anadromous fish for transport to the Coleman National Fish Hatchery on Battle Creek. This measure consists of improving the efficiency and performance of the fish trap below Keswick Dam to increase survival of anadromous fish captured at the facility, thereby providing additional adults and increased egg production for fish hatchery operations. Although this measure has potential to contribute to the primary planning objective of increasing anadromous fish populations in the upper Sacramento River, it would not necessarily contribute to increasing survival of anadromous fish in the upper Sacramento River. This measure was deleted from further development primarily because it would not improve spawning and rearing conditions necessary for natural and sustainable reproduction of anadromous fish in the upper Sacramento River.

- **Screen diversions on Old Cow and South Cow creeks –** This measure consists of screening diversion intakes in the Cow Creek watershed to reduce fish mortality. Over 100 agricultural diversions exist from the Cow Creek watershed; while many are small, larger diversions can entrain juvenile salmonids and other fish that use spawning habitat provided by the watershed. This measure would potentially reduce salmonid mortality at diversions within the Cow Creek watershed. This measure would not contribute directly to improved fish migration in the upper Sacramento River. Some of the largest diversions identified as part of this measure, such as Kilarch Powerhouse Ditch, South Cow Creek Powerhouse Ditch, and Bassett Ditch, are between 10 and 25 miles upstream from the confluence with the Sacramento River. In addition, several programs, including the CVPIA (b)(21) are already proceeding with installation of fish screens within the Sacramento River system. This measure was deleted from further development primarily because it is an independent action and would not directly contribute to anadromous fish survival within the primary Sacramento River study area.

- **Remove or screen diversions on Battle Creek –** This measure consists of removing or screening diversions and other water control facilities on Battle Creek to allow full use of the watershed's high-quality, cold-water spawning habitat. Several projects either have been, or are being implemented, on Battle Creek to improve access to habitat and spawning success, including the Battle Creek Salmon and Steelhead Restoration project and the Orwick Diversion Fish Screen Improvement Project. However, additional large portions of the upper Battle Creek watershed remain inaccessible to anadromous fish because of diversions. This measure would provide access to high-quality spawning habitat in the upper Battle Creek watershed. However, several programs, including the CVPIA (b)(21) are already proceeding with installing fish screens within the Sacramento River system. Furthermore, this measure would not contribute directly to improved fish migration in the upper Sacramento River. This measure was deleted from further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area.

- **Construct a migration corridor from the Sacramento River to the Pit River –** This measure consists of providing passage to spawning areas upstream from Shasta Dam for anadromous fish from the Sacramento River. One concept includes connecting the upper Pit River to the Sacramento River, which would consist of (1) constructing a fish channel between the Cow Creek basin and the Pit River Arm of Shasta Lake, (2) constructing a fish barrier to prevent fish from entering Shasta Lake, and (3) installing fish screens and flow control structures at various locations along the natural and man-made migration route to prevent straying. This and similar measures were deleted from further consideration primarily because of the (1) high cost for complex infrastructure, (2) major impacts to other facilities and extensive long-term operation and maintenance requirements, and (3) high uncertainty for the potential to achieve and maintain successful fish passage and spawning.

- **Cease operating or remove the Red Bluff Diversion Dam –** This measure consists of either ceasing the operation of the Red Bluff Diversion Dam or removing the facility completely. This measure was requested as part of the environmental scoping process. The two primary fish passage issues associated with the Red Bluff Diversion Dam are (1) delay and blockage of adults migrating upstream, and (2) the impedance and losses of juveniles emigrating downstream. Fish ladders located on each abutment of the dam have been ineffective, limiting access to remaining spawning habitat between Keswick Dam and Red Bluff. Predation is also problematic in Lake Red Bluff. Potential solutions to these problems were considered as part of the Red Bluff Diversion Dam Fish Passage Improvement Project. This is a cooperative effort led by Reclamation and the Tehama-Colusa Canal Authority. The project is developing a long-term solution to relieve conflicts between fish passage and agricultural diversion needs. A number of alternatives were being considered, including removing the barrier to fish by removing the gates completely and constructing pumps to divert water into the Tehama-Colusa Canal, improvements to the existing fish ladders, and construction of a bypass channel. This measure was deleted from further consideration in the SLWRI primarily because removing the gates was already one of the alternatives being considered in the Fish Passage Improvement Project FEIS/Environmental Impact Report release May 2008.

- **Reoperate the CVP to improve overall fish management –** This measure primarily includes reoperating all of the CVP facilities in the upper Sacramento River system to improve anadromous fish resources. This measure was requested as part of the environmental scoping process. Major CVP facilities in the Sacramento River watershed that could influence the primary planning objective besides Shasta Dam and Reservoir includes Keswick Dam and Reservoir and features of the Trinity and Sacramento River Divisions. Major facilities in the Trinity River Division include Trinity Dam and Trinity Lake on the Trinity River, Lewiston Dam and Lake on the Trinity River, and Whiskeytown Dam and Lake on Clear Creek. Major facilities in the Sacramento River Division include the Red Bluff Diversion Dam and various facilities within the Corning and Tehama-Colusa Canal service areas. Efforts were recently concluded by the U.S. Department of the Interior in the Trinity River ROD (DOI 2000). That decision primarily resulted in reoperating facilities within the Trinity River Division to improve fishery conditions on the Trinity River. Any further reoperation of the facilities within the Trinity River Division not adversely impacting other project purposes would likely not be allowed under the existing decision because reoperations likely could be accomplished only at the expense of fish on the Trinity River. As mentioned, a number of alternatives are being considered for addressing anadromous fish issues at the Red Bluff Diversion Dam, including removing the barrier to fish by removing the gates completely and constructing pumps, diverting water into the Tehama-Colusa Canal, improvements to the existing fish ladders, and construction of a bypass channel. This measure was deleted from further consideration in the SLWRI primarily because no opportunity appears to exist to effectively further reoperate the CVP facilities capable of affecting the Sacramento River that would not result in adversely impacting other project purposes.

- **Construct a fish ladder on Shasta Dam** – This measure primarily includes constructing a fish ladder on Shasta Dam to allow anadromous fish to access Shasta Lake and approximately 40 miles of the upper Sacramento River, about 24 miles of the lower McCloud River, and various small creeks and streams tributary to Shasta Reservoir. This measure was requested as part of the environmental scoping process. A fish ladder at Shasta Dam would need to be approximately 476 feet high. A number of high-head dams have been studied for fish ladders, many of which would have allowed fish passage to much more historical spawning areas than would be available upstream from Shasta Lake. All of these high-head dam fish ladders have been rejected mainly for cost reasons (fish trapping and hauling is much cheaper under these circumstances). In addition, a high ladder concept was attempted at the Pelton project on the Deschutes River in Oregon. At this location, the fish were not able to travel the entire distance safely because of the extreme length of the ladder, and the water temperature increased considerably at higher elevations. This measure was deleted from further consideration in the SLWRI primarily because of the estimated high cost to construct and operate the fish ladder, the low likelihood for success in getting the fish to successfully ascend the ladder, and the likely major impacts to existing warm- and cold-water species in the upper river reaches.

- **Reintroduce anadromous fish to areas upstream from Shasta Dam** – It is believed that this measure primarily includes trapping anadromous fish along the Sacramento River likely just downstream from Keswick Dam, transporting the fish by tanker truck to areas along the upper Sacramento River near Volmers or Delta on the Sacramento

River, and releasing the fish in the upper Sacramento River to spawn. It would also include some method of trapping potential out-migrating fish and transporting them to the Sacramento River near Keswick for release into the lower river. This measure was requested as part of the environmental scoping process. Numerous dams on the upper Pit and McCloud Rivers would preclude this measure on those water courses. This measure was deleted from further consideration in the SLWRI primarily because of the high cost to implement the plan, low likelihood for success due to the inability to recapture out-migrants, and likely major impacts to existing warm- and cold-water species in the upper river.

Measures Retained for Further Consideration

Each of the six management measures retained to address the primary planning objective of increasing anadromous fish survival was considered in greater detail to determine how they might become components of potential concept plans. Of the six measures initially retained, five were chosen for further development and inclusion in comprehensive plans. Measures are shown in Figure 2-2, and their major components, accomplishments are described below.

- **Restore abandoned gravel mines along the Sacramento River –** Protecting and restoring spawning and rearing habitat have been identified by National Oceanic and Atmospheric Administration Fisheries as a primary goal in the recovery of Sacramento River winter-run Chinook salmon. It is estimated that over 80 percent of the winter Chinook spawning population migrates to the upper Sacramento River when passage at the Red Bluff Diversion Dam is unobstructed. Therefore, restoring suitable spawning habitat in the upstream reach of the river has potential to benefit a large portion of the salmonid population.

  One method of increasing anadromous fish survival is rehabilitating lands formerly mined for gravel along the Sacramento River. Instream gravel mining degrades aquatic and floodplain habitat by (1) creating large artificial pits along the river that disrupt natural geomorphic processes and riparian regeneration, (2) stranding fish and encouraging predation, and (3) removing valuable gravel sources. Aquatic conditions at former gravel mining sites are typically unsuitable for spawning and rearing. High fish mortality occurs at many abandoned pits that effectively lose their connection with the river during low flow periods, stranding fish and encouraging unnatural predation rates. Because of changes in flow regime and reductions in coarse sediment input, the river is not capable of refilling and restoring many of these pits naturally. In addition, removing fine sediments during the gravel extraction process inhibits establishment of riparian vegetation that provides protective cover and shade for spawning and rearing.

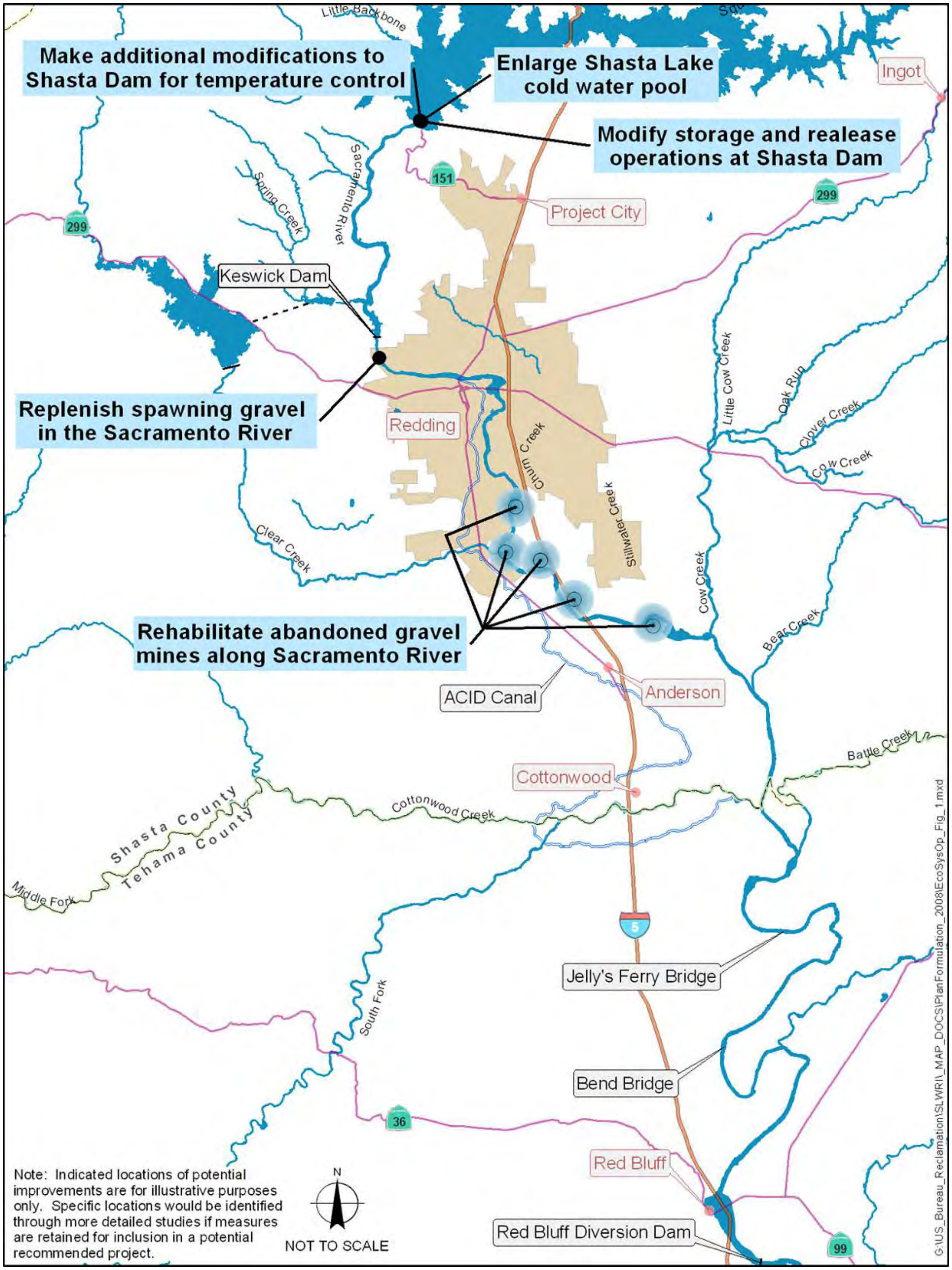

Figure 2-2. Measures Retained to Address Primary Planning Objective – Anadromous Fish Survival

Actions associated with this measure would help restore the natural complexity required for a healthy, self-sustaining river ecosystem. Actions would include filling deep pits (potentially requiring suitable fill material to be imported from local sources), recontouring the stream channel and floodplain to mimic natural conditions, and reconnecting the reclaimed area to the Sacramento River. Side channels and other features could be created to encourage spawning and rearing, and restored floodplain lands could be revegetated using native plants. Soil might need to be imported to replenish areas where gravel mining has resulted in a considerable loss of fine sediments. Hydrologic, hydraulic, and sedimentation studies would identify optimal restoration conditions and any actions necessary to offset or minimize undesirable hydraulic conditions caused by restoration.

This measure consists of acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Several potential sites for gravel mine restoration along the Sacramento River between Keswick and Red Bluff listed in Table 2-2. Figure 2-3 shows an example area for implementing this measure. Most of these sites consist of one or more deep pits surrounded by partially disturbed land, with the majority of sites consisting of disturbed lands that would require minimal restoration actions. For this assessment, however, a potential restoration area of 150 acres was considered. The exact size and location(s) would be determined in further studies.

Source: M. Kondolf, 1989

Figure 2-3. Example of Abandoned Gravel Mine with Isolated Pits (left side of photo)

Table 2-2. Potential Gravel Mine Restoration Sites Along the Sacramento River

Location	Approximate River Mile	Bank	Area acres
Red Bluff near Salt Slough	247	Left	140
Upstream from Stillwater Creek	282	Right	320
Redding	287-288	Right	135
Redding	287.5-288	Left	65
Redding	288.5-290.3	Left	305
Redding	292.5-294	Left	230

Primary accomplishments of gravel mine site restoration along the upper Sacramento River would be to (1) improve spawning success by increasing the amount of suitable spawning habitat along the Sacramento River for anadromous fish and (2) improve the health and vitality of self-sustaining riverside riparian ecosystems by restoring their connection with natural geomorphologic processes.

This measure would support the primary planning objective of increasing the survival of anadromous fish populations in the Sacramento River by eliminating stranding and restoring spawning and rearing habitat at one or more abandoned gravel pits. The measure also would support the secondary planning objective of conserving and restoring ecosystem resources along the upper Sacramento River through restoring riparian and floodplain habitat.

Although this measure was initially retained and considerably developed for inclusion in concept plans, as discussed above, it was later deleted from further development during the comprehensive plans phase. Subsequent evaluations related to the use of the SALMOD model have indicated that restoring these areas may not result in a significant benefit to anadromous fish. Concerns were also expressed that ranged from a low likelihood that these areas could be effectively used to increase spawning and rearing habitats to the likelihood for increased predation. Further, during public and stakeholder outreach meetings in late 2005 held primarily for environmental scoping purposes, there was little to no interest expressed for acquisitioning and restoring these areas. At this time, restoration of abandoned gravel mines is not included in further plan formulation activities for the SLWRI.

- **Construct instream aquatic habitat downstream from Keswick Dam** – This measure consists of constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam to encourage use of this reach by anadromous fish for spawning and rearing. Habitat enhancements in this measure included floodplain, riparian, and side channel habitats.

Side channels can support important habitat for anadromous salmonids, including rearing and spawning habitat. Side channel habitats provide refuge from predators and productive foraging habitat for juvenile anadromous salmonids. Salmonids also seem to prefer the hydraulic and channel bed conditions provided in side channels for spawning.

Riparian vegetation, including shaded riverine aquatic cover, provides juvenile salmonids cover from predators, habitat complexity, a source of insect prey, and shade for maintaining water temperatures within suitable ranges for all life stages. Juvenile salmonids prefer riverine habitat with abundant instream and overhead cover (e.g., undercut banks, submerged and emergent vegetation, logs, roots, other woody debris, and dense overhead vegetation) to provide refuge from predators, and a sustained, abundant supply of invertebrate and larval fish prey.

There is an opportunity to perform riparian and floodplain habitat restoration along the Sacramento River downstream from Keswick Dam to promote the health and vitality of the river ecosystem. Locations near tributary confluences that are inundated by floods on a fairly frequent basis would be targeted for restoration to maximize the potential for long-term success and benefits. Restoration would include replacing lost floodplain sediment, regrading or recontouring floodplains that have been disconnected from the river, removing berms or levees (as appropriate), and revegetating floodplain and adjacent riparian areas. Locations for restoration would be in areas with a 20 to 50 percent chance of flooding in any year to ensure riparian habitat growth and regeneration. If the lands chosen for restoration are not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.

This measure would support the secondary objective to conserve and restore ecosystem resources along the upper Sacramento River by restoring native riparian habitat, side channels, and associated floodplain lands. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish in the Sacramento River.

- **Replenish spawning gravel in the Sacramento River –** The restoration of aquatic habitat between Keswick Dam and Red Bluff is of high priority because this stretch is one of the few remaining spawning corridors available to anadromous fish along the Sacramento River. This measure would support the primary objective of increasing the survival of anadromous fish populations in the Sacramento River by contributing to replenishing spawning gravels used by anadromous fish.

Historically, the tributary watersheds upstream from Keswick and Shasta Dams provided a source of gravel and other coarse sediments to the Sacramento River. Gravels were continually replenished as they moved down the river system. Gravel recruitment is of particular importance to anadromous fish, which require clean gravels for their spawning beds. Dams, river diversions, gravel mining, and other obstructions have blocked or reduced natural gravel sources. Suitable spawning gravel has been identified as a potential limiting factor in the recovery of anadromous fish populations on the Sacramento River. Several other programs, including CALFED and the Anadromous Fish Restoration Program, have provided gravel replenishment on the Sacramento River in selected locations.

There are opportunities to replenish spawning gravel in the Sacramento River and along the lower reaches of its tributaries. The reach immediately downstream from Keswick Dam has no natural gravel sources and provides marginal spawning habitat. These gravel sources could be artificially augmented by gravel injections.

This measure would involve transporting and placing gravel into the Sacramento River downstream from Keswick Dam. Actions would include placing suitable gravels into the Sacramento River immediately below Keswick Dam. Structural treatments may be required below Keswick Dam to prevent the gravel from being washed downstream. Temporary construction easements could be required. Suitable spawning gravel would consist of uncrushed, natural river rock, washed and placed in the river at strategic locations. Hydraulic and geomorphic evaluations are needed to determine the most effective gravel size distribution and the most appropriate locations for gravel placement. The size and amount of gravel is first determined by the hydraulic characteristics of the river at the injection site and secondarily by the spawning characteristics of the targeted fish species. For the purpose of this evaluation, it is estimated that a total of 10,000 tons of gravel between 1 inch and 3 inches in diameter would be injected at one site.

Replenishing gravel in relatively stable reaches that lack natural gravel sources, preferably those with complex structures or large woody debris to trap and retain gravel, would increase the success and longevity of the measure. The reach immediately downstream from Keswick Dam has no natural gravel sources and currently provides marginal spawning habitat. Gravel placement would be concentrated in this uppermost reach, between Anderson and Keswick Dam. Gravel is typically moved downstream from the site of placement by high flows that occur, on average, about every 5 years. However, added spawning gravels continue to benefit the stream environment as they move through a river system, although the benefits tend to be less distinct farther downstream.

This measure would support the primary planning objective of increasing the survival of anadromous fish populations in the Sacramento River by restoring spawning gravels in stream channels that no longer have adequate gravel resources. After water temperature, the presence and quality of spawning gravel is probably the most important factor contributing to the reproductive success of anadromous fish.

- **Make additional modifications to Shasta Dam for temperature control** – Adverse water temperature conditions in the upper Sacramento River have been identified as a critical factor leading to decline of anadromous fish species. As demand for CVP water has increased over time, the ability to maintain suitable water temperatures downstream from Keswick Dam for salmonids has become increasingly difficult. The NMFS 1993 BO for CVP Operations (NMFS 1993) established water temperature criteria for the Sacramento River between Keswick Dam and Bend Bridge, or points upstream from Bend Bridge depending on climatic and water storage conditions. The existing TCD at Shasta Dam, shown in Figures 2-4 and 2-5, was constructed from 1996 to 1998 to help meet requirements of the 1993 BO.

Figure 2-4. TCD Located on Upstream Face of Shasta Dam

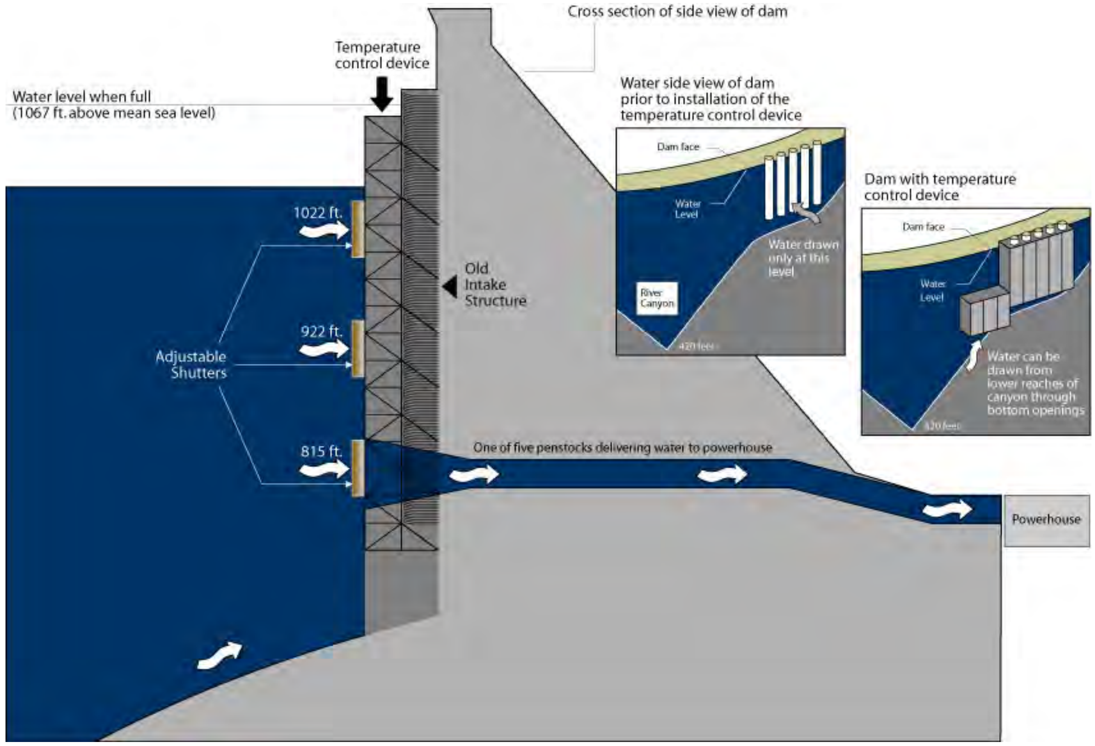

Figure 2-5. Shasta Dam Temperature Control Device

This measure consists of first assessing if modifications to the TCD are possible and feasible and, if so, implementing those modifications. This measure could be highly effective when combined with measures to increase storage space in Shasta Reservoir. For relatively small raises of Shasta Dam, the existing TCD structure would be retrofitted to account for additional dam height and to reduce leakage of warm water into the structure, but no new structure would be needed. However, modifications to the existing structure are more likely to become necessary for increasingly higher dam raises. For dam raises higher than about 50 feet, it is believed that major modifications to the TCD would be needed to manage the increasing depth and volume of water. Accordingly, modifications under this measure for higher dam raises would include widening the existing structure to increase intake capacity, and extending the device to a greater depth. In addition, this measure would provide for added structural modifications to the outlets at Shasta Dam for the purpose of temperature control.

Accomplishments of this measure would be to increase survival of anadromous fish populations in the Sacramento River by (1) increasing the ability of operators at Shasta Dam to meet downstream temperature requirements for anadromous fish, (2) providing more flexibility in achieving desirable water temperatures during critical spawning, rearing, and out-migration, and (3) extending the area of suitable spawning habitat farther downstream in the Sacramento River.

This measure would support the primary planning objective of increasing survival of anadromous fish populations in the Sacramento River. Also, it would complement potential measures to increase storage in Shasta Dam because additional temperature control improvements could be incorporated into the design of a dam raise and further improve cold-water releases. This measure would combine well with measures to improve aquatic spawning habitat in the Sacramento River because better water temperature regulation could allow anadromous fish to take greater advantage of these habitat improvements. This measure would not conflict with other environmental restoration measures or other known programs or projects on the upper Sacramento River.

- **Enlarge Shasta Lake cold-water pool –** Cold water released from Shasta Dam considerably influences water temperature conditions on the Sacramento River between Keswick Dam and the RBDD facilities. This measure includes increasing the volume of the cold-water pool in Shasta Lake by raising Shasta Dam and enlarging Shasta Lake primarily to help maintain colder releases for anadromous fish during certain periods. Increased storage volume could also help increase seasonal flows during dry and critically dry years in the upper Sacramento River that are important to fish populations.

  Possible operational changes to the timing and magnitude of releases from Shasta Dam, primarily to improve the quality of aquatic habitat, could be applied under an adaptive management plan. Changes in operating the cold-water pool could include increasing minimum flows, timing releases out of Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional water in storage to meet temperature requirements. Reclamation would manage the cold-water pool each year based on recommendations from the SRTTG.

  Dam raises ranging from about 6.5 feet to about 200 feet have been considered in previous studies by Reclamation. A dam raise of about 6.5 feet, as suggested in the CALFED ROD, would increase storage by about 256,000 acre-feet. A dam raise of about 200 feet would increase storage by about 9.3 MAF. The increased cold-water pool could be used to meet existing or proposed temperature targets or provide additional cold-water discharges during the summer, which could considerably extend the downstream reach of suitable spawning habitat. Increased volume could also help meet minimum flows in late fall in the upper Sacramento River.

  Raising Shasta Dam and enlarging Shasta Lake would result in impacts to natural resources and infrastructure around the reservoir rim, potentially requiring considerable mitigation and relocations. Impacts associated with dam raises of less than about 18 feet would be significant but likely manageable. Higher dam raises would result in major impacts to reservoir area resources and infrastructure, reducing the likelihood of economic justification. In addition to extreme impacts in the Shasta Lake area, very high dam raises (100 to 200 feet) might also result in major impacts to natural resources along the Sacramento River downstream from the dam. These impacts would likely eliminate serious consideration of high dam raises.

This measure would support the primary planning objective of increasing survival of anadromous fish populations by (1) improving water temperature control, (2) extending suitable spawning habitat, and (3) improving overall physical aquatic habitat conditions in the Sacramento River. It also would support the primary planning objective of increasing water supply reliability. The estimated certainty of this measure in achieving its intended accomplishments would be high.

This measure would complement the other primary and secondary planning objectives. Also, it would combine favorably with measures aimed at changing the timing and magnitude of releases from the increased pool, which would improve the quality of spawning and rearing habitat, increase attraction flows that cue in-migration, and improve water temperatures that cue out-migration. This measure would not conflict with other ecosystem restoration measures that were preliminarily retained, nor does it conflict with other known programs or projects on the upper Sacramento River.

- **Modify storage and release operations at Shasta Dam –** In addition to water temperature, flow conditions in the upper Sacramento River are important in addressing anadromous fish needs. Timing and magnitude of river flows are important to successful spawning and rearing of anadromous fish populations. This measure consists of enlarging Shasta Dam and modifying seasonal storage and releases to benefit anadromous fisheries in the Sacramento River by providing greater flexibility in achieving desirable river flows that would improve and expand suitable spawning and rearing habitat.

  Changes would be made to the timing and magnitude of releases performed to maintain target flows in spawning areas, and to improve the quality and quantity of aquatic habitat. Nearly all winter-run, and by far the majority of the spring-run and late-fall-run salmon in the Sacramento River, spawn in the reach upstream from the confluence with Battle and Cottonwood Creeks. It is within this reach of river that the measure would be most effective by reducing the frequency and magnitude of habitat dewatering. The quality of aquatic habitat could be further improved by cleaning spawning gravels. This measure could also include release changes during the flood season to permit “pulse flows" and other releases that could improve aquatic habitat conditions. Further, the measure could help provide additional control and dilution of acid mine drainage from Spring Creek.

Shasta Dam operates for multiple objectives, including water supply, flood control, water temperature, hydropower, and others. Modifying existing storage and release operations could adversely impact water supply reliability to agricultural and M&I uses or other beneficial uses of the water stored in the reservoir, which would be contrary to SLWRI goals and objectives. Therefore, this measure would need to include enlarging the storage space in Shasta Reservoir to mitigate potential adverse impacts to water supply reliability. This measure would not conflict with any ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects on the upper Sacramento River.

The estimated certainty of this measure in achieving its intended accomplishments would be moderate. The relationship between minimum river flows and increased survivability of salmon is not clear because many factors affect anadromous fish populations. Further, successful implementation would be highly dependent on the extent of dam modifications and reoperation that could be implemented while offsetting or minimizing adverse impacts to water supply or hydropower.

This measure was initially deleted from consideration because analyses indicated a decreased fisheries benefit with increasing Sacramento River flows compared to increasing the cold-water pool. However, this measure was subsequently retained as part of an adaptive management strategy for operation of the cold-water pool in Shasta Reservoir. Changes in operating the cold-water pool could include increasing minimum flows, timing releases out of Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional water in storage to meet temperature objectives.

Increase Water Supply Reliability

Various potential water management measures were identified to address the primary objective of increasing water supply reliability for M&I, agricultural, and environmental purposes to help meet current and future water demands. Of 22 measures considered to help increase water supply reliability (see Table 2-3), four were retained for possible inclusion in concept plans. Rationale is discussed for retaining or deleting measures in this section.

Measures Considered

Following is a brief discussion of the measures considered, which are separated into eight categories: (1) increased surface water storage, (2) reservoir reoperation, (3) improved conjunctive water management, (4) coordinated operation and precipitation enhancement, (5) demand reduction, (6) improved water purchases and transfers, (7) improved Delta export and conveyance, and (8) improved surface water treatment. Also included are additional descriptions of the three measures retained for further consideration.

Increase Surface Water Storage Measures identified to increase surface water storages are described below.

- **Increase conservation storage space in Shasta Reservoir by raising Shasta Dam –** This measure consists of increasing the amount of available space for conservation storage in Shasta Reservoir through raising Shasta Dam. A range of potential dam raises has been considered in previous studies, including raises of more than 200 feet. A raise of 6.5 feet is included in the Preferred Program Alternative for the CALFED ROD (2000). Raising Shasta Dam would contribute directly to the primary planning objectives, and previous studies have indicated that raising the dam would be technically feasible. Raising Shasta Dam also could contribute to the secondary planning objectives. In addition, there is likely strong Federal and non-Federal interest in this measure. Therefore, this measure was retained for further development.

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Table 2-3. Management Measures Addressing the Primary Planning Objective of Increasing Water Supply Reliability

Management Measure	Potential to Address Planning Objective	Status/Rationale
Increase Surface Water Storage		
Increase conservation storage space in Shasta Reservoir by raising Shasta Dam	**Very High** – Raising dam directly contributes to increased water supply reliability.	**Retained** – Consistent with primary planning objective and directly contributes to secondary planning objectives.
Construct new conservation storage reservoir(s) upstream from Shasta Reservoir	**Very Low** – Limited potential to effectively contribute to increased system water supply reliability or other planning objectives.	**Deleted** – Upstream storage sites capable of CVP system-wide benefits would be very costly, result in environmental impacts difficult to mitigate, and would be inconsistent with the CALFED ROD.
Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam	**Low** – Several sites/projects, including Auburn Dam Project, have demonstrated an ability to contribute to system water supply reliability.	**Deleted** – Although potentially feasible sites/projects exist that could increase water supply reliability, considerable overriding environmental and socioeconomic issues restrict implementation at this time.
Construct new conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Moderate to High** – Although not as effective as additional storage at Shasta, there is potential for offstream storage projects (NODOS) to contribute to increasing water supply reliability.	**Deleted** – Not as efficient as developing additional storage in Shasta Dam. NODOS being pursued as added increment to system through a separate feasibility-scope study initiated under Public Law 108-361.
Construct new conservation surface water storage south of the Sacramento-San Joaquin Delta	**Moderate** – Potential for surface water storage projects (upper San Joaquin River) to contribute to increasing water supply reliability to CVP primarily in the San Joaquin Valley and Tulare Lake basin area.	**Deleted** – Not an effective alternative to additional storage at Shasta. Does not contribute to other planning objectives. Upper San Joaquin River being pursued as added increment to system through feasibility-scope study initiated under Public Law 108-361.
Increase total or seasonal conservation storage at other CVP facilities	**Moderate** – Would require several projects to contribute to water supply reliability (e.g., raise Folsom and Berryessa).	**Deleted** – Not an efficient alternative to increasing storage in Shasta Reservoir; considerably higher unit cost for increased water supply. Known efforts to increase space in other Northern California CVP (or SWP) reservoirs rejected by CALFED.
Dredge bottom of Shasta Reservoir	**Very Low** – Limited potential to effectively contribute to increases in system water supply reliability or any other planning objective.	**Deleted** – Extremely high cost for very small potential benefit and severe environmental impacts.
Reoperate Reservoir		
Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability	**Moderate to High** – Potential for increment of increased water supply reliability at Shasta Reservoir.	**Retained** – Although potential for increased water supply reliability is limited, added opportunities exist for increased flood control and other management elements.
Increase the conservation pool in Shasta Reservoir by encroaching on dam freeboard	**Very Low** – Very small space increase possible.	**Deleted** – Very limited potential to encroach on existing freeboard above full pool, which is only 9.5 feet. High relative cost to resolve uncertainty issues related to encroachment.
Increase conservation storage space in Shasta Reservoir by reallocating space from flood control	**Low** – Space reallocated to water supply could contribute to increased water supply reliability.	**Deleted** – Very low potential for implementation due to considerable adverse impacts on flood control.
Improve Conjunctive Water Management		
Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Moderate** – Potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Deleted** – Implementing additional surface water storage project increment for Shasta would not be as efficient as new storage in Shasta Reservoir. Potential for shared storage in NODOS project is being considered in separate feasibility study initiated under Public Law 108-7.
Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam	**Moderate to High** – Considerable potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Deleted** –This measure was initially retained for inclusion in concept plans, then eliminated in the comprehensive plans phase due to subsequent operations modeling indicating trade-offs between conjunctive use water supply benefits and critical gains in fisheries accomplishments.
Develop additional conservation groundwater storage south of the Sacramento-San Joaquin Delta	**Moderate** – Potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Deleted** – Not as effective as storage north of the Delta and would not contribute to other study objectives.
Coordinate Operation and Precipitation Enhancement		
Improve Delta export and conveyance capability through coordinated CVP and SWP operations	**Moderate** – Potential to enhance system yield when combined with new storage and reoperation of Shasta.	**Deleted** – Joint point of diversion is being actively pursued in other programs. A likely without-project condition.
Implement additional precipitation enhancement	**Low** – Low potential to provide improvements to drought period water supply reliability.	**Deleted** – Not an effective alternative to new storage. Very limited potential to benefit drought period water supply reliability. Being actively pursued under without-project condition.

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Table 2-3. Management Measures Addressing the Primary Planning Objective of Increasing Water Supply Reliability (contd.)

Management Measure	Potential to Address Planning Objective	Status/Rationale
Reduce Demand		
Implement water use efficiency methods	**Moderate** – Potential to benefit overall State water supply issues.	**Retained** – Although water use efficiency does not add to increased supplies, conservation is being actively pursued through other programs. Conservation needs to be considered as an element of any plan considered in addressing California's future water picture.
Retire agricultural lands	**Moderate** – Would reduce water demand rather than increase ability to meet projected future demands.	**Deleted** – Not an alternative to new storage. Does not address planning objectives and constraints/criteria. Land retirement test programs being performed by Reclamation. On a large scale, could have considerable negative impacts on agricultural industry.
Improve Water Transfers and Purchases		
Transfer water between users	**Very Low** – Does not generate an increase in water supply reliability.	**Deleted** – Not an alternative to new water sources or reliable substitute for new storage at Shasta Reservoir. Will likely be accomplished with or without additional efforts to develop new sources.
Expand Delta Export and Conveyance Facilities		
Expand Banks Pumping Plant	**Moderate** – Potential to help increase water supply reliability south of the Delta.	**Deleted** – Not an alternative to new storage north of the Delta. Does not address planning objectives or constraints/principles/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Construct DMC/CA intertie	**Moderate** – Potential to help increase water supply reliability south of the Delta.	**Deleted** – Not an alternative to new storage north of the Delta. Does not address planning objectives or constraints/principles/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Improve Surface Water Treatment		
Implement treatment/supply of agricultural drainage water	**Very Low** – Very low potential to improve water supply reliability for agricultural uses.	**Deleted** – Not a viable alternative to new water storage. Very high unit water cost.
Construct desalination facility	**Low** – Although growing new source for urban water supplies in State, low potential to address SLWRI planning objectives.	**Deleted** – Not an alternative measure for drought period supplies. Not an alternative to new storage at Shasta. Very high unit water cost.

Key:
CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
DMC/CA = Delta-Mendota Canal/California Aqueduct
NODOS = North-of-the-Delta Offstream Storage
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
ROD = Record of Decision
SLWRI = Shasta Lake Water Resources Investigation
State = State of California
SWP = State Water Project

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- **Construct new conservation storage reservoir(s) upstream from Shasta Reservoir –** This measure consists of constructing dams and reservoirs at one or more locations upstream from Shasta Lake, primarily for increased water conservation storage and operational flexibility. Numerous reservoir storage projects have been considered and many constructed in the watershed upstream from Shasta Lake. Three of the most promising remaining sites include Allen Camp Reservoir (180,000 acre-feet on the Pit River in Modoc County), Kosk Reservoir (800,000 acre-feet on the Pit River in Shasta County), and Squaw Valley Reservoir (400,000 acre-feet on Squaw Valley Creek in Shasta County). These three potential project sites were deleted from further consideration because they (1) would only be capable of marginally improving water supply reliability to the CVP, (2) would not be consistent with screening criteria established in the CALFED Integrated Storage Investigations, (3) would likely not be supported in the local area because the water would need to be developed for CVP system reliability (not retained for local use), and (4) would result in a relatively high unit water cost to implement. In addition to the above three potential projects, an additional offstream storage site at Goose Valley near Burney was suggested to the SLWRI Product Delivery Team during a stakeholder meeting in Redding. A cursory evaluation indicated, however, that at a potential full pool storage of about 230,000 acre-feet, and with a generous estimate of available river flows available for diversion from the Pit River to the site, likely costs to develop the project would exceed water supply benefits by at least 2 to 1. Further, although larger sizes of a project at the Goose Valley site are physically feasible, there is little potential for water to fill the facility. Accordingly, this site was not considered further and this measure was deleted from further consideration in the SLWRI.

- **Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam –** Numerous onstream surface water storage projects along tributaries to the Sacramento River downstream from Shasta Dam have been investigated in past studies. Several projects have potential to contribute considerably to increasing water supply reliability, including the Cottonwood Creek Project (1.6 MAF on Cottonwood Creek north of Red Bluff), the Auburn Dam Project (up to about 2.3 MAF on the Middle Fork American River near Sacramento), and the Marysville Lake Project (920,000 acre-feet on the Yuba River near Marysville). Although each of these potential projects could considerably contribute to increasing the water supply reliability of the CVP and SWP systems, they have been rejected by State and local interests as potential candidates for new water sources. Each was eliminated from further consideration in the SLWRI primarily because they would not contribute to the primary planning objectives or because they would have significant overriding environmental issues and opposition. This measure was deleted from further consideration in the SLWRI.

- **Construct new conservation offstream surface storage near the Sacramento River downstream from Shasta Dam –** Various offstream reservoir storage projects have been evaluated in previous studies. All but one of the offstream reservoir storage projects were eliminated from further consideration in the CALFED ROD, primarily because of project cost considerations, potential environmental impacts, and lands and relocation issues. The one project retained for further consideration in the ROD is Sites Reservoir, with a storage capacity of up to 1.8 MAF. DWR is studying Sites Reservoir and alternatives under the North-of-the-Delta Offstream Storage (NODOS) Project. Sites Reservoir would be filled primarily by water diverted from the Sacramento River and tributaries during periods of excess flows through the Tehama-Colusa Canal, Glenn-Colusa Irrigation District Canal, and/or a new pipeline near Maxwell. Another potential source of water for filling the reservoir is moving (predelivery) Tehama-Colusa Canal Authority and Glenn-Colusa Irrigation District water from Shasta Reservoir during the spring and storing it at Sites Reservoir for delivery during the irrigation season. Reclamation received Federal feasibility study authority for NODOS under Section 215 of PL 108-7 in September 2003. NODOS has the potential to increase the water supply reliability of Sacramento Valley users, the CVP, and SWP; improve Delta water quality; contribute to ecosystem restoration; and provide water to support the Environmental Water Account. The objectives of the NODOS project are different than those of Shasta enlargement; NODOS would not be a substitute for enlarging Shasta Dam and Reservoir and was eliminated from further consideration in the SLWRI.

- **Construct new conservation surface water storage south of the Sacramento-San Joaquin Delta –** A relatively large portion of the CVP's future water needs is located in service areas in the San Joaquin River basin, south of the Delta. In addition, large demands will continue to be made, primarily on the SWP, to provide water for M&I purposes farther south via the California Aqueduct and for increased water supply reliability to the South Bay areas. A portion of these demands could be provided by onstream and/or offstream surface water storage within the San Joaquin River basin. Numerous surface water storage sites have been identified in the past along the east and west sides of the San Joaquin Valley and in areas to the west of the Delta near Stockton.

  Potential onstream storage sites are exclusively located on the east side of the valley due to the lack of substantial annual runoff from the Coast Range. Several potential onstream storage sites could include enlarging Pardee Reservoir on the Mokelumne River, enlarging and modifying

Farmington Dam on Littlejohns Creek, and additional storage on the upper San Joaquin River. Numerous potential offstream storage sites also have been considered in the San Joaquin Valley. Several potential sites have been identified on the east side of the valley and would receive diverted flows from nearby rivers, but most sites are on the west side of the valley and designed to receive pumped water primarily from the California Aqueduct during periods of excess flows. Potential sites would include Los Vaqueros enlargement, Ingram Canyon Reservoir, Quinto Creek Reservoir, and Panoche Reservoir.

All of the potential onstream or offstream storage projects south of the Delta were deleted from further consideration primarily because they would not (1) contribute to the objectives of the SLWRI or (2) be as efficient or effective as additional storage in an enlarged Shasta Reservoir. In addition, feasibility-scope investigations for both Los Vaqueros Reservoir and upper San Joaquin River storage were authorized in Section 215 of Public Law 108-7. Both studies are addressing specific planning objectives that are unique to their geographic areas, but differ from those of the SLWRI.

- **Increase total or seasonal conservation storage at other CVP facilities –** This measure primarily consists of providing additional conservation storage space in other major CVP (and/or SWP) reservoirs in the Sacramento River watershed through enlarging existing dams and reservoirs. Besides Shasta Dam and Lake, projects primarily would include additional storage in facilities such as Lake Berryessa on Putah Creek, Folsom Lake on the American River, Trinity Lake on the Trinity River, and Lake Oroville on the Feather River. It is believed that, of the existing reservoirs in the CVP/SWP systems, increasing water supply reliability through modifying Shasta Dam and Lake would be the most cost-effective. Further, all known efforts to increase storage space in other Northern California CVP (or SWP) reservoirs were rejected by CALFED and local interest groups. For these reasons, and because this measure would not address all SLWRI planning objectives, constraints, principles, and criteria, this measure was deleted from further consideration in the SLWRI.

- **Dredge bottom of Shasta Reservoir –** This measure consists of increasing the total storage space in Shasta Reservoir by excavating either deposited or native materials below full pool elevation. In general, this measure is not practical for large impoundments due to cost; however, it is included here for completeness and because it was a specific request in the environmental scoping process. For comparison purposes, an estimate was made that considered removing 100,000 acre-feet of dredged material from Shasta Reservoir. This volume in Shasta Reservoir would result in approximately 22,000 acre-feet per year of additional drought period yield to the CVP. An increased volume of 100,000 acre-feet is about 160 million cubic yards, or the equivalent volume of the area of a football field over 14 miles high. Excavation costs vary widely depending on the type of material and location of excavation. Soil that is movable by scraper machines can be excavated and dumped locally for about $3 per yard while dredged soil costs much more, over $10 per yard, and rock excavates are about $10 per yard. Assuming that Shasta Reservoir is drawn down and half of the volume is removed by scraper and half by excavation, and then assuming transport and disposal of the material locally at an additional cost of approximately $3 yard, this measure would have a total cost of about $1.5 billion. This cost does not include any real estate costs or expenditures to mitigate for drawing down Shasta Lake or for the disposal of the materials. In addition, the soil and rock could not be sold because no need exists for this quantity of fill, and local fill sources are usually available. The resulting equivalent cost of increasing water supply reliability would be nearly $5,000 per acre-foot. This unit cost is multiple times greater than that of other sources. Accordingly, this measure was deleted from further consideration.

Reoperate Reservoir The three measures described below involve increasing the conservation storage space by altering the operations of Shasta Dam and Reservoir.

- **Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operations for water supply reliability –** This measure consists of changing the flood control operations of Shasta Dam and Reservoir (without reducing the maximum flood pool) with a goal of increasing water supply reliability. This measure would focus on revising the operation rules for flood control such that the facility could potentially be managed more efficiently for flood control, thereby freeing some seasonal storage space for water supply. A primary constraint would be to ensure no adverse impacts to the existing level of flood protection provided by the Shasta Dam project. It is believed that some degree of operational efficiency could be gained through a critical assessment of reservoir operations using more current analytical and weather forecasting tools. Although the potential for increased water supply reliability through reoperation efficiencies for flood control is believed to be limited, this measure was retained for further detailed consideration for possible inclusion in concept plans.

- **Increase conservation pool in Shasta Reservoir by encroaching on dam freeboard –** This measure consists of increasing the conservation storage space in Shasta Reservoir by raising the full pool elevation without raising Shasta Dam. The current full pool elevation at Shasta Dam is 1,067 feet above mean sea level (elevation 1,067) and the top-of-dam elevation is approximately elevation 1,076.5. Accordingly, the design freeboard above maximum water surface elevation is 9.5 feet. It is estimated that major modifications would be required to the dam and appurtenances to allow operational encroachments on the design freeboard of the dam, only to gain a small potential increase in reservoir storage. This measure was deleted from further consideration primarily because it would have low potential to effectively address the planning objective.

- **Increase the conservation storage space in Shasta Reservoir by reallocating space from flood control –** This measure consists of decreasing the maximum seasonal flood control storage space in Shasta Reservoir and dedicating that space to water supply reliability in the CVP. It also includes constructing flood protection features along the Sacramento River to mitigate for potential induced flood damages. The maximum seasonal flood control storage space in Shasta is 1.3 MAF from December 1 through March 20, depending on accumulated seasonal inflow volumes. Reducing seasonal flood control storage space would reduce the ability of the reservoir to control peak flood flow releases. This would result in an increase in the frequency of flooding and flood damages along the Sacramento River downstream from Shasta Dam. This measure was deleted from further consideration in the SLWRI primarily because of its likely adverse impacts on flood controls.

Improve Conjunctive Water Management The following three measures were identified to improve conjunctive water management.

- **Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam –** This measure consists of developing surface water transfer storage capabilities near the Sacramento River downstream from Shasta Dam to use in conjunction with storage in Shasta Reservoir. This storage would be an extension of storage space in Shasta Reservoir. Water temporarily stored or “parked” in the transfer storage facility would be delivered to local CVP contractors in substitution for their current diversions via either the Anderson-Cottonwood Irrigation District facilities or Tehama-Colusa Canal water users facilities. Water not diverted from the water users would remain in the Sacramento River to benefit anadromous fish, for delivery to downstream water users, and/or for Delta water quality. One possibility identified would be to consider some of the space in the Sites Reservoir project, or NODOS, which was previously described as conjunctive use storage for Shasta. This possibility is being considered in studies by DWR. However, development of a separate surface water storage project or space in the Sites Project expressly as part of the SLWRI is believed to be inconsistent with the planning objectives and constraints for the SLWRI. Accordingly, this measure was deleted from further consideration in the SLWRI. It continues to be considered, however, as part of the NODOS project.

- **Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam –** This measure consists of developing groundwater storage near the Sacramento River. Similar to the surface storage measure described above, releases from Shasta Dam would be diverted from the Sacramento River and used to recharge local groundwater rather than be stored in a surface water facility. During drought periods, stored groundwater would be pumped for local uses. This pumped water would be substituted for surface water that would have otherwise been diverted from the Sacramento River during the irrigation season. Several options have been identified. One option would be similar to surface water conjunctive use storage except diverted water would be stored in groundwater basins adjacent to the Sacramento River. However, this option would be very costly because of the amount of land or land rights required. Another option would be to work with existing water contractors in the Sacramento River valley to exchange surface water for in-lieu pumped groundwater, depending on the water year.

  The in-lieu option of this measure was retained primarily because it would have potential to increase water supply reliability and would be consistent with the identified plan formulation constraints and criteria. Also, it would be consistent with CALFED goals for the water storage component of the August 2000 ROD and would not conflict with other planning objectives.

- **Develop additional conservation groundwater storage south of the Sacramento-San Joaquin Delta –** This measure consists of either developing new groundwater recharge projects south of the Delta or contributing to existing recharge projects. It would include diverting flows during periods of excess from the San Joaquin River, Delta-Mendota Canal (DMC), or California Aqueduct and helping recharge depleted groundwater basins. It is believed that this measure would have limited potential to allow storage from modifying Shasta to be temporally stored south of the Delta for later use during critical dry periods. Conjunctively using water in the DMC or California Aqueduct has been pursued in other CALFED programs. These conjunctive use scenarios would not be considerably influenced by added system storage north of the Delta. This measure would not be as effective or efficient as increased storage space in Shasta Reservoir and would not contribute to the other primary planning objective. Accordingly, this measure was deleted from further consideration in the SLWRI because it would not effectively address primary planning objectives of the SLWRI.

Coordinate Operation and Precipitation Enhancement The two measures discussed below involve coordinating operations and precipitation enhancement.

- **Improve Delta export and conveyance capability through coordinated CVP and SWP operations –** This measure primarily consists of improving Delta export and conveyance capability through a more effective coordinated management of surplus flows in the Delta. A specific application of the measure would be the joint point of diversion. Joint point of diversion operations would allow Federal and State water managers to use excess or available capacity in their respective south Delta diversion facilities at the Jones and Banks pumping plants. Currently, little excess capacity exists in the Federal pumps at Jones, but some additional capacity is available in the SWP pumps at Banks. The potential added benefit to CVP through joint point of diversion operations during average and critically dry years would be about 61,000 and 32,000 acre-feet, respectively. This measure is being actively pursued by Reclamation and DWR and it is highly likely that some form of the joint point of diversion will be implemented in the future. This measure was deleted from further consideration in the SLWRI because it would not effectively address the primary planning objectives, and is likely to be implemented, in some form, independent of the SLWRI.

- **Implement additional precipitation enhancement –** Precipitation enhancement is a process by which clouds are stimulated to produce more rainfall or snowfall than they would naturally. This process is accomplished by seeding a cloud with a substance such as silver iodide, an ice-like structure, that encourages water to form ice particles heavy enough to fall out as rain or snow. Precipitation enhancement has been practiced continuously in California since the 1950s for water supply and hydroelectric power purposes. It is estimated that about a 2 to 15 percent increase in annual precipitation or runoff can be achieved by this process. Indications are that precipitation enhancement is highly cost-effective in increased average annual rainfall. It has been determined that this technology likely does not decrease downwind precipitation. However, environmental concerns exist about weather modification.

  It is important to understand that precipitation enhancement is not a short-term remedy for droughts because supply increases can only be achieved during years when it would otherwise rain or snow naturally, meaning in above-average precipitation years. Accordingly, precipitation enhancement is not an alternative to new system storage, which focuses on conserving water in wetter years for use in drier years. In addition, this technology is being pursued under the without-project condition. This measure was deleted from further consideration in the SLWRI primarily because it would not address the planning objectives and is not an alternative to new storage in Shasta Reservoir.

Reduce Demand Measures identified to reduce demand and thus increase water supply reliability are described below.

- **Implement water use efficiency methods –** Water use efficiency methods can help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies remain relatively static, effective use of supplies can reduce potential critical impacts to urban and agricultural resources resulting from water shortages.

  Reclamation is an implementing agency for the CALFED Water Use Efficiency program (CALFED 2000). The Water Use Efficiency Program was developed to support efficient use of water supplies developed by CALFED. The program is comprised of a combination of technical assistance, grants and loans, and directed studies in program areas including: agricultural water conservation, urban water conservation, water recycling, and desalination. The program coordinates with, builds on, and supplements the work of the Agricultural Water Management Council and the California Urban Water Conservation Council. Supporting information for the program is contained in a *2006 Water Use Efficiency Comprehensive Evaluation* for the CALFED Water Use Efficiency Element (CALFED 2006) and the *California Water Plan 2009 Update* (DWR 2009).

  The 2009 *California Water Plan Update* (DWR) also identified a host of agricultural and urban water conservation measures. It is important to note that water "saved" by conservation practices is often water that, without conservation, would return to the hydrologic system and become a supply for other users. Accordingly, conservation does not simply mean reducing consumptive uses for crops in agricultural areas or for dwelling units in urban areas. Truly effective conservation applies when it consists of reducing irrecoverable water, or reducing water use that otherwise would be lost to the hydrologic system. For agricultural uses, examples of irrecoverable water would be (1) water used to leach salts from the soil and subsequently lost to the system through collection and evaporation (2) water lost to excessive evaporation or transpiration, or (3) channel evaporation losses. For urban uses, examples of genuine water conservation would be reducing (1) residential landscape water lost to evaporation or transpiration; (2) commercial, industrial, and institutional losses that are not recoverable; and (3) water distribution system losses or leakage in areas where water would not be recoverable.

The 2006 CALFED document indicated that the potential for recovering currently irrecoverable agricultural losses in the Sacramento and San Joaquin River Basins could be about 142,000 acre-feet on an average annual basis - with resulting unit costs of about $200 per acre-foot. Larger recoveries of currently irrecoverable agricultural losses are technically feasible; however, the costs to achieve these amounts increase considerably. The report also identified various urban water use efficiency programs with the potential of reducing average annual urban water use up to about 1.1 MAF per year by 2030 through a series of best management practices. These practices ranged from potentially cost-efficient regional opportunities likely to be implemented in the future to those requiring grant funding and cost-sharing before they could be implemented. It is estimated that implementation costs (using approaches somewhat similar to those being considered for the surface water storage projects) would exceed about $300 per acre-foot for these reductions. Note that either recovery of irrecoverable agricultural losses, or reductions in urban water use during drought years would be considerably less than in average years. Accordingly, the unit cost for achieving drought period reductions in water use would be considerably greater than the average unit cost above.

Many actions planned under the CALFED Water Use Efficiency program will be accomplished with or without implementation of other projects to address water supply reliability. Future implementation of “Projection Level One” urban and agricultural conservation savings for a without-project condition is included in CALFED Common Assumptions for Water Storage Projects for application in current planning. This level includes continued implementation of best management practices equivalent to those observed during the first 13 years of CALFED. It is estimated that Level One has a potential to reduce future agricultural losses by about 49,000 acre-feet per year and urban demands in the State by about 1.2 MAF per year. Additional water conservation measures will likely play a major role in California’s future water picture. The California Water Plan as well as numerous State and Federal agencies endorse and actively engage in water use efficiency actions. Water use efficiency will constitute a significant element in helping to reduce demands to help offset future shortages in water supplies. Accordingly, water use efficiency was retained as a potential project element to be considered to the extent possible in the implementation of a potential plan of action for the SLWRI.

- **Retire agricultural lands –** Recent studies indicate that by retiring about 150,000 acres from irrigated croplands in the San Joaquin Valley, the demand for irrigation water could be reduced by about 260,000 acre-feet per year under average conditions. It is estimated that in dry and critically dry years, potential savings through this measure could be much reduced from the average annual value because it is during these water-short years that marginal lands are normally allowed to go fallow. Some estimates have placed the drought period demand reduction at between 100,000 and 150,000 acre-feet per year. The estimated construction cost to acquire land rights to permanently retire lands from irrigated agriculture uses amounts to about $500 million, resulting in an equivalent dry-period unit water cost of about $300 per acre-foot. Although the equivalent unit cost of water for this measure may be found competitive with other potential water sources, this measure was deleted from further consideration. This is primarily because of the likely limited ability of this measure to actually address helping meet future water demands in the Central Valley. First, as mentioned, marginal lands are already often allowed to fallow during drought periods. Further, there would be a high degree of uncertainty regarding the institutional ability to acquire sufficient additional land rights necessary to preclude future irrigated agriculture on lands identified for inclusion in a project/program. This especially would be the case if efforts were made to acquire and retire higher productivity lands that may actually lead to water savings during drought periods. Further, there is believed to be a limited ability to successfully apply this measure to lands in the Central Valley at costs similar to those above for less productive lands. Lastly, this measure would not address other planning objectives of the SLWRI.

Improve Water Transfers and Purchases In order to improve water transfers and purchases, the following measure was identified.

- **Transfer water between users –** Water purchases and transfers do not generate new water for the CVP. They simply consist of transferring water between a seller willing to forgo a water use for a time and a willing buyer within the Central Valley. The availability and price of a supply for purchase and used for transfer depends on several factors such as year type, other available supplies, storage capabilities, and transmission capacity. Temporary and long-term (greater than 1 year, as defined by DWR) transfers between water districts have increased from about 80,000 acre-feet in 1985 to over 1.2 MAF in 2001. This trend is expected to continue as the demand for available supplies continues. Only about 20 percent of the transfers are based on agreements greater than 1 year. Most depend on the water spot market. Both Reclamation and DWR also have active water transfer programs and a significant number of water transfers will continue to occur in the future under without-project conditions as available supplies become scarce. Further, the future of the Environmental Water Account depends on the ability to acquire and transfer water through the Delta to mitigate impacts of south Delta pumping curtailment to benefit at-risk fish. Because of these and other projects and actions, and ongoing infrastructure limitations on conveying water from north of the Delta south, it is believed that as water supply demands continue to grow and exceed developed supplies, especially during dry years, and as market conditions change, the cost of water is expected to increase considerably. It is likely that the most feasible and reliable water transfers will be implemented under without-project conditions. Any remaining opportunities for transfers likely would be small, include high uncertainties, be difficult to implement, and be more costly. In addition, water transfers are unlikely to contribute to improving water quality (particularly during dry periods) or provide a less-costly Environmental Water Account replacement supply (transfers are a water acquisition tool already used by the Environmental Water Account). Consequently, this measure was deleted from further consideration primarily because it would not be a long-term reliable substitute for new storage in Shasta Reservoir.

- **Expand Delta Export and Conveyance Facilities –** The two measures in this category would divert surplus water when safe for fish, then bank, store, transfer, and release the surplus water as needed to protect fish and to compensate water users. This could be accomplished by increasing the capacity of conveyance facilities of the CVP and SWP at several locations, as follows:

    - **Expand Banks Pumping Plant –** The current allowable pumping capacity at the SWP Banks Pumping Plant is 6,680 cfs. Efforts are underway by Reclamation and DWR to construct fish protection features under the South Delta Improvements Program to allow increasing the allowable pumping capacity to 8,500 cfs during certain seasonal periods. The maximum installed pumping capacity at Banks is about 10,300 cfs. This measure primarily includes implementing additional physical features and operational improvements aimed at benefiting the overall water quality of the Delta to further increase the allowable pumping capacity at Banks from 8,500 cfs to 10,300 cfs during certain seasonal periods, and splitting the increased pumping capacity equally between the CVP and SWP. This increased capacity would allow more water that otherwise would flow to the Pacific Ocean to be conveyed south of the Delta. It is estimated that the average annual increase in supplies south of the Delta allocated to the CVP could amount to over 100,000 acre-feet. The estimated unit cost for the increase in water supply reliability would be highly efficient when compared with other potential sources of new water supplies. However, because this measure would not contribute to the SLWRI planning objectives or identified plan formulation constraints, principles, and criteria, it was not viewed as a potential alternative to new storage in Shasta Reservoir. Accordingly, it was deleted from further consideration in the SLWRI.

- **Construct Delta Mendota Canal/California Aqueduct (DMC/CA) intertie –** The pumping capacity of the CVP Jones Pumping Plant into the DMC in the south Delta is 4,600 cfs. However, because of land subsidence in the southern reaches of the DMC, the effective capacity is limited to 4,200 cfs. Studies have considered modifying the subsided reach of canal and constructing a new canal parallel to the existing DMC. However, it appears that a more cost-effective measure would be to connect the DMC to the California Aqueduct. In some locations, the two canals are about 400 feet apart horizontally and 50 feet apart vertically. A potential intertie would consist of constructing pumps and a 400 cfs capacity conveyance canal between the two facilities several miles south of the Jones Pumping Plant. It is estimated that this measure would result in an average annual increase in supplies south of the Delta of about 55,000 acre-feet. It is believed that the unit cost for the increase in water supply reliability for this measure would be comparable to other potential sources of new water supplies. However, because this measure would not contribute to the planning objectives of the SLWRI or identified plan formulation constraints, principles, and criteria, it was not viewed as a potential alternative to new storage in Shasta Reservoir. Accordingly, it was deleted from further consideration in the SLWRI.

Improve Source Water Treatment The following two measures were identified to improve source water treatment.

- **Implement treatment/supply of agricultural drainage water –** This measure consists of collecting agricultural drainage from farms along the Sacramento and San Joaquin Rivers and treating the drainage water for reuse. Major elements of this measure likely include an agricultural drainage collection system, pretreatment of drainage water, desalination facilities, ancillary facilities associated with desalination and brine disposal, and conveyance of treated water to end users. In addition, removing total organic carbon and pesticides plus supplementary disinfection may also be required before municipal agencies would consider using the treated agricultural runoff as a potable supply. While this measure may have potential to provide some water supply reliability to urban users, it is far too costly for agricultural users. It would be costly to initially implement and operate, problems would exist relating to brine disposal, and it would likely be unacceptable to stakeholders and the public. Accordingly, this measure was deleted from further consideration.

- **Construct desalination facility –** This measure consists of constructing seawater or brackish surface or groundwater desalination plants to supplement existing water supplies and help offset future demands. There are 23 desalination facilities with a total capacity of about 80,000 acre-feet per year currently operating in California to provide water for municipal purposes. It is estimated that by 2030, a total of 49 desalination facilities with a cumulative capacity of nearly 600,000 acre-feet per year will be in operation in California. Primary elements of any of the facilities include a water intake, pretreatment, desalination, brine disposal, and ancillary facilities for the desalination treatment plant. In addition, a conveyance system is needed to transport the desalinated water to the customer or to the water agency distribution systems. Although technological advances have substantially decreased treatment costs, desalination remains costly compared with most other water sources. Even with continual improvement in membrane technology, energy costs can account for as much as one-half the total cost of desalination.

Desalination is most efficient when used as a base supply because the plants can be better and more cost-effectively maintained if continuously operated, rather than if they are only operated during drought periods. Alternately, if desalination were operated as a base supply in all years, reserving contract water for use during drought periods, less expensive average and wet-year contract water would be forgone in most years. Consequently, desalination by itself would be a highly inefficient option for agencies that rely on multiple water sources or only intend to use desalination as a drought or emergency supply.

Depending greatly on the quality of the source water and the cost of power, desalination today can range from about $700 to several thousand dollars per acre-foot. As mentioned, desalination is energy intensive and, with rising power costs, it is expected to continue to be relatively expensive. Even if the unit cost for a base supply plant were measurably reduced, desalination by itself would likely not be superior to other potential water sources to address the primary planning objective of agricultural water supply reliability in the SLWRI. Accordingly, this measure was deleted from further consideration primarily because it would not be an alternative to new storage in Shasta Reservoir and if it were, its unit costs would be far greater than new supplies from Shasta or other sources.

Measures Retained for Further Consideration

Four of the above management measures to increase water supply reliability were retained for further consideration and possible inclusion in concept plans. Of these four, three were carried forward for inclusion in comprehensive plans. Their major components and accomplishments are described below.

- **Increase conservation storage space in Shasta Reservoir by raising Shasta Dam –** This measure consists of structural raises of Shasta Dam ranging from about 6.5 feet to approximately 200 feet. Chapter 3 includes descriptions of features, accomplishments, major impacts, and costs for various dam raises within this range. Also included in the chapter is a comparison of various dam raise options.

- **Increase effective conservation storage space in Shasta Reservoir by increasing efficiency of reservoir operation for water supply reliability** – This measure consists of modifying the operation of Shasta Dam to improve water supply reliability. It can also assist in improving flood control. Potential methods to improve water supply reliability include modifying rainflood parameters – those which address space for flows from winter rainfall – in the operation rules for Shasta Reservoir and modifying the Shasta Dam release schedule. The goal of the operation changes would be to minimize the required evacuation of the reservoir during the period from about late November through March, and to possibly allow the reservoir to be filled more rapidly in the spring. As mentioned, a primary criterion would be to prevent adversely affecting existing flood protection provided by Shasta Dam and possibly improve it. These possible reoperation opportunities are described in the reference report *Assessment of Potential of Shasta Dam Reoperation for Flood Control and Water Supply Improvement* (Reclamation 2004b).

  Although this measure was retained for inclusion in concept plans, its specific features and their influence on water supply reliability and flood damage reduction would not be developed until detailed operations modeling could be accomplished in further investigations as part of comprehensive alternative plan formulation in the SLWRI.

- **Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam** – This in-lieu conjunctive water management measure primarily consists of using the incremental increase in stored water in Shasta Reservoir to support a shift in the timing of water diversion from the Sacramento River to help increase water supply reliability to other CVP and possibly SWP water users in dry periods. Under this measure, for agricultural interests willing to participate in an in lieu program, during average and wetter years, more surface water from an increased storage space in Shasta Reservoir would be diverted from the Sacramento River and used in-lieu of groundwater pumping. Accordingly, during drought years, less surface water would be delivered to agricultural users, who would depend more on groundwater supplies, allowing more of the normally diverted surface water to be delivered to other users. The in lieu conjunctive water management program would need to include incentives to agricultural users to warrant their participation.

Although this plan was initially retained due to significant water supply benefits, it was eliminated from further development during the comprehensive plan phase. Subsequent operations modeling indicated tradeoffs between conjunctive use water supply benefits and critical gains in fisheries accomplishments. The resulting reduction in benefits to fisheries operations in dry and critical years was deemed unacceptable in terms of meeting primary project objectives.

- **Implement water use efficiency methods –** Water use efficiency methods can help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow, and available supplies remain relatively static, more effective use of supplies can reduce potential critical impacts to urban and agricultural resources resulting from water shortages. The California Water Plan Updates 2005 and 2009 (DWR 2005, DWR 2009) identified a host of urban and agricultural water use efficiency measures. The 2009 plan indicates that water use efficiency measures, although costly and difficult to implement, will play a major role in California's water future. Water use efficiency will constitute a significant element in helping to reduce demands to help offset future shortages in water supplies. Accordingly, water use efficiency was retained for consideration as a potential project element for any plan to be considered for the SLWRI.

Measures to Address Secondary Planning Objectives

Various management measures were identified to address the five secondary planning objectives. For each secondary planning objective, measures were identified and separated into categories. In the following sections, the rationale is discussed for retaining or deleting each measure.

Conserve, Restore, and Enhance Ecosystem Resources

Identifying potential ecosystem restoration opportunities included water management measures to address the secondary planning objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam. Of the 19 management measures identified to address the secondary planning objective of ecosystem restoration, three were retained for possible inclusion in concept plans (see Table 2-4).

It should be mentioned that some of the measures deleted from further consideration in this appendix for the purpose of ecosystem restoration might be determined in further studies to be suitable for helping mitigate potential adverse impacts of comprehensive alternative plans. Further, some measures or expansions of measures retained for further consideration also could be considered for mitigating adverse environmental and related impacts.

Measures Considered

Following is a brief discussion of the measures considered, which are separated into three categories: (1) improving cold-water and warm-water fisheries, (2) restoring and conserving riparian and wetland habitat, and (3) improving other fish and wildlife habitat. Rationale is included in this section for retaining or deleting measures. Also included are additional descriptions of the three measures retained for further consideration.

Table 2-4. Management Measures Addressing the Secondary Planning Objective of Conserving, Restoring, and Enhancing Ecosystem Resources

Management Measure	Potential to Address Planning Objective	Status/Rationale
Enhance Cold-Water and Warm-Water Fishery Habitat		
Construct shoreline fish habitat around Shasta Lake	**Moderate to High** – Contributes to ecosystem restoration goals within watershed.	**Retained** – Would complement measures to increase storage in Shasta Lake.
Construct instream fish habitat on tributaries to Shasta Lake	**Moderate to High** – Contributes to ecosystem restoration goals within watershed.	**Retained** – Would complement measures to increase storage in Shasta Lake. High local interest.
Increase instream flows on the lower McCloud River	**Moderate** – Potential to benefit aquatic resources on lower McCloud River.	**Deleted** – Considerable impacts to hydropower.
Reduce acid mine drainage entering Shasta Lake	**Moderate** – Considerable benefit under certain hydrologic conditions.	**Deleted** – Considerable implementation, O&M, and liability issues.
Reduce motorcraft access to upper reservoir arms	**Moderate** – Potential to benefit fisheries in Shasta Lake.	**Deleted** – Motorcraft management is under the purview of USFS.
Increase instream flows on the Pit River	**Moderate** – Potential to benefit aquatic resources in upper Pit River.	**Deleted** – Considerable impacts to hydropower.
Restore and Conserve Riparian and Wetland Habitat		
Restore riparian and floodplain habitat along the Sacramento River	**High** – Directly contributes to ecosystem restoration along mainstem Sacramento River.	**Retained** – Would be compatible with other primary study objectives. Consistent with other restoration programs and projects in the primary study area.
Restore wetlands along the Fall River and Hat Creek	**Low** – Very low potential to contribute to ecosystem restoration in the Shasta Lake area.	**Deleted** – Considerably removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Conserve upper Pit River riparian areas	**Low** – Very low potential to contribute to planning objective.	**Deleted** – Significantly removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Restore riparian and floodplain habitat along lower Clear Creek	**Moderate** – Indirectly supports planning objective.	**Deleted** – Considerable benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Promote Great Valley cottonwood regeneration on Sacramento River	**Moderate –** Potential to contribute to planning objective.	**Deleted** – High uncertainty for Federal participation and low potential to contribute to primary and other secondary planning objectives.
Conserve riparian corridor along Cow Creek	**Moderate** – Indirectly supports planning objective.	**Deleted** – Considerable benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Remove and control nonnative vegetation in the Cow Creek and Cottonwood Creek watersheds	**Moderate** – Indirectly supports planning objective.	**Deleted** – Considerable benefit to tributaries. Independent action and would not contribute to primary or secondary planning objective conditions along mainstem Sacramento River.
Improve Other Fish and Wildlife Habitat		
Create a parkway along the Sacramento River	**Moderate** – Can contribute to ecosystem restoration in the study area.	**Deleted** – Primarily focuses on land acquisition and conversion to public uses. As a project element, it would be a non-Federal responsibility with little direct Federal interest. Elements are a likely without-project condition.
Enhance forest management practices to conserve bald eagle nesting habitat	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Remove and control nonnative plants around Shasta Lake	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Control erosion and restore affected habitat in the Shasta Lake area	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Develop geographic information system for Shasta to Red Bluff reach	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted –** Would not directly contribute to other primary or secondary planning objectives. GIS mapping likely a without-project condition as part of other ongoing studies and projects.
Implement erosion control in tributary watersheds	**Moderate** – Indirectly supports planning objective.	**Deleted** – Considerable benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions near Shasta Lake or along mainstem Sacramento River.

Key:
GIS = geographic information system
O&M = operations and maintenance
USFS = U.S. Forest Service

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Improve Cold-Water and Warm-Water Fishery Habitat The following measures were identified to improve cold-water and warm-water fishery habitat.

- **Construct shoreline fish habitat around Shasta Lake –** Many of the shallow, warm-water areas along the shoreline of Shasta Lake are capable of providing preferred habitat for juvenile fish and other adult resident fish species. The shorelines of most natural lakes and water bodies are lined with trees, rocks, debris, and other structures that provide cover. However, the shoreline of Shasta Lake is comparatively barren, which increases juvenile mortality. The lack of shoreline cover and suitable shallow-water fish habitat is due to several factors, including steep topography, soils, wave action, and seasonal water fluctuations in the lake. These factors cause erosion and prevent vegetation from becoming established within the lake drawdown area. This measure consists of improving shallow, warm-water habitat around the shoreline of Shasta Lake by planting resistant vegetation and placing large woody debris, boulders, and other aquatic "cover" structures within the drawdown area of the lake. This measure would not be universally applicable. It would be considered only at locations where the physical parameters (soils, slopes, existing vegetation, etc.) would allow. This measure would support the secondary planning objective of conserving and restoring ecosystem resources in the Shasta Lake area. It would not conflict with any other ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects in the vicinity of Shasta Lake. This measure was retained for potential inclusion in concept plans primarily because it would be compatible with potential measures to raise Shasta Dam; habitat treatments could be extended, as needed, into the additional drawdown area.

- **Construct instream fish habitat on tributaries to Shasta Lake –** Tributary streams are an important environmental resource in the primary study area, supporting a variety of native and nonnative fish and other aquatic organisms. However, the quality and quantity of instream aquatic habitat has decreased over the last century because of the construction of dams, modification of stream hydrology, and other human influences. This measure consists of improving and restoring instream aquatic habitat on the lower reaches of key tributaries to Shasta Lake using various structural techniques to enhance fish passage and improve overall aquatic connectivity. It would not conflict with other known programs or projects in the vicinity of Shasta Lake. This restoration measure was retained for further consideration primarily because it would be compatible with potential measures to raise Shasta Dam and with other potential ecosystem restoration measures.

- **Increase instream flows on the lower McCloud River –** This measure consists of increasing releases from McCloud Dam for the purpose of increasing flows on the lower McCloud River. This measure would benefit fisheries on the lower McCloud River. Currently, McCloud Dam operations are part of the Pit-McCloud Hydroelectric Project. Water is exported from the McCloud River watershed through a tunnel to Iron Canyon Reservoir and from there to a powerhouse on the Pit River. Dam operations maintain minimum flows between 40 and 50 cfs on the lower McCloud River. This measure was deleted from further consideration for addressing the objective of ecosystem restoration primarily because of the considerable adverse impact on hydropower generation. However, it is a good example of a measure that may be reconsidered in the future to help mitigate adverse impacts.

- **Reduce acid mine drainage entering Shasta Lake –** This measure consists of remediating the residual adverse environmental impacts of abandoned former mining operations on aquatic conditions in Shasta Lake and its tributaries. This measure was deleted from further consideration because of numerous implementation issues, including high operations and maintenance (O&M) requirements necessary for success and liability issues. This measure may be reconsidered in the future to help mitigate adverse impacts.

- **Reduce motorcraft access to upper reservoir arms –** This measure consists of imposing additional boating and personal watercraft restrictions on portions of Shasta Lake. This measure was eliminated from further consideration primarily because motorcraft activity on Shasta Lake is already regulated by Federal and State boating laws, Shasta County, and USFS; additional regulations (if applicable) would be more appropriate as part of these existing programs.

- **Increase instream flows on the Pit River –** This measure consists of increasing instream flows on the lower Pit River to benefit native fish and aquatic habitat through performing power buy-outs, altering power generation operations, or removing selected water diversions or diversion facilities. This measure was eliminated from further consideration primarily because of the considerable adverse impact on hydropower generation from these existing facilities.

Restore and Conserve Riparian and Wetland Habitat Seven measures were identified to restore and conserve riparian and wetland habitat. Each measure is described below.

- **Restore riparian and floodplain habitat along the Sacramento River –** Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that improve the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. These areas are seasonally flooded on a frequent basis, interacting with dynamic river processes such as erosion and deposition. Riparian and floodplain terrace habitat along the Sacramento is limited between Keswick Dam and Red Bluff. This is partially due to the natural topography and hydrology of the region; the Sacramento River is naturally more entrenched in this reach, and floodplains are narrow compared with the broad alluvial floodplains found lower in the Sacramento River system. This measure consists of restoring riparian and floodplain habitat at specific locations along the Sacramento River to promote the health and vitality of the river ecosystem. It would not conflict with other ecosystem restoration measures that were preliminarily retained or with other known programs or projects on the upper Sacramento River. The restoration would support the goals of the Sacramento River Conservation Area Forum, CALFED, and other programs associated with riparian restoration along the Sacramento River. This measure was retained for further consideration primarily because it would have a high likelihood of success in accomplishing effective restoration and would indirectly benefit aquatic habitat conditions for anadromous fish.

- **Restore wetlands along the Fall River and Hat Creek –** This measure consists of restoring marshlands and wetlands along the Fall River and Hat Creek in the Pit River watershed. This measure was deleted from further consideration primarily because it is an independent action and would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Conserve upper Pit River riparian areas –** This measure primarily consists of conserving high-value existing stands of riparian vegetation along the upper Pit River through acquiring environmental easements, and installing fencing and natural vegetation barriers around riparian corridors affected by grazing animals. This measure was deleted from further consideration primarily because it is an independent action and would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Restore riparian and floodplain habitat along lower Clear Creek –** This measure includes restoring floodplain and riparian habitat along lower Clear Creek. This measure was deleted from further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Promote Great Valley cottonwood regeneration on the Sacramento River –** This measure consists of actively supporting the Great Valley cottonwood regeneration concept along the Sacramento River. This includes working to replace lost floodplain sediment, recontouring floodplains that have disconnected from the river, and revegetating floodplain areas that could support Great Valley cottonwoods. This measure was deleted from further consideration primarily because (1) there would be major complexities associated with continuing Federal participation in an ongoing broad-scope program in the Sacramento Valley, and (2) it would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Conserve riparian corridor along Cow Creek –** This measure consists of protecting and conserving the riparian corridor along Cow Creek. It primarily includes acquiring environmental easements, installing livestock fencing, developing natural vegetation barriers, and replanting streamside grasses, shrubs, and trees. This measure would not directly contribute to improved ecological conditions along the upper Sacramento River. This measure was deleted from further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Remove and control nonnative vegetation in the Cow Creek and Cottonwood Creek watersheds –** This measure consists of abating exotic vegetation in the Cow Creek and Cottonwood Creek watersheds through removing invasive species from riparian corridors. Periodic monitoring and reapplication of control measures would be required to maintain long-term benefits and effectiveness. In addition, this measure would likely have a limited ability to provide consistent and reliable benefits, compared with the other measures proposed. This measure was deleted from further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.

Improve Other Fish and Wildlife Habitat The following measures were identified to improve other fish and wildlife habitat.

- **Create a parkway along the Sacramento River –** Interest is growing in conserving public access to area rivers, lakes, streams, and other natural resources, and protecting their recreational, environmental, and aesthetic values. For instance, local groups have successfully established public parks and other ecosystem-focused conservation areas around Redding. This measure consists of establishing a natural, riverfront parkway along the Sacramento River near the Redding and Anderson urban areas to conserve riparian and floodplain habitat and promote habitat continuity along the river corridor. While this restoration would support the goals of the Sacramento River Conservation Area Forum, CALFED, and other programs, it is primarily focused on acquisition of lands and land rights, and converting existing uses to those supporting public uses. Because of the high focus on land acquisition, there would be little known Federal interest and small potential to contribute to the primary or other secondary planning objectives of the SLWRI. In addition, elements of this measure are being implemented as part of other programs, and this measure is likely a without-project condition. Accordingly, this measure was deleted from further consideration in the SLWRI.

- **Enhance forest management practices to conserve bald eagle nesting habitat –** This measure consists of enhancing bald eagle nesting habitat at various locations around Shasta Lake through forest management practices, including thinning, applying insecticides to reduce mortality from bark beetles and other pests, control stocking in conifer stands to encourage growth of large trees, and managing underbrush to protect important stands from wildfires. This measure was deleted from further consideration primarily because it is a likely without-project condition.

- **Remove and control nonnative plants around Shasta Lake –** This measure consists of removing and controlling nonnative species at various locations around Shasta Lake primarily through herbicides, physical removal, or controlled burning. This measure was deleted from further consideration primarily because it is a likely without-project condition. Also, it is similar to programs being implemented in the study area by USFS.

- **Control erosion and restore affected habitat in the Shasta Lake area –** This measure consists of restoring highly erodible lands in the Sacramento River and Pit River watershed near Shasta Lake that have been impacted by timber harvest, historic smelter blight, and other human activities. This measure was deleted from further consideration primarily because it is a likely without-project condition. Also, it is similar to programs being implemented in the study area by USFS.

- **Develop geographic information system for Shasta to Red Bluff reach –** This measure consists of developing a geographic information system (GIS) for the Sacramento River and tributaries between Shasta Dam and Red Bluff. This measure was deleted from further consideration primarily because (1) it would not directly contribute to accomplishing the primary planning objectives and (2) GIS-based mapping is being developed by numerous regional studies and local entities.

- **Implement erosion control in tributary watersheds –** This measure consists of implementing local erosion control projects in watersheds tributary to the Sacramento River to prevent loss of key floodplain and riparian habitat, and to conserve the quality of aquatic habitat impaired by excessive sediment input. This measure was deleted from further consideration as a potential restoration element primarily because it would not contribute to improved ecological conditions near Shasta Lake or along the upper Sacramento River and would not directly contribute to accomplishing the primary or other secondary planning objectives.

Measures Retained for Further Consideration

Each of the three management measures retained to address the secondary objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam were considered in greater detail to determine how they might become components of concept plans. The locations of the retained measures are shown in Figure 2-6 and described below in terms of their major components, and accomplishments.

- **Construct shoreline fish habitat around Shasta Lake –** The shorelines of most natural lakes and water bodies are lined with trees, rocks, debris, and other structures that provide aquatic cover. But the shoreline of Shasta Lake and other reservoirs is comparatively barren, increasing juvenile fish mortality. The lack of shoreline cover and suitable shallow water fish habitat is due to several factors, including the steep topography, soils, wave action, and seasonal water fluctuations in the reservoir. These factors cause erosion and prevent vegetation from becoming established within the reservoir drawdown area. In addition, large woody debris entering the lake from its tributaries is removed annually due to boating concerns. Shallow, warm-water areas along the shoreline of Shasta Lake provide preferred habitat for juvenile fish and other adult resident fish species. This measure would improve shallow, warm-water fish habitat at specific locations around the shoreline of Shasta Lake using resilient vegetation and aquatic "cover" structures within the upper drawdown area of the lake.

  This measure would involve (1) installing artificial fish cover, including complex woody structures, (2) planting water-tolerant and/or erosion-resistant vegetation at prescribed locations within the reservoir drawdown area, and (3) performing selective reservoir rim clearing of specific trees and vegetation. Applications would be chosen, as appropriate, for site-specific shoreline conditions, taking into consideration bank slope, rate of erosion, proximity to tributaries, soils, and the presence of existing cover or vegetation. It is estimated that about 20 structures and approximately 400 selective plantings would be required for each acre of shoreline restored. The estimated life of the artificial cover structures could depend on the type of structure.

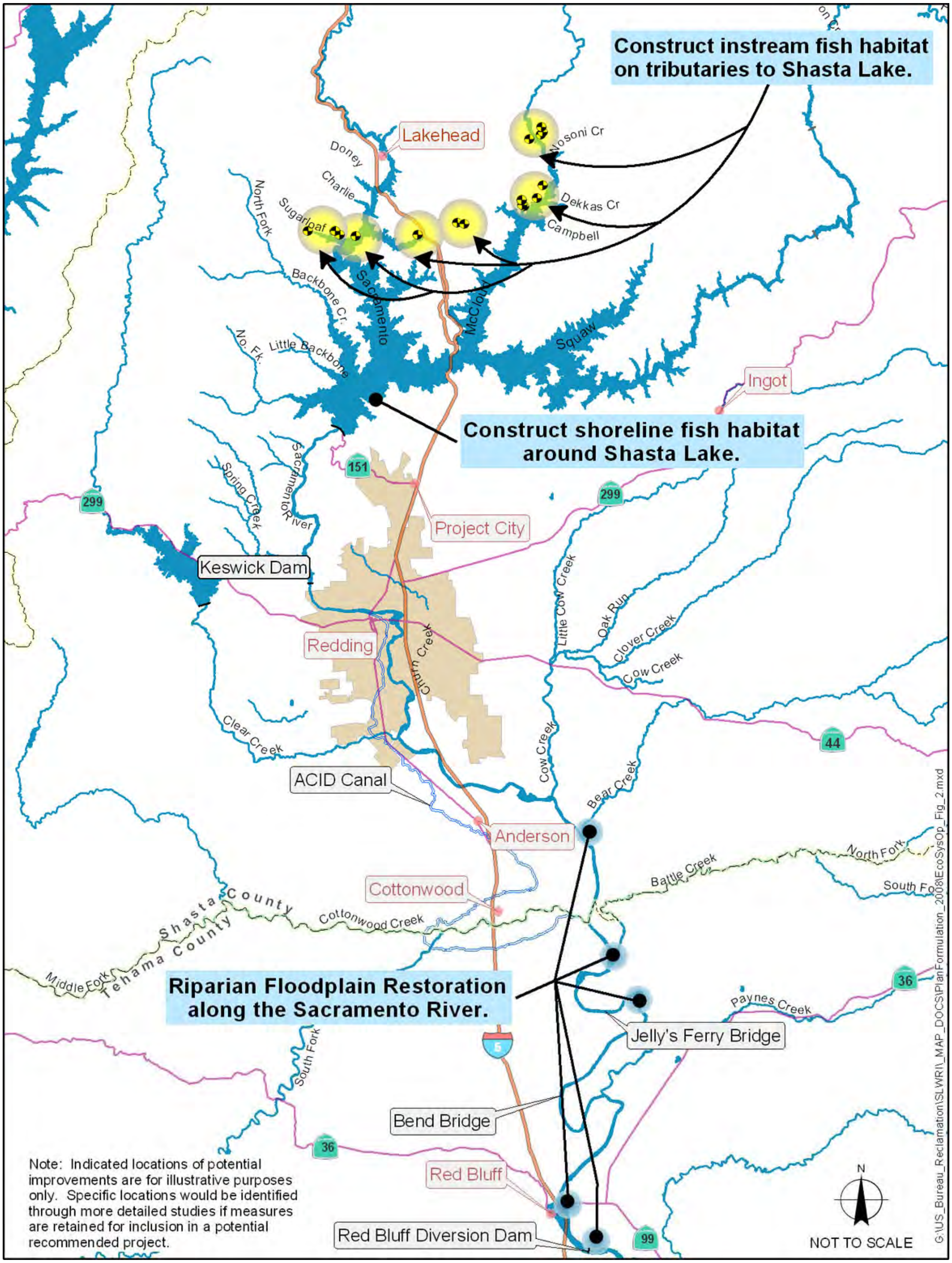

Figure 2-6. Measures Retained to Address Secondary Planning Objective – Ecosystem Restoration

It is estimated that locations near the mouths of tributaries would be targeted for restoration because their lower reaches provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Further, fishermen and other recreational users favor the mouths of tributaries. Shoreline areas with gradual slopes provide a wider, shallow-habitat area and would be more appropriate than steep banks that are prone to accelerated erosion. In addition, the sites would need to be undeveloped, provide reasonable construction access, and not be subject to considerable recreational disturbances (i.e., adjacent to marinas, picnic areas, campgrounds, or other areas that attract large numbers of people). Several major and minor tributaries to Shasta Lake appear to have a high potential for application of this measure. For the purpose of this initial evaluation, it is estimated that sites at the mouths of eight perennial tributaries would be selected with approximately 5 acres of shoreline suitable for restoration at each site. Other areas also may have a high potential and would be evaluated in future studies.

Major accomplishments of this measure would be to (1) increase the survival of juvenile fish by improving the quantity of available cover and overall quality of shallow-water habitat, and (2) benefit land-based species that inhabit the shoreline of Shasta Lake through establishing resilient vegetation. This measure would support the secondary planning objective of conserving and restoring ecosystem resources in the Shasta Lake area. Increased shallow-water fish survival also would enhance recreational sportfishing opportunities in the lake.

Potential measures to raise Shasta Dam would increase the reservoir drawdown area that is subject to erosion and other factors that diminish shoreline habitat. This measure would complement measures to raise Shasta Dam because shoreline habitat treatments could be extended, as needed, into the additional drawdown area. This measure does not conflict with any other ecosystem restoration measures that were preliminarily retained, nor does it conflict with other known programs or projects in the vicinity of Shasta Lake.

The estimated certainty of the measure in achieving its intended accomplishments is moderate, primarily because numerous factors affect the sustainability of habitat within the drawdown area of the lake. An adaptive management approach that would monitor and modify restoration elements would improve the likelihood of success.

- **Construct instream fish habitat on tributaries to Shasta Lake –** Tributary streams are an important environmental resource in the primary study area, supporting a variety of native and nonnative fish and other aquatic organisms. However, the quality and quantity of instream aquatic habitat has decreased over the last century because of construction of dams, modification of stream hydrology, and other human influences. The quantity and quality of aquatic habitat in the tributaries of Shasta Lake are influenced primarily by the presence of road crossings and culverts, although in some cases other structures or grade controls (e.g., transitional deltaic deposits) may constitute barriers to aquatic connectivity, including fish passage. Barriers may also be created by adverse water quality conditions, particularly high water temperature or toxic materials. This measure would conserve and/or restore instream aquatic habitat on the lower reaches of key tributaries to Shasta Lake (see Figure 2-6).

Two categories of potential aquatic habitat enhancement in tributaries are discussed below: (1) identifying and correcting barriers to fish passage that are critical to various life stages for native fish species, particularly at culverts and other human-made barriers, and (2) identifying and implementing feasible aquatic habitat improvements intended to conserve or restore degraded aquatic and riparian habitat in tributaries to Shasta Lake.

Fish passage improvements include restoring and/or enhancing a minimum of five perennial stream crossings to help enable upstream and downstream passage for all life stages of native fish in Shasta Lake. Barriers to fish passage in the watersheds above Shasta Lake are primarily associated with culverts or other types of stream crossings. Typical passage problems created by culverts and other road crossings are as follows:

- Excessive drop at the downstream end of a crossing (perched outlet)
- Water velocities within the crossing that are too fast for fish to swim upstream
- Constriction of flow as it enters a crossing, causing excessive water velocities and turbulence at the inlet
- Lack of sufficient water depth in a culvert for fish to swim
- Debris accumulation across an inlet or within a culvert

Aquatic habitat restoration includes efforts to reestablish or enhance aquatic connectivity, and reestablish or conserve riparian vegetation needed to provide shade, cover, and organic material. Additionally, aquatic habitat restoration includes reducing sediment and other pollutants associated with roads and other human-made disturbances from discharging into streams flowing into Shasta Lake. These opportunities are consistent with recommendations developed in watershed assessments prepared by the Shasta-Trinity National Forest for lands in close proximity to Shasta Lake. The watershed assessments identify roads, specifically stream crossings, as opportunities for enhancing aquatic connectivity and reducing the impacts of road-related sediment on aquatic habitat. As with other elements of the aquatic enhancement program, it is anticipated that additional site evaluations would be conducted to prioritize opportunities based on available funding.

The lower reaches of intermittent and perennial streams tributary to Shasta Lake that support aquatic organisms native to the upper Sacramento River would be targeted for aquatic restoration under this measure because they provide year-round fish habitat. Although up to nearly 20 miles of stream could be considered for this measure, initial implementation would likely be restricted to larger tributaries, after which the potential to expand to smaller tributaries could be assessed. For this measure, it is estimated that instream aquatic restoration would be performed along a total of 8 miles of stream, or about 2 miles along the lower reaches of each of the four major tributaries to Shasta Lake. It is estimated that many of the restoration activities would be conducted on Federal lands.

Major accomplishment of this measure would be to improve the quality and availability of aquatic habitat on tributary streams. This measure would support the secondary planning objective of conserving and restoring ecosystem resources in Shasta Lake. Both native and nonnative fish would benefit, including some lake fish that spawn on the lower reaches of the tributaries. It could also benefit steelhead, a native species that must be planted in the lake annually, as some natural reproduction occurs on the lower reaches of the tributaries to Shasta Lake. Improving aquatic habitat also would enhance recreational sportfishing opportunities in the area.

This restoration measure would complement potential efforts to restore shoreline fish habitat in Shasta Lake because many juveniles that use shoreline habitat hatch on the lower reaches of the tributaries. Thus, improving and restoring aquatic habitat on the tributaries would increase the number of juveniles entering Shasta Lake. This measure would be compatible with potential measures to raise Shasta Dam and does not conflict with any other ecosystem restoration measures that were preliminarily retained. This measure does not conflict with other known programs or projects in the vicinity of Shasta Lake.

The estimated certainty of this measure in achieving its intended accomplishments is high. Most of the major tributaries to Shasta Lake are highly regulated, reducing the potential for improvements to be damaged or destroyed during extreme flow events. Similar activities have been accomplished with success on other similar stream systems. DFG, the Cantara Trust, and the Coordinated Resource Management Plan group have participated in similar restoration activities in Shasta County. Restoration actions should be coordinated with local restoration groups, tribes, landowners, and DFG, as appropriate.

- **Restore riparian and floodplain habitat along the Sacramento River –** Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that improve the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. These areas are seasonally flooded on a frequent basis, interacting with dynamic river processes such as erosion and deposition. Riparian and floodplain terrace habitat along the Sacramento River is limited between Keswick Dam and Red Bluff. This measure consists of restoring riparian and floodplain habitat at specific locations along the Sacramento River to promote the health and vitality of the river ecosystem (see Figure 2-6).

  This measure would involve acquiring and revegetating floodplain terraces and adjacent riparian areas with native plants. Suitable locations for restoration would be in areas with a 20 percent to 50 percent chance of flooding in any year (commonly referred to as 2-year to 5-year floodplains). Locations near the confluences of perennial creeks and streams tributary to the Sacramento River would have potential to provide maximum benefits. Continuity is also important to the health and vitality of riparian areas; small, isolated patches of riparian habitat tend to be less productive than larger, continuous stretches of habitat. It is estimated that a limited amount of land contouring and imported fill material would be required at several locations where the historic floodplain has been disconnected from the river or disturbed by human activity.

  For the purpose of this preliminary evaluation, it is estimated that a total of 500 acres would be restored at one or more sites. Planting mix, composition, and density would be determined by a more detailed site analysis, but could include native cottonwood, willow, box elder, valley oak, western sycamore, elderberry, and a variety of understory brush species. Temporary irrigation would be provided on an as-needed basis. The revegetated areas are expected to develop into self-sustaining riparian habitats within 1 to 4 years of initial planting, based on results of previous riparian restoration projects along the Sacramento River. Regraded floodplain areas are expected to change over time depending on hydrologic conditions, but it is anticipated that no elements of this measure would need to be replaced or reapplied during the 50-year project life. The site would be fenced to reduce the potential for access by livestock.

This measure would involve land acquisition, floodplain contouring and other earthwork, and revegetation. There appears to be local support for this type of restoration project along the Sacramento River. The primary accomplishment of this measure would be to restore native riparian habitat and associated floodplain lands. This measure would support the secondary planning objective of conserving and restoring ecosystem resources along the upper Sacramento River. Riparian habitat contributes to species diversity, water quality, and the quality of instream aquatic habitat, providing shade and a source of woody debris. In this manner, this measure indirectly supports the primary planning objective of increasing the survival of anadromous fish on the Sacramento River. The estimated certainty of this measure achieving the intended accomplishments is very high. Similar restoration projects along the Sacramento River have provided favorable, sustainable results.

This measure would combine favorably with potential measures to modify Shasta Dam because operational changes could benefit the natural riverine processes that drive sustainable riparian habitat regeneration. This measure would not conflict with other ecosystem restoration measures preliminarily retained, or other known programs or projects on the upper Sacramento River. Restoration would support the goals of the Sacramento River Conservation Area Forum, CALFED, and other restoration programs.

Reduce Flood Damage

Of five management measures identified to help reduce flood damages and contribute to public safety along the Sacramento River, two were initially retained for further development and possible inclusion in concept plans (Table 2-5). Of those two initially retained measures, one was carried forward for incorporation in comprehensive plans. Following is a brief description of the measures and rationale for retaining or deleting measures.

Table 2-5. Management Measures Addressing the Secondary Planning Objectives of Reducing Flood Damage, Developing Additional Hydropower Generation, Maintaining and Increasing Recreation, and Maintaining or Improving Water Quality

Management Measure	Potential to Address Planning Objective	Status/Rationale
Reduce Flood Damage		
Update Shasta Dam and Reservoir flood management operations	**Moderate to High** – Directly contributes to planning objective.	**Retained** – Compatible with any potential modification of Shasta Dam and Reservoir. Potential to realize an increase in flood control with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning constraints/criteria.
Increase flood management storage space in Shasta Reservoir	**Moderate** – Considerable potential to further reduce peak flows on upper Sacramento River; however, low potential to reduce flood damages due to the relatively high level of protection from existing facilities.	**Deleted** – Would conflict with the primary planning objectives. Estimated low potential for economic justification (costs are expected to exceed benefits). For increased space via raising Shasta Dam, it is expected that dam raise construction costs would considerably exceed flood control benefits. For space increase through reoperation, expected costs to replace reduction in water reliability would also considerably exceed flood control benefits.
Implement nonstructural flood damage reduction measures	**Moderate** – Partially contributes to planning objective.	**Deleted** – Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Implement traditional flood damage reduction measures	**Moderate** – Partially contributes to planning objective.	**Deleted** – Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Route PMF from top of conservation pool	**Moderate to High** – Directly contributes to public safety issues at Shasta Dam.	**Deleted** – This measure already is consistent with existing reservoir conditions and operations, making further changes unnecessary.
Develop Additional Hydropower Generation		
Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head	**Moderate to High** – Directly contributes to planning objective.	**Retained** – Potential to realize an increase in hydropower output from Shasta with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning constraints/criteria.
Construct new hydropower generation facilities	**Moderate** – Directly contributes to planning objective.	**Deleted** – This measure would directly contribute to the secondary planning objective but it is an independent action and not directly related to accomplishing the primary planning objectives. Although potential to realize additional hydropower benefits with increased/replaced hydropower facilities, could be pursued regardless of primary planning objectives.

Table 2-5. Management Measures Addressing the Secondary Planning Objectives of Reducing Flood Damage, Increasing Hydropower, Maintaining and Increasing Recreation, and Maintaining or Improving Water Quality (contd.)

Management Measure	Potential to Address Planning Objective	Status/Rationale
Maintain and Increase Recreation Opportunities		
Maintain and enhance recreation capacity, facilities, and opportunities	**High** – Would directly contribute to planning objective.	**Retained** – Considerable potential to be added to alternatives to directly benefit recreation.
Develop new NRA recreation plan	**Low to Moderate** – Although contribute to planning objective, likely scope would be much greater.	**Deleted** – Developing a new NRA recreation plan is a completely separate process and should be pursued under that process. Scope is far beyond recreation being added as an increment to a water resources plan with the identified primary planning objectives for SLWRI.
Reoperate reservoir for recreation	**High** – Would directly contribute to planning objective.	**Retained** – Considerable potential to be added to alternatives to directly benefit recreation.
Maintain or Improve Water Quality		
Improve operational flexibility for Sacramento-San Joaquin Delta water quality by increasing storage in Shasta Reservoir.	**Moderate** – Would contribute to secondary planning objective	**Retained** – Potential to contribute to the secondary planning objective of maintaining or improving water quality conditions in the Sacramento River downstream from Shasta Dam and the Delta.

Key:
NRA = National Recreation Area
PMF = probable maximum flood
SLWRI = Shasta Lake Water Resources Investigation

- **Update Shasta Dam and Reservoir flood management operations –** This measure consists of revising the established rules for operating Shasta Dam and Reservoir for flood management. This measure would include reassessing existing seasonal flood control storage space needs at Shasta using updated information on regional hydrologic and meteorological conditions and rainfall/runoff characteristics in the drainage basin. Potential methods to improve flood control would include improved long-range weather forecasting, implementing additional forecast-based reservoir drawdown to provide additional space for anticipated high-flow events, changing criteria regarding the rate of outflows from Shasta Dam for flood control, and modifying target peak flows at Bend Bridge. This measure was retained for further consideration primarily because it would be compatible with any potential modification of Shasta Dam and Reservoir. It would not conflict with other secondary planning objectives, planning constraints, or criteria. As with reoperation for water supply reliability, although the concept of this measure is being retained for further development, its specific features and their influence on water supply reliability and flood damage reduction would not be developed until detailed operational modeling can be accomplished in further investigations as part of detailed alternative plan formulation in the SLWRI.

- **Increase flood management storage space in Shasta –** This measure consists of increasing the flood control storage space in Shasta Reservoir primarily through raising the dam or reducing water conservation storage space. A variation would be to substitute water conservation storage space in Shasta with storage in another reservoir, such as the NODOS project, and use vacant seasonal space in Shasta for increased flood control. However, it is estimated that potential flood damage reduction benefits to be gained from either action would be far less than the costs to create increased storage space, either in Shasta Reservoir or other facilities. For increased space resulting from raising Shasta Dam, it is estimated that the cost to raise the dam would considerably exceed potential flood control benefits. For space increase through reoperation, the expected costs to replace reduction in water reliability would also considerably exceed flood control benefits. This measure was deleted from further consideration primarily because it would likely conflict with the primary planning objectives. In addition, it would not be economically feasible (costs are expected to exceed benefits).

- **Implement nonstructural flood damage reduction measures –** Typical nonstructural (or nontraditional) flood damage reduction measures can include (1) flood-proofing (temporary or permanently closing structures, raising existing structures, and constructing small walls or levees around structures), (2) floodplain evacuation (moving structures and their contents to safer sites), (3) development of restrictions (restricting future building in flood-prone areas), and (4) flood warning (flood forecasting, warning, evacuation, and post-flood reoccupation and recovery). This measure was deleted from further consideration primarily because it is an independent action and would not be directly related to accomplishing the primary or other secondary planning objectives. Also, programs are already in place through Federal and State agencies to address flood hazard mitigation.

- **Implement traditional flood damage reduction measures –** Various structural methods to reduce flood damages include constructing levees or modifying the flood-carrying capacity of a river system. This measure was deleted from further consideration primarily because it is an independent action and would not be directly related to accomplishing the primary or other secondary planning objectives. Also, programs are already in place through Federal and State agencies to address flood hazard mitigation.

- **Route Probable Maximum Flood from top of conservation pool –** Shasta Dam can safely pass the computed Probable Maximum Flood (PMF). However, routing the PMF from the top of the conservation pool (4.5 MAF) would provide an additional margin of public safety in the event of an extremely rare flood event approaching or equaling the PMF. This measure was initially retained for development in concept plans, then deleted from further consideration during the comprehensive plan phase. Subsequent evaluation showed that existing reservoir operations and conditions already were consistent with this measure, making it unnecessary.

Develop Additional Hydropower Generation

Two measures were considered to increase hydropower potential in the study area (see Table 2-5). Following is a brief description of each measure:

- **Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head –** This measure consists of modifying the hydropower generation facilities at Shasta Dam to take advantage of any increases in water surface elevations resulting from enlarging the dam, if applicable. Nearly all releases from Shasta and Keswick Dams are made through their generating facilities. On occasion, however, outflows during flood operations are made through the flood control outlets and over the spillway. During these instances, the existing powerplant is bypassed for much of the flood control (space evacuation) release. Power generated during these brief and infrequent periods generally has a lower value due to usually abundant supplies during winter periods. Raising Shasta Dam would allow the potential to reduce these flood releases in winter and allow water to pass through the generators later in the year when the water is usually more valuable. Further, with higher water surface elevation, greater energy levels (head) would be available for operating the turbines. With the greater total head, the existing power facilities, including turbines and penstocks, may need to be replaced, especially with large dam raises (e.g., 100- or 200-foot raises). This measure was retained for consideration as part of concept plans that include modifying Shasta Dam.

- **Construct new hydropower generation facilities –** This measure consists of constructing new hydropower facilities at Shasta Dam to increase the electrical generation capabilities from the project. This measure was deleted from further consideration primarily because it would not contribute either directly or indirectly to addressing the primary planning objectives and because it can be accomplished independently of modifying Shasta Dam and Reservoir.

Maintain and Increase Recreation Opportunities

Recreation is not a specific purpose to the Shasta Division of the CVP. No formal recreation facilities were developed as part of the original project. However, in Public Law 89-336 (8 November 1965), Congress established the Whiskeytown-Shasta-Trinity National Recreation Area (NRA). Resulting from that act and subsequent direction, nearly all lands surrounding Shasta Lake that were acquired for the construction and operation and maintenance of Shasta Dam and Reservoir are now within the NRA. Recreation-related activities on these lands and on Shasta Lake are administered by USFS under its responsibility to manage the NRA.

Increasing the storage in Shasta Lake would provide a larger water surface for recreation than exists today. Conversely, the larger lake area would also adversely impact some of the existing facilities and activities. It is believed that Reclamation has the authority to increase the size of Shasta Dam and Reservoir without the requirement to mitigate for adverse impacts to the existing Federal recreation-related facilities. However, doing so would be counterproductive to the planning objectives of maintaining and increasing recreation opportunities at Shasta Lake. In addition, raising Shasta Dam and Reservoir would also provide opportunities to improve recreation resources in the area.

Accordingly, the following general measures were identified to help maintain and increase recreation opportunities at Shasta Lake:

Maintain and Enhance Recreation Capacity, Facilities, and Opportunities

Major recreation activities at Shasta Lake include the following:

- Water skiing/wakeboarding
- Using personal watercraft
- Fishing

- Houseboating
- Canoeing/kayaking
- Swimming

Water-related land activities include the following:

- Camping
- Hiking and backpacking
- Wildlife viewing
- Picnicking
- Interpretive program

Recreation is not a specific purpose of the Shasta Division of the CVP, and no formal recreation facilities were developed as part of the original project. However, in 1965, Congress established the Whiskeytown-Shasta-Trinity NRA. As a result of that act and subsequent direction, USFS manages recreation within the NRA, which includes managing numerous water resources and related recreation activities at Shasta Lake. Increasing the storage in Shasta Lake would provide a larger water surface for recreation.

This measure would focus on maintaining existing recreation capacity at Shasta Dam and Lake through relocating and modernizing recreation facilities adversely affected by a higher lake level. It also includes enhancing opportunities related to the larger lake surface and modernized recreation facilities. This measure was retained for further development in the SLWRI.

- **Develop New NRA Recreation Plan –** USFS has indicated a desire to update the existing plan for the Whiskeytown-Shasta-Trinity NRA. USFS would like to use the opportunity created by raising Shasta Dam and Reservoir for that purpose. It is believed, however, that developing, coordinating, and implementing a new NRA plan is a separate Federal action and far outside the scope of the SLWRI. Accordingly, this measure was deleted from further consideration in the SLWRI.

- **Reoperate Reservoir for Recreation –** This measure consists of changing the established rules for operating Shasta Dam and Reservoir for flood management to benefit recreation resources on Shasta Lake. A claim by many of the recreation interests around Shasta Lake is that often the lake is forced to draw down in early spring for flood control and then, because of limited inflows the remainder of the season, the lake cannot recover, which adversely impacts recreation (as well as water supply). Locals cite 2004 as an example. They also claim that the existing reservoir operation rules for flood control are outdated (based on a USACE report dated 1977, nearly 30 years ago) and that by using more recent data and current technologies, the drawdown would not be required in some years, or would not be as significant. There is limited potential for changes in flood management rules to allow for more operational flexibility in reservoir drawdown requirements in response to storms with improved advanced forecasting. Additionally, with an increase in reservoir depth due to raising Shasta Dam, reservoir reoperation would likely include raising the bottom of flood control pool elevation, allowing for higher winter and spring water levels. This measure was retained for further consideration primarily because it may be compatible with any potential modification of Shasta Dam and Reservoir. In addition, it would likely be compatible with other primary and secondary planning objectives.

Maintain or Improve Water Quality

One management measure was considered to maintain or improve water quality in the study area (see Table 2-5). Following is a brief description of the measure, which was retained for further consideration:

- **Improve operational flexibility for Delta water quality by increasing storage in Shasta Reservoir –** This measure consists of providing improved operational flexibility for Delta water releases by providing additional storage in Shasta Reservoir. Shasta Dam has the ability to provide increased releases, as well as high flow releases, to reestablish Delta water quality. Improved Delta water quality conditions could provide benefits for both water supply reliability and ecosystem restoration by potentially increasing Delta outflow during drought years, and reducing salinity during critical periods. This measure was added to the comprehensive plans and was retained primarily because it had the potential to meet the secondary planning objective of maintaining or improving water quality conditions in the Sacramento River downstream from Shasta Dam and the Delta.

Measures Summary

Tables 2-6 and 2-7 summarize the water management measures that were carried forward for potential inclusion in concept plans to address the primary and secondary planning objectives, respectively. Those carried forward are believed to best address the objectives of the SLWRI, with consideration of planning constraints and criteria. It should be noted that measures that have been dropped from consideration at this stage might be reconsidered in the future as mitigation measures or other plan features. Similarly, additional measures not considered herein may be added to alternative plans as they are formulated.

Table 2-6. Measures Retained to Address the Primary Planning Objectives

Primary Planning Objective	Management Measure	
Increase Anadromous Fish Survival	Restore Spawning Habitat (Abandoned Gravel Mines) [1]	Restore abandoned gravel mines along the Sacramento River.
	Construct Instream Aquatic Habitat	Construct instream aquatic habitat downstream from Keswick Dam
	Replenish Spawning Gravel	Replenish spawning gravel in the Sacramento River.
	Modify TCD	Make additional modifications to Shasta Dam for temperature control.
	Enlarge Shasta Lake Cold-Water Pool	Enlarge Shasta Dam and Reservoir to increase the cold-water pool in the lake to benefit anadromous fish.
	Modify Storage and Release Operations at Shasta Dam	Modify storage and release operations at Shasta Dam to benefit anadromous fish
Increase Water Supply Reliability	Increase Conservation Storage	Increase conservation storage space in Shasta Reservoir by raising Shasta Dam.
	Conjunctive Water Management [1]	Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam.
	Reoperate Shasta Dam	Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability.
	Reduce Demand	Identify and implement, to the extent possible, water use efficiency methods.

Notes:
[1] These measures were retained for development in concept plans in the initial alternatives phase, but were later eliminated from further consideration during the comprehensive plans phase.

Key:

TCD = temperature control device

Table 2-7. Measures Retained to Address the Secondary Planning Objectives

Secondary Planning Objective	Management Measure	
Conserve, Restore, and Enhance Ecosystem Resources	Restore Shoreline Aquatic Habitat	Construct shoreline fish habitat around Shasta Lake.
	Restore Tributary Aquatic Habitat	Construct instream fish habitat on tributaries to Shasta Lake.
	Restore Riparian Habitat	Restore riparian and floodplain habitat along the upper Sacramento River.
Reduce Flood Damage	Modify Flood Operations Guidelines	Update Shasta Dam and Reservoir flood management operations.
	Route PMF From Top of Conservation Pool [1]	Route the Probable Maximum Flood from the top of the conservation pool in Shasta Reservoir.
Develop Additional Hydropower Generation	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head.
Maintain and Increase Recreation	Maintain and Enhance Recreation Facilities	Maintain and enhance recreation capacity, facilities, and opportunities.
	Reoperate Reservoir	Increase recreation use by stabilizing early season filling in Shasta Lake.
Maintain or Improve Water Quality	Increase Operational Flexibility	Improve operational flexibility for Delta water quality by increasing storage in Shasta Reservoir.

Notes:
[1] These measures were retained for development in concept plans in the initial alternatives phase, but were later eliminated from further consideration during the comprehensive plans phase.
Key:
PMF = Probable Maximum Flood

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Chapter 3
Shasta Dam and Reservoir Enlargement Scenarios

This chapter summarizes information developed on enlargement scenarios for Shasta Dam and Reservoir and identifies potential sizes recommended for further development into concept plans.

In the 1999 Reclamation report titled *Appraisal Assessment of the Potential for Enlarging Shasta Dam and Reservoir* (Reclamation 1999), an evaluation was made of the major features, issues, and costs associated with three potential raise scenarios for Shasta Dam and Reservoir: Low-Raise Option (6.5-foot raise), Intermediate-Raise Option (102.5-foot raise), and High-Raise Option (202.5-foot raise). Information from the report was reviewed and is summarized in this appraisal-level assessment.

A breakpoint analysis was conducted in early 2003 to identify the elevations of Shasta Dam raises for which implementation costs would considerably change due to the need for relocations or modifications of major project features (Reclamation 2004a). The analysis identified two fundamental cost components associated with raising Shasta Dam and enlarging Shasta Reservoir: (1) modifying the main dam and appurtenances and (2) modifying reservoir infrastructure and facilities. It was concluded in the analysis that the first major breakpoint in costs for increasing the size of Shasta Reservoir would occur with a top-of-full-pool raise from elevation 1,067 to about elevation 1,087.5 (20.5-foot raise), which would correspond to a dam raise of about 18.5 feet. This is primarily due to the need to relocate the Pit River Bridge with dam raises greater than about 18.5 feet. The second major breakpoint would occur with a top-of-full-pool raise to about elevation 1,100, which would correspond to a dam raise of about 30 feet. Raises of up to about 30 feet could likely be accomplished by raising the existing dam crest while higher dam raises would require increasing the dam mass, and constructing cofferdams and other facilities. Accordingly, two additional dam raise scenarios (approximately 18.5 and 30 feet) were developed in an effort to assess the relationship between the height of a dam raise and resulting cost of new water supplies.

Information is presented below on (1) rationale for establishing a dam raise of 18.5 feet and (2) the three scenarios included in the 1999 report and two expanded low-level dam raise scenarios. Also included is a comparison of the various dam raise scenarios.

Rationale for 18.5-Foot Dam Raise

As mentioned, it is estimated that the Pit River Bridge would need to be relocated for Shasta Dam raises greater than about 18.5 feet. A dam raise of 18.5 feet would allow for an increase in the full pool by about 20.5 feet or from elevation 1,067 to about elevation 1,087.5. Even with dam raises up to 18.5 feet, considerable modifications would need to be made to two piers of the bridge. These modifications are described in the Engineering Summary Appendix.

Figure 3-1 shows an elevation view of the Pit River Bridge south Abutment Number 2. Correspondence from the Union Pacific Railroad Company (UPRR) identified a minimum clearance between the low cord of the bridge and an increased water surface of 4 feet. The lowest point of the Pit River Bridge is at the south end of the structure. For this project, a minimum clearance of 1 foot below the south abutment bearing attachment to the main bridge structure was selected. This would allow a minimum clearance of 4.5 feet between the new full pool elevation and the main bridge structural elements.

It should be mentioned that storage in Shasta Reservoir, with or without raising the dam, is expected to reach full pool elevation in the future about as often it has in the past. This occurs to about once every 3 to 4 years, after the flood season, usually in May and/or early June. Durations would be only several days at the maximum elevation, but the high water condition could last several weeks. The south end of the Pit River Bridge is about 11 feet lower than the north end of the structure. Accordingly, the likely minimum clearance between the bridge and full pool elevation available for boat traffic during high water periods would be about 15 feet.

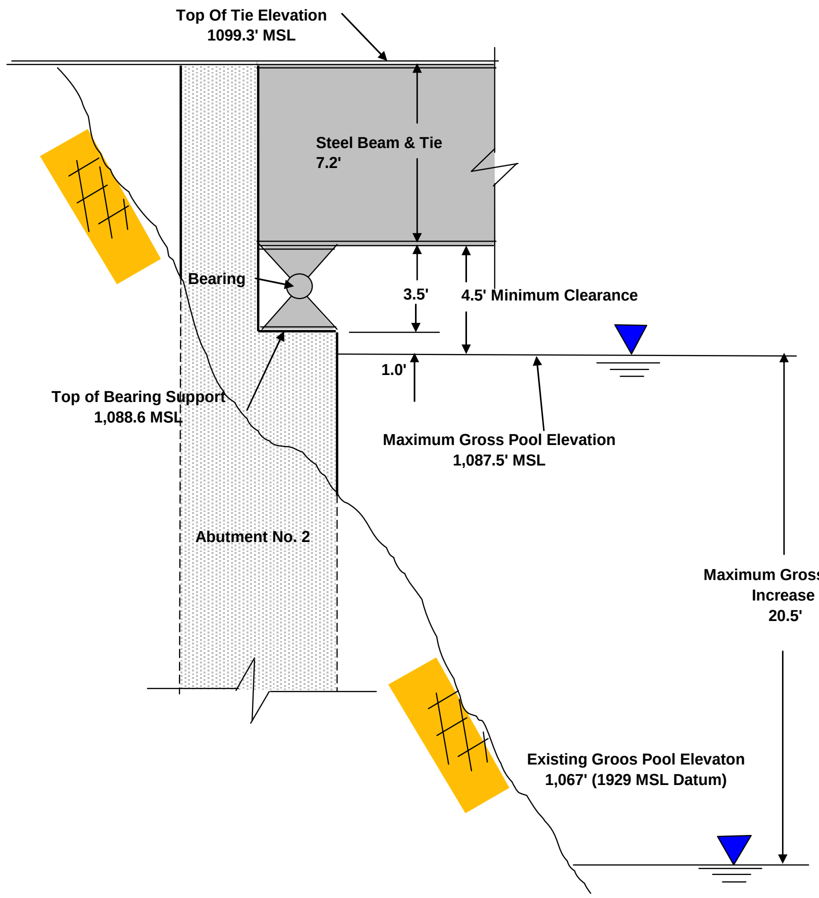

Figure 3-1. Elevation Sketch Showing the South End of the Pit River Bridge with Respect to the Existing and Increased Full Pool Elevation at Shasta Lake

Dam Raise Scenarios

Following is a description of the three dam raise scenarios included in the 1999 appraisal report (Reclamation 1999) and two expanded low-level scenarios.

Low-Level Raise – 6.5 Feet

Major components, accomplishments and costs, system yield, implementation costs, and unit costs for the low-level raise (6.5 feet) are described in this section.

Major Components

The 6.5-foot Low-Level Raise scenario consists of a structural dam raise of 6.5 feet with a new enlarged crest elevation at 1,084 feet. This scenario would have a new top of joint-use storage space at elevation 1,075.5, and result in an additional 8.5 feet of water in the reservoir. The total capacity of this new reservoir would be 4.84 MAF, which is an increase of 256,000 acre-feet above the existing available storage. At full pool storage, the reservoir would cover about 30,700 acres, which is an increase of about 1,100 acres over existing conditions (4 percent increase). Table 3-1 lists major features associated with this dam raise scenario.

Table 3-1. Shasta Dam and Reservoir Enlargement Features

Item	Baseline	Low-Level Raise – 6.5 Feet	Expanded Low-Level Raise – 18.5 Feet	Expanded Low-Level Raise – 30 Feet	Inter-mediate-Level Raise – 102.5 Feet	High-Level Raise – 202.5 Feet
Dam Crest Raise (feet)	NA	6.50	18.50	30.00	102.50	202.50
Dam Crest Elevation (feet)	1,077.50	1,084.00	1,096.00	1,107.50	1,180.00	1,280.00
Full Pool Raise (feet)	NA	8.50	20.50	32.00	104.50	204.50
Full Pool Elevation (feet)	1,067.00	1,075.50	1,087.50	1,099.00	1,171.50	1,271.50
Reservoir Capacity (MAF)	4.55	4.81	5.19	5.57	8.47	13.89
Surface Area @ Full Pool Elevation (acres)	29,600	30,700	32,100	33,700	44,200	60,800
Capacity Increase (MAF)	NA	0.26	0.63	1.02	3.92	9.34

Key:
MAF = million acre-feet
NA = not applicable

The dam raise would be limited to the existing dam crest and appurtenant structures only, with mass concrete placed in blocks on the existing concrete gravity section and precast concrete panels used to retain compacted earthfill placed on wing dam embankment sections. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be extended up to the new crest elevation and the main TCD enclosure would be extended to the new full pool elevation.

Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only, waterstops and other seepage control measures would be provided. However, with a new full pool elevation of 1,075.5, about seven existing vehicle and railroad bridges would need to be either considerably modified or relocated. Table 3-2 lists estimated infrastructure impacts associated with various increases in full pool. Minor modifications to the Pit River Bridge, which carries Interstate 5 (I-5) and the Water Use Efficiency near Bridge Bay, would be required with this scenario.

The expanded full pool would impact about 45 structures, which would need to be removed or relocated (see Figure 3-2). However, few impacts would occur to reservoir rim ecosystem resources or reservoir-area developed properties.

Table 3-2. Reservoir Infrastructure Impacts and Actions for Elevations 1,070 – 1,280[1]

New Top of Joint-Use Elevation	Impact Remediation Actions
1,072	Relocate UPRR Doney Creek Bridge, UPRR Sacramento River Bridge (2nd Crossing), relocate segment of Bully Hill Road impacted on Squaw Creek Arm
1,073	Relocate portion of Lakeshore Drive impacted by Charlie Creek Bridge
1,074	Relocate McCloud River Bridge and Didallas Creek Bridge; relocate portion of Silverthorn Road impacted on Pit River Arm
1,075	Relocate Second Creek Bridge
1,076	Relocate portion of Lakeshore Drive impacted by Doney Creek Bridge
1,077	Relocate portion of impacted Conflict Point Road (on north side of Salt Creek)
1,078	Build embankment for UPRR at Bridge Bay
1,080	Build embankment for I-5 at Lakeshore; relocate portion of Gilman Road impacted near McCloud Bridge, and portion of Fender Ferry Road impacted near McCloud Bridge
1,090	Relocate UPRR Lakeshore Drive Overcrossing by Charlie Creek
1,091	Relocate Pit River Bridge; relocate UPRR Sacramento River Bridge (2nd Crossing); relocate portion of I-5 impacted by Lakeshore (not necessary with protective dike)
1,094	Relocate UPRR Lakeshore Drive Overcrossing by Doney Creek
1,096	Relocate Wittawaket Creek Bridge and UPRR Sacramento River Bridge, 3rd Crossing
1,097	Relocate UPRR I-5 overpass
1,099	Relocate Squaw Creek Bridge
1,100	Begin to remediate impacts to Silverthorn community (population 1,100 to 1,250)
1,105	Relocate portion of West Side Road impacted at Squaw Creek Bridge
1,106	Reservoir full pool at top of powerhouse at Pit 7 Dam[2]
1,109	Relocate UPRR Sacramento River Bridge, 4th Crossing
1,110	Relocate UPRR Dog Creek Bridge
1,111	Relocate UPRR Salt Creek Bridge
1,114	Relocate Fender Ferry Bridge (Sacramento River near Delta)
1,134	Jones Valley Dike becomes necessary
1,135	Relocate Fender Ferry Bridge (upper Pit River)
1,143	Relocate Tunnel Gulch Viaduct on I-5; relocate UPRR O'Brien Creek Bridge
1,150	Begin to remediate impacts to town of Delta (population 1,150 to 1,190)
1,165	Begin to remediate impacts to town of Pollock (population 1,165 to ~1,220)
1,170	Begin to remediate impacts to town of Lakehead (population 1,170 to ~1,220)
1,172	Relocate UPRR O'Brien Creek Bridge
1,180	Clickapudi Cove Dike becomes necessary
1,230	Bridge Bay and Centimundi dikes become necessary
1,278	Reservoir full pool at crest of Pit 7 Dam[2]

Notes:
[1] This table does not include impacts to specific buildings. Impacted portions of roads, communities, and other infrastructure would be relocated where possible. In cases where relocation is not feasible, facilities may need to be abandoned.
[2] Specific remediation actions at the Pit 7 Dam have not yet been determined. The elevation at which the dam would likely need to be abandoned is between elevation 1,106 (powerhouse yard floor) and elevation 1,278 (crest of dam).
Key:
Delta = Sacramento-San Joaquin Delta
I-5 = Interstate 5
UPRR = Union Pacific Railroad

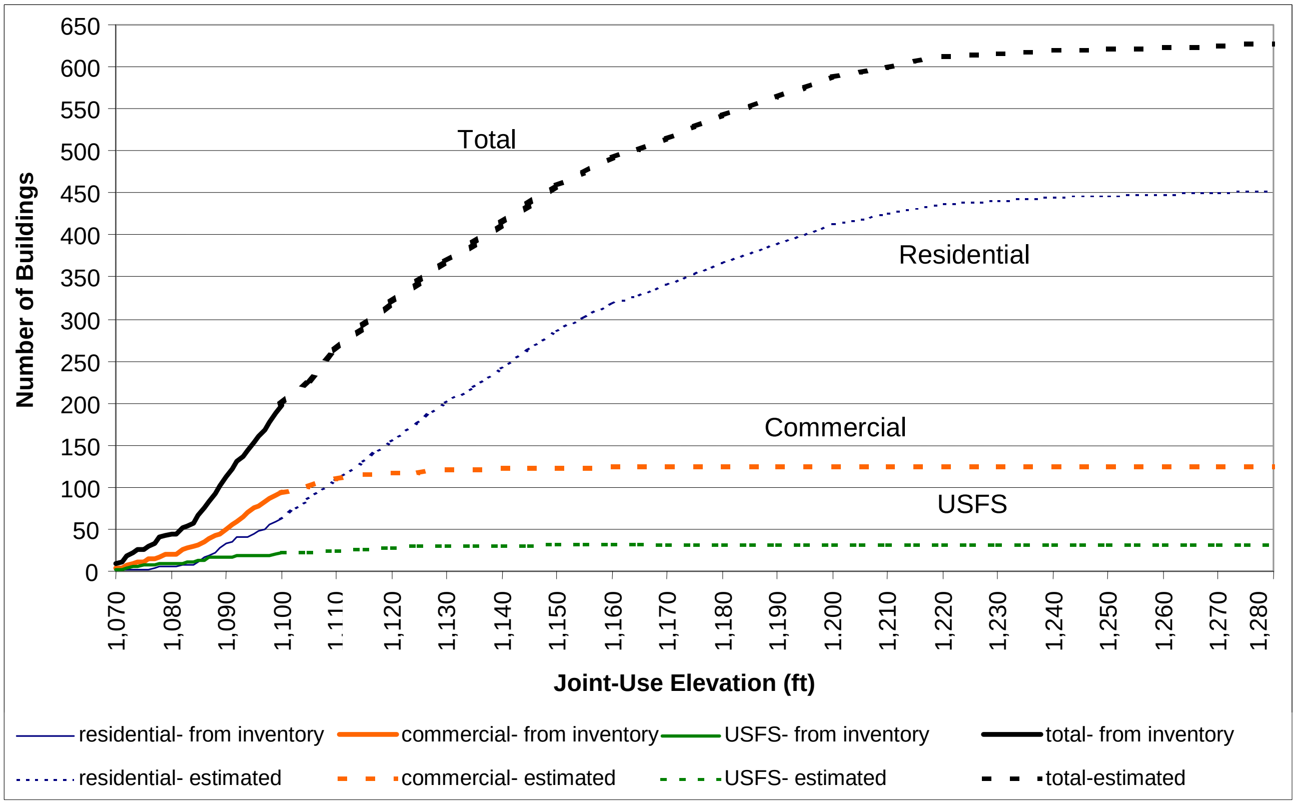

Figure 3-2. Estimated Number of Structures Affected by Increasing the Height of Shasta Dam and Reservoir

Accomplishments and Costs

Although not to the extent of higher raises and associated larger reservoir sizes, this scenario would have the potential to contribute to both primary planning objectives and is also consistent with the goals in the CALFED ROD (CALFED 2000). It could support each of the secondary planning objectives and help increase anadromous fish survival by creation of a small increased cold-water pool. In addition, it could help reduce flood damage along the upper Sacramento River, increase hydropower generation, and slightly increase potential reservoir area recreation opportunities. It would also have minor impacts on the McCloud River and associated issues relating to the State special designation of that waterway.

System Yield

Water system operation studies for the CVP and SWP were made using the CalSim-II mathematical model for the five dam raise scenarios described in this section. Table 3-3 compares annual yield for simulated CVP and SWP deliveries for average year and drought year, conditions with Banks Pumping Plant capacity at 6,680 cfs, for various Shasta Dam raise scenarios. The table shows the relative increase in reliability of each dam raise scenario to meet future demands. As expected, higher dam raise scenarios have a considerably higher potential to meet future demands.

It should be mentioned that the estimated system yield shown in Table 3-3, which was estimated in 2003, differs from that shown in other sections of this appendix and in the main report. This is due to continuing updates in the CalSim-II model. It is important to understand that these differences in system yields would not change the fundamental conclusions reached concerning cost efficiencies associated with relative increases of Shasta Dam and Reservoir.

Table 3-3. CVP/SWP System Yield Increase (2003 Estimates)

Dam Raise	Average Year Conditions[1] (TAF per year)	Drought Year Conditions[1] (TAF per year)
Low-Level Raise – 6.5 Feet	48	72
Expanded Low-Level Raise – 18 Feet	71	125
Expanded Low-Level Raise – 30 Feet	110	185
Intermediate-Level Raise – 102.5 Feet	214	425
High-Level Raise – 202.5 Feet	331	703

Note:
[1] Yields differ from other sections of appendix and main report due to update of CalSim-II model used. Differences are relative and do not change the overall conclusions reached.
Key:
CVP = Central Valley Project
SWP = State Water Project
TAF = thousand acre-feet

Preliminary Implementation Costs Preliminary estimates of total first and annual costs for Shasta Dam raise scenarios were developed for relative comparison purposes. Costs were based primarily on updating information contained in Reclamation's 1999 appraisal report to October 2003 price levels, a 5-5/8 percent interest rate, and a 100-year analysis period. Estimated costs are summarized in Table 3-4.

It should be mentioned that, as with system yield above, the costs shown here will differ from those shown elsewhere in this appendix and in the main report. This is primarily due to updates in cost estimates and price level changes. However, it is important to note that these changes would not change the fundamental conclusions reached concerning cost efficiencies associated with relative increases of Shasta Dam and Reservoir.

Table 3-4. First and Annual Costs for Dam Raise Options

Dam Raise Options	First Cost @ 2003 Price Levels ($millions)1	Annual Costs @ 2003 Price Levels ($millions)2
Low-Level Raise	282	19
Expanded Low-Level Raise – 18.5 Feet (without major relocations)	408	28
Expanded Low-Level Raise – 18.5 Feet (with major relocations)	1,060	75
Expanded Low-Level Raise – 30 Feet (block raise)	1,250	89
Expanded Low-Level Raise – 30 Feet (mass raise)	1,330	94
Intermediate-Level Raise – 102.5 Feet	3,890	283
High-Level Raise – 202.5 Feet	5,250	383

Notes:
[1] Most information updated by price levels and interest rates from May 1999 Shasta Dam and Reservoir Enlargement, Appraisal Assessment, by Reclamation. October 2003 price levels.
[2] Construction period of 6 years for lower raise scenarios, and 8 to 10 years for higher raise scenarios. Average annual costs based on 5-5/8 percent over a 100-year project life.

Figure 3-3 shows the estimated first cost for each scenario; two cost estimates were developed for each Expanded Low-Level Raise scenario. The intent of the two estimates was to determine the influence of major cost breaks or jumps resulting from implementing major relocations for the 18.5-foot raise scenario, and additional dam construction costs for the 30-foot raise scenario. Cost estimates for each Expanded Low-Level Raise scenario in the table are based primarily on interpolating costs between the Low-Level and Intermediate-Level raises.

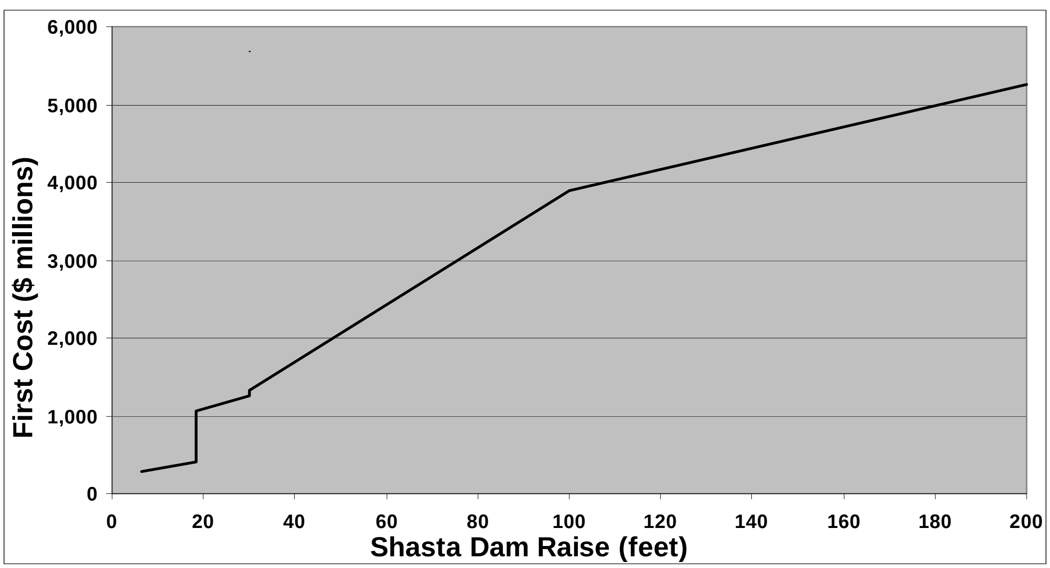

Figure 3-3. Estimated First Cost for Various Shasta Dam Raises at 2003 Price Levels

Unit Costs Table 3-5 summarizes the estimated total storage, water supply yield, and first and annual costs for each scenario considered. The table also shows the estimated unit cost of water for the various dam raise scenarios, and estimates of unit costs for the two Expanded Low-Level scenarios, including major relocations and dam construction costs at estimated major breakpoints. The total storage unit cost in the table is the estimated cost to develop an acre-foot of new storage. Total storage unit cost is the total first cost divided by the additional storage created by the scenario. The unit cost for new water supply yield is computed using estimates of both average annual and drought yield. Unit cost information from Table 3-5 as a function of new dam crest elevation was used to create the plot in Figure 3-4. The need for major relocations (primarily for I-5 and UPRR facilities) for a dam raise of about 18.5 feet (elevation 1,095) has a dramatic effect on the estimated unit cost for new storage and new water supplies at Shasta. The need to change construction methods for a dam raise of about 30 feet (elevation 1,107.5) has a considerably smaller influence.

Table 3-5. Water Supply Unit Cost Summary (2003 conditions)

Description	Low-Level Raise – 6.5 Feet	Expanded Low-Level Raise – 18.5 Feet		Expanded Low-Level Raise – 30 Feet		Inter-mediate-Level Raise	High-Level Raise
		Without Bridges	With Bridges	Block Raise	Mass Raise		
Added Storage (1,000 acre-feet)	256	634	634	1,020	1,020	3,920	9,340
Yield (1,000 acre-feet per year)							
- Average Annual	48	71	71	110	110	214	331
- Drought Year	72	125	125	185	185	425	703
Unit Cost ($/acre-foot) [1]							
- Total Storage[2]	970	640	1,670	1,230	1,300	990	560
- Yield – Average Annual[3]	410	400	1,050	810	850	1,320	1,160
- Yield – Drought Year[4]	270	225	600	480	510	670	550

Notes:
[1] First cost divided by increase in total storage.
[2] Annual cost divided by average annual yield.
[3] Annual cost divided by drought year yield.

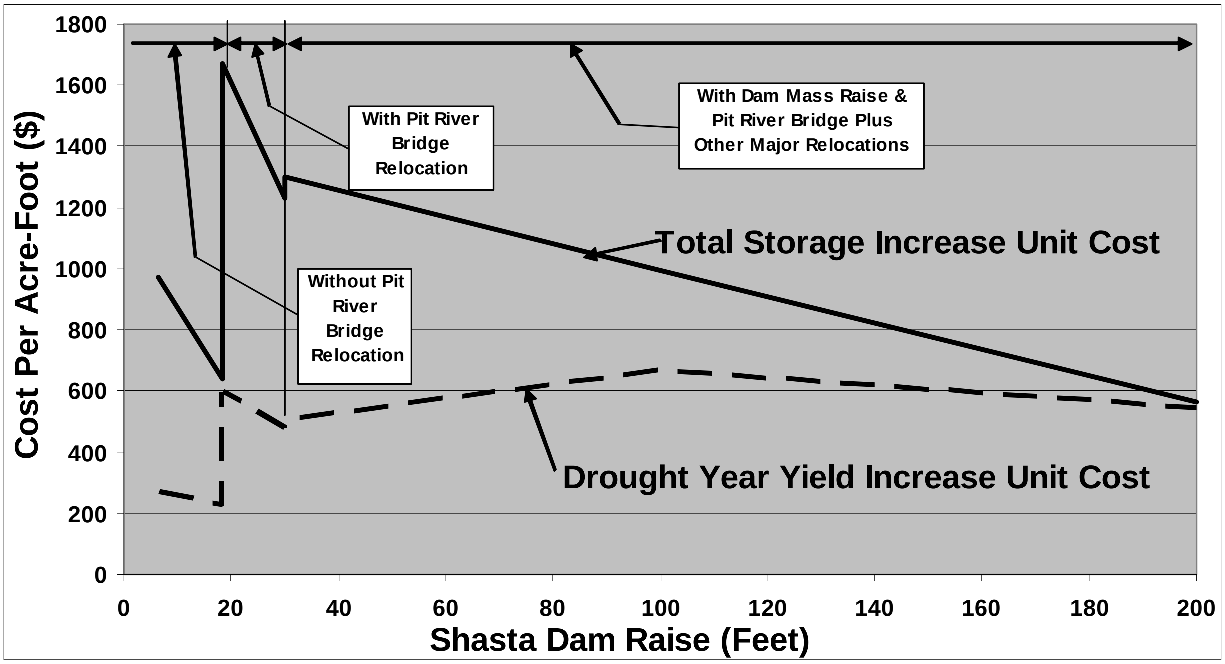

Figure 3-4. Plot of Total Storage and Water Supply Reliability Yield Unit Cost (2003 price levels) for Various Increases of Shasta Dam Raise

Expanded Low-Level Raise – 18.5 Feet

Major components, accomplishments, and costs for the Expanded Low-Level Raise (18.5 feet) are described in this section.

Major Components

This scenario consists of a structural dam raise of 18.5 feet with a new crest at elevation 1,096. The total capacity of this new reservoir would be 5.19 MAF, which is an increase of 634,000 acre-feet above the existing available storage. At full pool storage, the reservoir would cover about 32,100 acres, which is an increase of about 2,500 acres over existing conditions (9 percent).

The dam raise would be limited to the existing dam crest and appurtenant structures only, with mass concrete placed in blocks on the existing concrete gravity section and concrete wing dams constructed on both abutments. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be raised up to the new crest elevation and the main TCD enclosure would be extended to the new full pool elevation.

The 18.5-foot Expanded Low-Level Raise scenario would require a new crest roadway, spillway bridge, elevators, gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only; waterstops and other seepage control measures would be provided.

As can be determined from Table 3-2, with the increased full pool at elevation 1,087.5, an estimated seven bridges in the reservoir area would need to be modified and/or relocated. Pending the results of additional analysis, it appears that this scenario represents the likely greatest dam raise without full relocation of I-5 and the UPRR Pit River Bridge at Bridge Bay. Even at a full pool elevation increase of 20.5 feet, the water surface would encroach to within 4 feet of the low cord of the bridge, which is believed to be the minimum freeboard allowable before full relocation for railroad bridges. To prevent adverse impacts to two bridge piers (Piers 3 and 4) resulting from periodic inundation, the project would include constructing a skirting system around the upper portions of the piers. For clearance for houseboats, a maximum full pool raise would be limited to about 14 feet. However, it is believed that because of the infrequent occurrences of the water surface reaching full pool during high recreation periods, appropriate mitigation features can be included for this scenario.

The expanded full pool area would require about 130 structures (2003 estimate) to be removed or relocated (see Figure 3-2). Relatively minor impacts would occur to reservoir rim ecosystem resources. However, this scenario also includes relocating many reservoir area recreation facilities.

Accomplishments and Costs

This scenario would contribute considerably to both primary planning objectives. It also could support each secondary planning objective. Increasing the full pool storage at Shasta Reservoir by about 634,000 acre-feet by raising the dam 18.5 feet would increase the average annual and annual drought year yield based on 2003 CalSim-II modeling assumptions by about 71,000 and 125,000 acre-feet (67,000 and 133,000 acre-feet in 2006 evaluations), respectively (see Table 3-5). It could also help increase anadromous fish survival by increasing the cold-water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would slightly increase potential reservoir area recreation opportunities. This scenario is generally consistent with the goals and objectives in the 2000 CALFED ROD. It would have minor and manageable impacts on the McCloud River and issues relating to the State special designation of that waterway.

As shown in Table 3-4, to accomplish this magnitude of dam raise without major reservoir area relocations, the estimated first cost based on 2003 price levels for this scenario would be about $408 million. The estimated average annual cost would be about $28 million. This would result in a unit cost for the new storage space in Shasta Reservoir of about $640 per acre-foot (Table 3-5). The resulting estimated unit costs for average annual and drought year yield would be about $400 and $225 per acre-foot, respectively (see Figure 3-4).

Tables 3-4 and 3-5 and Figures 3-3 and 3-4 also show the estimated impact on the first, annual, and unit costs for an 18.5-foot dam raise, including the possible relocation of I-5 and the UPRR Pit River Bridge at Bridge Bay. It is believed that this relocation would be needed for a dam raise greater than about 18.5 feet. With these additional relocations, the first cost would increase to an estimated $1.06 billion. The estimated total unit storage cost would increase to about $1,670 per acre-foot. The estimated unit cost for average annual and drought year yield would be about $1,050 and $600 per acre-foot, respectively.

Expanded Low-Level Raise – 30 Feet

Major components and accomplishments and costs for the Expanded Low-Level Raise (30 feet) are described in this section.

Major Components

This scenario consists of a structural dam raise of 30 feet with a new crest at elevation 1,107.5 (see Table 3-1). This scenario would have a new top of joint-use (full pool) storage space at elevation 1,099, resulting in an additional 32 feet of water in the reservoir. The total capacity of this new reservoir would be 5.57 MAF, an increase of 1.02 MAF above the existing available storage. At full pool storage, the reservoir would cover about 33,700 acres, which is an increase of about 4,100 acres over existing conditions (14 percent).

This scenario represents the likely greatest dam raise without major modification of the dam mass (concrete overlay on downstream face) and replacement of wing dams, river outlets, and penstocks. The dam raise would be limited to the existing dam crest and appurtenant structures only, with mass concrete placed in blocks on the existing concrete gravity section and concrete wing dams constructed on both abutments. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be raised up to the new crest elevation and the main TCD enclosure would be extended to the new full pool elevation.

The 30-foot Expanded Low-Level Raise scenario would require a new crest roadway, spillway bridge, elevators and gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only, waterstops and other seepage control measures would be provided.

The expanded full pool area would require about 200 structures to be removed or relocated (see Figure 3-2). This scenario would also result in impacts to various major and minor transportation, recreation, hydropower, and other reservoir area facilities. In addition, it would require replacement of the Pit River Bridge at Bridge Bay and 12 other major and minor reservoir area bridges and roadway segments. Also, most recreational facilities would require relocation. Considerable impacts to reservoir rim and tributary stream ecosystem resources would occur.

Accomplishments and Costs

This scenario also would contribute considerably to both primary planning objectives and support each of the secondary planning objectives. Increasing the full pool storage at Shasta Reservoir by over 1 MAF through raising the dam 30 feet would increase the average annual and annual drought year yield to the CVP by an estimated 110,000 and 185,000 acre-feet, respectively (see Table 3-5). It could help increase anadromous fish survival by creating an increased cold-water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would increase potential reservoir area recreation opportunities. This scenario is generally consistent with the goals and objectives in the 2000 CALFED ROD. It would, however, have impacts on the lower McCloud River and issues relating to the State of California Species of Special Concern designation in that watershed.

As shown in Table 3-4 and Figure 3-3, the estimated first cost based on 2003 price levels for this scenario would be about $1.25 billion. The estimated average annual cost is $89 million. This would result in a unit cost for the new storage space in Shasta Reservoir of about $1,230 per acre-foot (Table 3-5). Estimated unit costs for average annual and drought year yield would be about $810 and $480 per acre-foot, respectively.

It is believed that for dam raises greater than about 30 to 50 feet, the existing concrete gravity dam section would need to be raised using a mass concrete overlay as opposed to raising the dam using concrete blocks. Tables 3-4 and 3-5 and Figures 3-3 and 3-4 also show the estimated impact on first, annual, and unit costs for a 30-foot dam raise, including this change in construction method. With the mass concrete overlay raise, the first cost would increase to an estimated $1.33 billion and the estimated total unit storage cost would increase to about $1,300 per acre-foot. The estimated unit cost for average annual and drought year yield would be about $850 and $510 per acre-foot, respectively.

Intermediate-Level Raise – 102.5 Feet

Major components and accomplishments and costs for the Intermediate-Level Raise (102.5 feet) are described in this section.

Major Components

The Intermediate-Level Raise scenario consists of a structural dam raise of 102.5 feet to a new crest at elevation 1,180 (see Table 3-1). The new top of joint-use storage space would be at elevation 1,171.5. This would allow for storage of an additional 104.5 feet of water in the reservoir above the existing joint-use storage pool elevation. Total capacity of this new reservoir would be 8.47 MAF, or an increase of 3.92 MAF above the existing available storage. At full pool storage, the reservoir would cover about 44,200 acres, which is an increase of about 14,600 acres over existing conditions (49 percent). Figure 3-5 includes the aerial extent of the Intermediate-Level Raise scenario in relationship to other dam raise scenarios being considered.

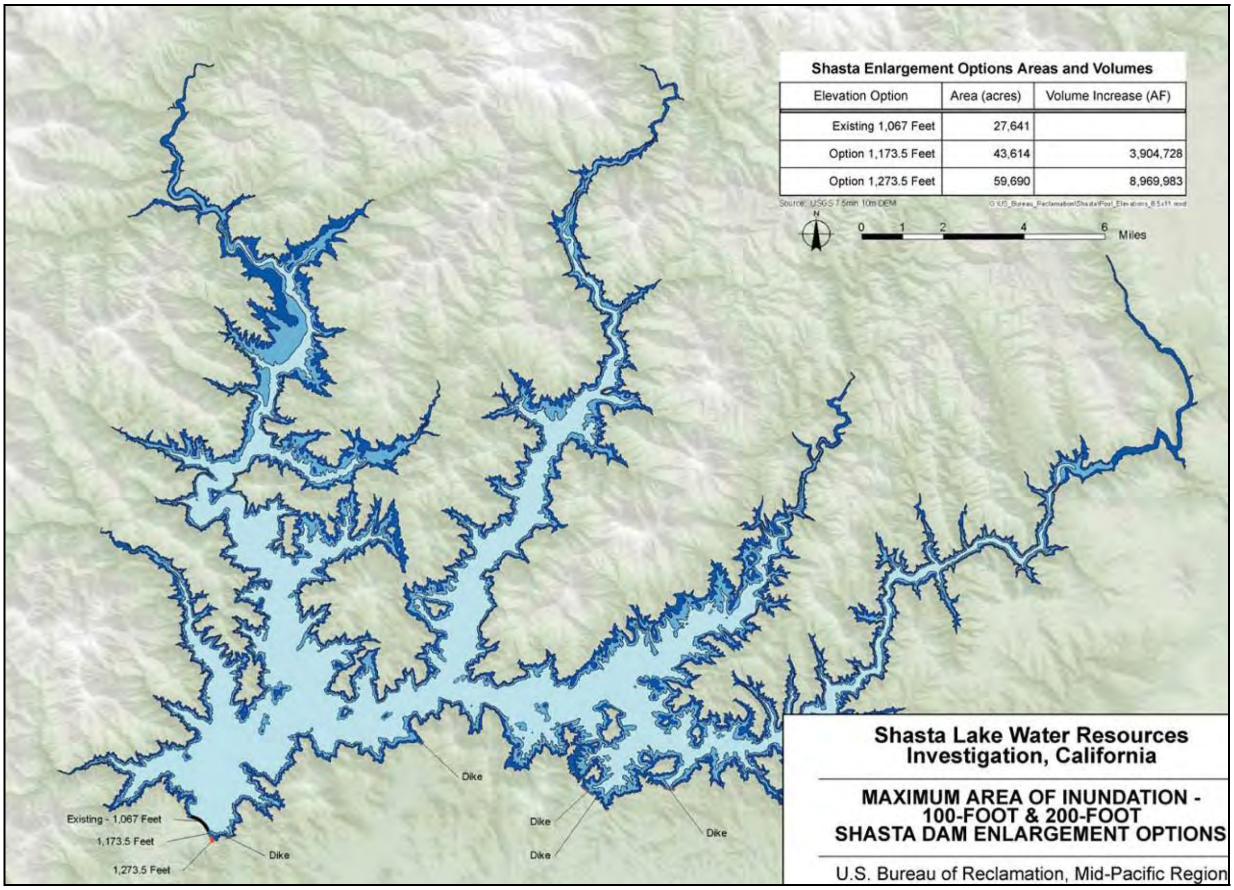

Figure 3-5. Shasta Lake Maximum Area of Inundation for 100-foot and 200-foot Dam Raise Options

The existing concrete gravity dam section would be raised using a mass concrete overlay on the main section of the dam with roller-compacted concrete wing dams constructed on both abutments. The left wing dam would extend approximately 1,380 feet, and the right wing dam would extend approximately 420 feet. The mass concrete overlay on the downstream face of the existing dam in the main section would extend from elevation 1,180 down to the foundation contact at the downstream toe on a 0.7:1 slope. The spillway section would be made thicker to accommodate the gated spillway crest.

This dam raise scenario would require a new crest roadway, spillway bridge, elevators, and a gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. It would also involve constructing two new saddle dikes at Jones Valley and Clickapudi Creek.

The expanded full pool area would require about 520 structures to be removed or relocated (see Figure 3-2). This scenario also would result in impacts to numerous major and minor transportation, recreation, hydropower, and other reservoir area facilities. New power facilities would likely be needed at Shasta

Dam, primarily including improvements to the existing penstocks. In addition, most recreational facilities would require relocation. Considerable impacts would occur to historical and cultural resources in the Shasta Lake area. Major impacts would occur to reservoir area and tributary stream ecosystem resources. The Intermediate-Level Raise would also require relocation or abandonment of the Pacific Gas and Electric Company (PG&E) Pit 7 Dam and Powerhouse on the upper Pit River just upstream from Shasta Lake.

It is important to note that in addition to the Pit River Bridge, which would be the single most costly relocation item associated with a dam raise, 20 other bridges cross Shasta Lake or one of its tributaries. A considerable number of bridge relocations would be required with minor increases in the top of joint-use elevation, and all of the main reservoir bridges would need to be relocated with a top of joint-use raise of about 73 feet. However, with greater increases in top of joint-use elevations, major railroad and/or roadway system relocation (UPRR and I-5) also would be required.

Accomplishments and Costs

This scenario would considerably contribute to both primary planning objectives and also support each of the secondary planning objectives. Increasing the full pool storage at Shasta Reservoir by 3.9 MAF by raising Shasta Dam 102.5 feet would increase the estimated average annual and critical dry period yield to the CVP by an estimated 214,000 and 425,000 acre-feet, respectively (see Table 3-5). It could help increase anadromous fish survival by creating a small increased cold-water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would result in a considerable increase in potential reservoir area recreation opportunities. However, it would have major impacts on the McCloud River and issues relating to the State special designation of that waterway.

Because of the considerable increase in storage in Shasta Reservoir for this scenario, and resulting influence on residual available water resources in the upper watershed, planning for other potential water resources projects would be likely influenced measurably. Also, because this scenario requires most of the infrastructure within the reservoir area to be relocated, considerable disruption would occur to local and interstate roadway and railroad transportation, recreation, and related facilities in the Shasta Lake region.

As shown in Table 3-4 and Figure 3-3, the estimated first cost (2003 price levels) for this scenario is about $3.9 billion with an estimated average annual cost of about $283 million. The estimated unit cost for the new storage space in Shasta Lake would be about $990 per acre-foot. The resulting unit cost for the average annual and drought year water supply yield would be about $1,320 and $670 per acre-foot, respectively (Table 3-5).

High-Level Raise – 202.5 Feet

Major components and accomplishments and costs for the High-Level Raise (202.5 feet) are described in this section.

Major Components

The High-Level Raise scenario consists of a structural dam raise of 202.5 feet to a new crest at elevation 1,280 (see Table 3-1). The new top of joint-use storage space would be at elevation 1,271.5. This would allow storage of an additional 204.5 feet of water in the reservoir. The total capacity of this new reservoir would be 13.89 MAF, an increase of 9.34 MAF above the existing available storage. This dam raise represents the highest practical raise of Shasta Dam. Enlargements beyond this point would begin to experience considerable geological foundation problems. At least one upstream PG&E dam and powerhouse would be relocated with the high level raise – Pit 7 Dam and powerhouse on the upper Pit River. At full pool storage, the reservoir would cover about 60,800 acres, which is an increase of about 31,200 acres over existing conditions (105 percent). Figure 3-5 shows the aerial extent of the High-Level Raise scenario in relationship to other dam raise scenarios being considered.

The existing concrete gravity dam section would be raised using a mass concrete overlay on the existing dam crest and downstream face. The upstream face within the curved nonoverflow sections would extend vertically to the new dam crest at elevation 1,280, and the downstream face would have a 0.7:1 slope to the downstream toe. The dam crest would be completed with a crest cantilever for the roadway surface, sidewalks, and parapet walls. Existing elevator shafts would be extended to the new dam crest, and new elevator towers would be provided. The spillway section would require a thicker section to accommodate the gated spillway crest.

The new dam crest would include a crest roadway and spillway bridge, passenger and freight elevators, and three gantry cranes. This option would require constructing four saddle dikes to close off the gaps between mountain peaks in the upper watershed. A new powerplant and associated switchyard facilities would be included on the left abutment. The existing powerplant would continue to be operated within its operation range. The existing penstocks on the right abutment would be upgraded.

The expanded full pool area would require nearly 630 structures to be removed or relocated. As with the Intermediate-Level Raise scenario, this scenario would require replacement of major infrastructure associated with Shasta Dam and Reservoir.

Considerable impacts would occur to historical and cultural resources in the Shasta Lake area. Major impacts would occur to reservoir area and tributary stream ecosystem resources. This scenario would have major and likely irreversible impacts to the McCloud River and issues relating to the State special designation of that waterway.

Accomplishments and Costs

This High-Level Raise scenario would contribute considerably to both primary planning objectives and support each of the secondary planning objectives. Increasing the full pool storage at Shasta Reservoir by 9.1 MAF by raising Shasta Dam 202.5 feet would increase the estimated average annual and critical dry period yield to the CVP by an estimated 330,000 and over 700,000 acre-feet, respectively (see Table 3-5). It would considerably increase anadromous fish survival by creating a very large increased cold-water pool. In addition, because of the considerable increase in total space in Shasta Reservoir capable of capturing considerably more peak flood flows, this scenario could help resolve many existing flood problems along the upper Sacramento River. It would result in major increases in hydropower generation. It also would result in a substantial increase in water-oriented recreation in Shasta Lake by more than doubling the lake surface area at full pool elevation.

Because of the considerable increase in storage in Shasta Reservoir for this scenario, and resulting influence on residual available water runoff from the upper Sacramento River watershed, planning for other potential water resources projects in the Central Valley very likely would be influenced measurably. Also, because the scenario would require most of the infrastructure within the reservoir area to be relocated, considerable disruption would occur to local and interstate roadway and railroad transportation, recreation, and related actions in the Shasta Lake region.

The estimated first cost for this scenario (2003 price levels) is about $5.2 billion with an estimated average annual cost of about $383 million (see Table 3-4). The estimated unit cost for new storage space in Shasta Lake would be about $560 per acre-foot (Table 3-5). The resulting unit cost for the average annual and drought year water supply yield would be about $1,160 and $550 per acre-foot, respectively (Table 3-5).

Initial Screening

The five dam raise scenarios were compared to identify the scenarios that should be considered in more detail and included in concept plans. Table 3-6 is a summary comparison and screening of each scenario. As shown in the table, three Shasta Dam enlargement scenarios were identified for development into concept plans: the Low-Level Raise – 6.5-foot scenario, Expanded Low-Level Raise – 18.5-Foot scenario, and High-Level Raise – 202.5-foot scenario. The Expanded Low-Level Raise – 30-foot, Intermediate-Raise, and all other Shasta Dam and Reservoir enlargement scenarios were eliminated from further consideration. Following is a summary of each scenario.

- **Low-Level Raise – 6.5 Feet** – On the basis of an estimated unit cost per an increase in drought year yield of $270 per acre-foot, this scenario would be one of the most efficient of the five considered. Primarily due to (1) the relatively low cost for additional dry period yield, (2) high reliability of accomplishing its identified benefits, (3) low overall impact to ecosystem and related resources, (4) ability to combine with other measures, and (5) consistency with goals in the 2000 CALFED ROD, this scenario was retained for more detailed analysis as part of the concept plans.

- **Expanded Low-Level Raise – 18.5 Feet** – On the basis of an estimated unit cost per increase in drought year yield as low as $225 per acre-foot, this scenario also would be one of the most efficient of the five considered. This option was retained for more detailed analysis, primarily due to (1) the potential for additional dry period yield and high potential to influence average year water supply reliability, (2) low implementation cost and water supply reliability cost, (3) relatively low overall impact to ecosystem and related resources, and (4) consistency with the goals of the 2000 CALFED ROD.

- **Expanded Low-Level Raise – 30 Feet** – On the basis of an estimated high unit cost per new system yield, this scenario would result in relatively low economic efficiency compared with the 6.5-foot and 18.5-foot scenarios. Primarily due to considerably higher implementation costs relative to accomplishments, this scenario was deleted from further consideration.

Table 3-6. Summary Comparison of Shasta Dam Raise Scenarios (2003 Analysis)

Description	Low-Level Raise (6.5 feet)	Expanded Low-Level Raise (18.5 feet)	Expanded Low-Level Raise (30 feet)	Intermediate-Level Raise (102.5 feet)	High-Level Raise (202.5 feet)
Major Features					
Dam Crest Raise (feet)	6.5	18.5	30	102.5	202.5
Full Pool Raise (feet)	8.5	20.5	32	104.5	204.5
Capacity Increase (million AF)	0.26	0.63	1.02	3.92	9.34
Surface Area Increase (%)	4	8	14	49	105
Water Reliability Accomplishments					
Drought Year Yield (AF/year)	72	125	185	425	703
CVP Yield Replacement (%)[1]	13	20	31	77	100
Cost (2003 Price Levels)					
First Cost ($ millions)	282	408	1,250	3,890	5,250
Annual Cost ($ millions)	19	28	89	283	383
Unit Cost ($/AF)[2]	270	225	480	670	550
Major Advantages	• Low unit cost. • No major relocations. • Consistent with 2000 CALFED ROD. • Can contribute to both primary planning objectives. • Potential to provide about 5 and 14 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins. • Low impacts in reservoir rim area.	• Low unit cost. • No major relocations. • Consistent with goals of 2000 CALFED ROD. • Can contribute to both primary planning objectives. • Potential to provide up to about 7 and 20 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can contribute to both primary planning objectives. • Potential to provide up to about 11 and 31 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can contribute to both primary planning objectives. • Can contribute considerably to increased recreation, hydropower, and flood control secondary objectives. • Potential to provide about 27 and 77 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can considerably contribute to both primary planning objectives. • Can contribute considerably to increased recreation, hydropower, and flood control secondary objectives. • Potential to provide about 45 and 100 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins. • Likely lowest-cost project capable of resolving current and future water supply shortages.

Table 3-6. Summary Comparison of Shasta Dam Raise Scenarios (2003 Analysis) (contd.)

Description	Low-Level Raise (6.5 feet)	Expanded Low-Level Raise (18.5 feet)	Expanded Low-Level Raise (30 feet)	Intermediate-Level Raise (102.5 feet)	High-Level Raise (202.5 feet)
Major Disadvantages	• Relatively low potential to meet primary objectives.	• Marginal potential to meet primary objectives. • Moderate reservoir rim impacts.	• Very high unit cost. • Requires major reservoir area relocations.	• High unit water cost. • Requires major reservoir area relocations. • High reservoir area impacts.	• High unit water cost. • Requires major reservoir area relocations. • Very high reservoir area impacts.
Status	• **Retained** for further development – low unit water cost.	• **Retained** for further development – considerable accomplishments for planning objectives and low unit water cost.	• **Deleted** from further consideration – major relocations and high unit water cost.	• **Deleted** from further consideration – major reservoir impacts and high unit water cost.	• **Retained** for further consideration – high potential to meet current and future water shortages.

Notes:
[1] Percent replacement of CVPIA water reallocation.
[2] Unit cost for drought year yield.

Key:
AF = acre-feet
CVP = Central Valley Project
ROD = Record of Decision

- **Intermediate-Level Raise – 102.5 Feet** – On the basis of an estimated high unit cost per new system yield, this scenario also would result in low economic efficiency compared with the other dam raise scenarios. Primarily due to considerably higher implementation costs and unit costs for water supply reliability relative to overall accomplishments, this scenario was deleted from further consideration.

- **High-Level Raise – 202.5 Feet** – On the basis of an estimated high unit cost per new system yield, this scenario would result in relatively low economic efficiency. However, no other known single surface water storage project or combination of surface water projects in the Central Valley of California is as capable of considerably addressing the projected future water shortages with comparable unit water costs as the High-Level Raise scenario. This scenario could provide nearly half the total expected 2020 water shortages of the CVP and SWP. Also, it could almost completely fulfill the water supply replacement objectives of the CVPIA. It would, however, result in major resources impacts in the reservoir area. Primarily because unit costs for new water storage and for average annual yield reliability would be highly competitive at the magnitude of potential developed supplies compared to other surface water storage projects considered by CALFED, this scenario was carried forward for inclusion in a concept plan.

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Chapter 4
Concept Plans

A set of plans that were conceptual in scope (concept plans) was formulated from the retained management measures presented in Chapter 2. Because there is a vast array of potential measure combinations and sizes, the strategy was not to develop an exhaustive list of concept plans or to optimize outputs. Rather, the purpose of this phase of the formulation process was to (1) explore an array of different strategies to address the primary planning objectives, constraints, considerations, and criteria, and (2) identify concepts that warranted further development in the comprehensive plans phase.

The formulation strategy was to develop an array of concept plans representative of the range of potential actions to address objectives of the SLWRI. First, two sets of plans were developed that focused on either anadromous fish survival (AFS) or water supply reliability (WSR) as the single primary planning objective. Three AFS plans and four WSR plans were developed. Although the AFS and WSR plans focused on single planning objectives, each generally contributes to both primary planning objectives. In the three AFS concept plans, for example, emphasis was placed on the combinations of measures that could best address the fish survival goals while considering incidental benefits to WSR, if possible. Second, five concept plans were developed that included measures to address both primary and, to a lesser degree, secondary planning objectives. These are termed combined objective (CO) plans.

This chapter is organized into three sections, beginning with a discussion of the measures contained in the concept plans, including a discussion of features that are common to some or all of the plans. The AFS, WSR, and CO concept plans then are discussed individually. Last, the concept plans are compared to determine the relative scope of comprehensive alternative plans.

Overview of Concept Plan Features

Table 4-1 summarizes how the retained measures were combined to form concept plans that focus on anadromous fish, water supply reliability, or COs. The concept plans and their unique features are discussed individually in the remaining sections of this chapter. Raises of 6.5 feet and 18.5 feet were evaluated with enlarged storage capacities of 290,000 acre-feet and 636,000 acre-feet, respectively. Subsequent evaluations determined that the increases in capacity for these raises are 256,000 acre-feet and 634,000 acre-feet, respectively. Calculated values referenced in this chapter are from the June

2004 *Initial Alternatives Information Report* (Reclamation 2004a). The total capacity for the 18.5-foot raise was also refined to 5.19 MAF (from 4.55 MAF). The current comprehensive plans discussed in Chapter 5 reflect these changes.

Table 4-1. Summary of Concept Plan Features

Concept Plan	Features													
	Dam Raise	Primary Planning Objective Focus							Secondary Planning Objectives Addressed [4]					
		Water Supply Reliability [2]		Anadromous Fish Survival					Environmental Restoration			Flood Control and Hydropower		Recreation
	Raise Shasta Dam[1] (feet)	Increase Conservation Storage	Perform Conjunctive Water Management[3]	Reoperate Shasta Dam	Modify TCD	Replenish Spawning Gravel	Enlarge Shasta Lake Cold-Water Pool	Increase Minimum Flows[3]	Restore Shoreline Aquatic Habitat	Restore Tributary Aquatic Habitat	Restore Riparian Habitat	Modify Flood Control Operations and Implement Shasta Public Safety,[3] Features	Modify Hydropower Facilities	Maintain and Increase Recreation Opportunities
AFS-1	6.5	*		Changes to water supply operations and modification of the TCD would likely be included, to some extent, in any alternative that includes raising Shasta Dam.			X					Changes to flood control operations at Shasta Dam, Public Safety,[3] and hydropower facilities would likely be part of any alternative that includes physically modifying Shasta Dam; the degree and details of these changes will be included in feasibility level alternative plans.		Included in feasibility level alternative plans.
AFS-2	6.5	*					*	X						
AFS-3	6.5	*				X	*	X						
WSR-1	6.5	X					*							
WSR-2	18.5	X					*							
WSR-3	202.5	X					*							
WSR-4	18.5	X	X				*							
CO-1	6.5	X				X	X							
CO-2	18.5	X				X	X							
CO-3	18.5	X				X	X	X						
CO-4	6.5	X	X			X	X		X	X	X			
CO-5	18.5	X	X			X	X		X	X	X			

Notes:

[1] Raising Shasta Dam provides both water supply and temperature benefits, regardless of how the additional storage is exercised. While the AFS measures focus on use of the additional space for anadromous fish survival, they also provide significant water supply benefits. Similarly, the WSR measures focus on water supply reliability but the reservoir enlargements also provide coincidental benefits to anadromous fish.

[2] All concept plans will include attention to water demand reduction.

[3] These measures were used for evaluation because they were retained at the time of plan formulation. However, they have since been removed from consideration.

[4] Water quality was not used as an evaluation feature because it was not retained at the time of plan formulation.

Key:

* Coincidental benefit, although not a primary focus of the concept plan
AFS= anadromous fish survival
CO = combined objectives
TCD = temperature control device
WSR = water supply reliability
X = Primary focus of concept plan

Many of the concept plans share common physical features related to raising Shasta Dam. These include the physical or construction features of dam enlargement, and reservoir area relocations and other impacts.

Each of the concept plans includes enlarging Shasta Dam and Reservoir by 6.5 feet, 18.5 feet, or 202.5 feet. Table 4-2 summarizes various changes in Shasta Dam and Lake for the three dam raises.

Table 4-2. Shasta Dam and Lake Changes – Dam Raise Scenarios

Item	Existing	6.5-Foot Raise	18.5-Foot Raise	202.5-Foot Raise
Shasta Dam				
Type	Concrete Gravity	Concrete Gravity	Concrete Gravity	Concrete Gravity
Construction Means	-	Block Raise (crest)	Block Raise (crest)	Mass Raise (overlay)
Crest Elevation[4]	1,077.5	1,084.0	1,096.0	1,280.0
Dam Crest Length[4]	3,460	3,660	3,770	4,930
Dam Crest Width[4]	30	30	30	30
Shasta Lake				
Elevation Change				
Increase in Full Pool[4]	-	8.5	20.5	204.5
Elevation of Full Pool[4]	1,067.0	1,075.5	1,087.5	1,271.5
Elevation Minimum Operating Pool[4]	840	840	840	840
Capacity (1,000 acre-feet)				
Capacity Increase	-	290[1]	636[1]	9,338
Total at Full Pool[2]	4,552	4,842[1]	5,188	13,890
Minimum Operating Pool	590	590 / 880[3]	590	590
Surface Area Increase (acres)	-	1,100	2,500	31,200

Notes:

1 Subsequent evaluations refined the storage capacity increase with a 6.5-foot raise and with an 18.5-foot raise to 256,000 acre-feet and 634,000 acre-feet, respectively. Total capacity for an 18.5-foot raise has been refined to 5,190,000 acre-feet.

2 Increase in full pool elevation is greater than the magnitude of the dam raise, largely due to the increased efficiency of the steel radial spillway gates that would replace the existing drum gates.

3 Concept Plan AFS-1 includes increasing the minimum operating pool to 880,000 acre-feet. All other plans assume an existing minimum operating pool of 590,000 acre-feet.

4 All elevations are in feet above mean sea level.

Plans Focused on Anadromous Fish Survival

Three concept plans were formulated from the management measures retained to address the primary planning objective of anadromous fish survival. The main focus of these concept plans is on anadromous fish survival in the upper Sacramento River, but each contributes somewhat to water supply reliability. While numerous possible combinations of the type and size of the measures make up these concept plans, those shown in Table 4-1 and described below are believed to be reasonably representative of the range of potential actions.

Each of the three AFS concept plans includes raising Shasta Dam 6.5 feet, which would raise the full pool level by 8.5 feet and enlarge the reservoir by 290,000 acre-feet. Although larger dam raises could produce greater benefits to fisheries, the goal at this stage in plan formulation was to provide a common baseline from which the relative performance of the three AFS concept plans could be compared. The primary difference between the three AFS concept plans is in how the additional storage gained by the raise would be used to benefit anadromous fish. AFS-1 focuses the additional storage on regulating water temperature in the upper Sacramento River, while AFS-2 and AFS-3 focus the additional storage on regulating flows in the upper Sacramento River. AFS-3 also adds an additional increment, fish habitat restoration on the upper Sacramento River.

AFS-1– Increase Cold-Water Assets with Shasta Operating Pool Raise (6.5 Feet)

AFS-1 focuses on the primary planning objective of anadromous fish survival by raising Shasta Dam 6.5 feet to enlarge the pool of cold water in Shasta Lake. Major plan components include (1) raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the cold-water pool and regulating water temperature in the upper Sacramento River and (2) increasing the size of the minimum operating pool to 880,000 acre-feet.

Both of the major plan components focus on increasing the volume of cold water in Shasta Lake available for regulating water temperature on the upper Sacramento River. AFS-1 would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 MAF. The existing TCD would be extended and potentially modified. In addition, the minimum end-of-October carryover storage target would be increased from 1.9 MAF to about 2.2 MAF, increasing the minimum operating pool to 880,000 acre-feet. This would allow additional cold water to be stored for use the following year. No changes would be made to the existing seasonal temperature targets for anadromous fish on the upper Sacramento River, but the ability to meet these targets would be improved.

For this plan, major relocations include modifying the Pit River Bridge, replacing 7 other bridges, relocating 45 structures, and inundating numerous small segments of existing paved and nonpaved roads. About 20 buildings associated with marinas or resorts would be affected directly, and about 25 other buildings associated with ancillary facilities could be affected indirectly because of their proximity to the new water surface at full pool.

Major benefits of AFS-1 include the following:

- **Anadromous Fish Survival –** Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. AFS-1 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. This would be accomplished by raising Shasta Dam by 6.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD, and can have an extended influence on river temperatures farther downstream. Hence, the most significant benefits to anadromous fish would occur upstream from Red Bluff, but some degree of benefit could be realized as far downstream as the Delta.

  Relationships between anadromous fish mortality and environmental conditions (including water temperature) are very complex. Recent significant strides have been made, however, to try and assess these relationships and resulting influences on increases or decreases in fish populations. For this study, the SALMOD computer model was used to simulate the dynamics of freshwater salmonid populations in the upper Sacramento River. The model's premise is that egg and fish mortality are directly related to spatially and temporally variable micro- and macrohabitat limitations, which themselves are related to the timing and amount of streamflow and other meteorological variables. Information on this model and its application to the SLWRI is presented in the Modeling Appendix. On the basis of this model assessment, it is estimated that AFS-1 could significantly contribute to an average annual increase (reduction in mortality) of salmon. For higher dam raise scenarios with corresponding increases in the minimum operating pool, the benefit to salmon would be proportionally greater.

- **Water Supply Reliability –** AFS-1 would only incidentally contribute to increasing the water supply reliability of the CVP and SWP systems.

- **Other Benefits –** Although the focus of this concept plan was on benefiting anadromous fish in the upper Sacramento River by increasing the cold-water pool in Shasta Lake, minor secondary benefits would occur. The higher water surface in the reservoir would result in a net increase in power generation. The ability to manage floods would not increase significantly. AFS-1 does not include any specific measures to address the secondary planning objective of environmental restoration. Water-oriented recreation at Shasta Lake, and the services it supports, are very important to the economic health and well-being of the community of Redding and surrounding area. AFS-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

The most significant benefit of AFS-1 is the significant increase in anadromous fish population. The plan would not provide significant benefits to water supply reliability, although it would provide incidental increases in hydropower. Consequently, all initial costs for this plan would be allocated to anadromous fish survival.

AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 Feet)

AFS-2 focuses on the primary planning objective of anadromous fish survival by increasing minimum seasonal flows in the upper Sacramento River from the current 3,250 cfs to about 4,200 cfs. The primary component of AFS-2 includes raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run salmon on the upper Sacramento River.

Additional storage created by raising the dam would be focused on increasing the minimum flow target for winter-run Chinook salmon on the upper Sacramento River, consistent with the goals of the January 2001 *Final Restoration Plan* for the Anadromous Fish Restoration Program. Similar to AFS-1, this concept plan would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 MAF, and extend the existing TCD to achieve efficient use of the expanded reservoir. AFS-2 differs from AFS-1 in that the additional storage would be used to increase minimum flows, rather than temperature, and no changes would be made to the carryover target volume or minimum operating pool.

For this concept plan, the additional storage would allow the minimum flow target in the upper Sacramento River to be increased from 3,250 cfs to 4,200 cfs, without adversely impacting water supply deliveries to the CVP. Although 4,200 cfs does not represent flows that produce optimal spawning conditions in the river (closer to 5,000 cfs), it is believed to represent a possible balance between the various beneficial uses of the reservoir.

The benefits of AFS-2 are as follows:

- **Anadromous Fish Survival –** In addition to temperature, river flow is an important factor influencing anadromous fish survival. Flows in the upper Sacramento River are highly influenced by releases from Shasta Dam, particularly during dry years. Higher instream flows would provide access to additional spawning and rearing habitat sites, extend the area of suitable habitat farther downstream, and generally improve aquatic and riparian habitat conditions along the river. Further, over 80 percent of the total (combined) population of spring-run, late-fall-run, and endangered winter-run Chinook salmon spawn between Keswick Dam and Battle Creek. AFS-2 would use the additional 290,000 acre-feet of storage in Shasta to increase minimum flows in this reach of the upper Sacramento River between October 1 and April 30. Benefits would occur primarily during drier years, when flows often fall to the current minimum flow of 3,250 cfs. For example, the average daily outflow from Keswick fell below 4,200 cfs on about 175 days between 1998 and 2004 (period of current operating rules). It should be noted that this figure represents flows averaged over 24-hour periods, and does not reflect hourly fluctuations or every day that flows fell below 4,200 cfs (or the duration of these occurrences).

  A preliminary assessment was conducted, using an existing hydraulic model of the upper Sacramento River, to estimate the increase in available spawning habitat that would occur if flows increased from 3,250 cfs to 4,200 cfs. Although the preliminary assessment has limitations, it provides a means for comparing the relative performance of the concept plans. On the basis of this assessment, it is estimated that AFS-2 could decrease the amount of spawning area between Keswick and Battle Creek that normally becomes dewatered during low flow years by about 170 acres.

  Although the focus of AFS-2 is on increasing minimum flows, raising Shasta Dam also increases the available cold-water pool and allows operators greater flexibility in regulating water temperature in the upper Sacramento River. Based on preliminary analyses, improved temperature conditions under AFS-2 would result in an estimated average annual increase of the salmon population.

- **Water Supply Reliability** – As mentioned previously, using the additional storage to increase minimum flows would result in little or no increase in water supply reliability to the CVP. However, AFS-2 would incidentally contribute to increasing average and dry period water supply reliability to the SWP system. This increase corresponds to about 20,000 acre-feet during critical years.

- **Other Benefits** – A preliminary assessment indicated that the higher water surface in the reservoir would result in a net increase in power generation. Flood control operations at Shasta Dam and Reservoir would continue as under existing conditions. AFS-2 does not include any specific measures to address the secondary planning objective of environmental restoration. However, increasing minimum flows would provide incidental benefits to riparian habitat along the upper Sacramento River. AFS-2 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described for AFS-1. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

AFS-3 – Increase Minimum Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 Feet)

AFS-3 addresses the primary planning objective of anadromous fish survival through a dual focus on (1) instream habitat restoration and (2) increasing minimum seasonal flows on the upper Sacramento River by enlarging Shasta Dam and Reservoir, similar to AFS-2. Major plan components include (1) raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run Chinook salmon on the upper Sacramento River and (2) acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to restore about 150 acres of aquatic and floodplain habitat.

These components are focused on increasing the quality and quantity of spawning habitat on the upper Sacramento River. Similar to AFS-2, minimum spring flows for winter-run Chinook salmon would increase from 3,250 cfs to 4,200 cfs; the capacity of the reservoir would increase by 290,000 acre-feet to a total of 4.84 MAF; and the existing TCD would be extended to achieve efficient use of the expanded reservoir.

AFS-3 differs from AFS-2 in that an additional increment of instream habitat would be provided by gravel mine restoration along the upper Sacramento River. For the purpose of this initial evaluation, suitable areas totaling 150 acres would be chosen from one or more abandoned gravel mines (see potential sites in Figure 4-1).

Restoration would involve filling deep pits, recontouring the stream channel and floodplain to mimic more natural topography, and reconnecting the reclaimed area to the Sacramento River. Side channels and other features would be created to encourage spawning and rearing, and restored floodplain lands would be revegetated using native riparian plants.

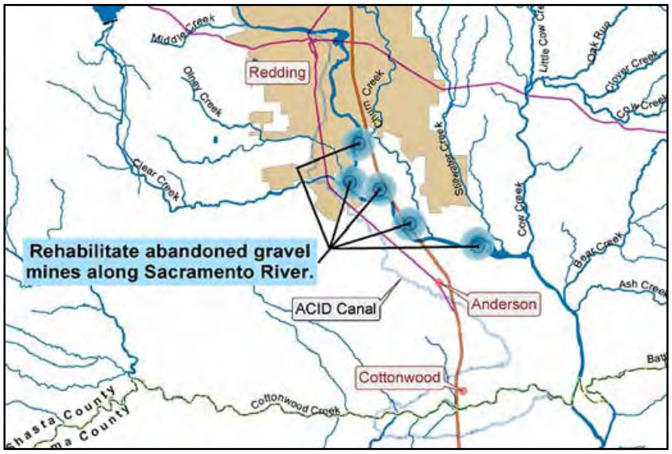

Figure 4-1. Potential Locations Along Sacramento River Where Abandoned Gravel Mines Could Be Considered for Restoration

The primary benefits of AFS-3 include the following:

- **Anadromous Fish Survival** – As described previously, instream flows and the availability of suitable aquatic habitat in the reach between Keswick Dam and Battle Creek are particularly influential on the survival of anadromous fish. AFS-3 would support the primary planning objective of anadromous fish survival by increasing minimum flows from October 1 through April 30 and restoring 150 acres of aquatic and floodplain habitat at one or more inactive gravel mines on the upper Sacramento River. Together, it is estimated that the minimum flow increase and habitat restoration would add approximately 320 acres (restored gravel mines at 150 acres and increased flows at 170 acres) of potential spawning habitat to the upper Sacramento River between Keswick and Battle Creek.

- **Water Supply Reliability** – AFS-3 would incidentally contribute to increasing average and dry period water supply reliability to the SWP system. This increase corresponds to about 20,000 acre-feet during critical years.

- **Other Benefits** – The higher water surface elevations in the reservoir would result in a net increase in power generation of about 32 gigawatt-hours (GWh) per year. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. AFS-3 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that of AFS-1 and AFS-2. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

Plans Focused on Water Supply Reliability

Four concept plans were formulated from the management measures retained to address the primary planning objective of increasing water supply reliability. Although each WSR concept plan contributes somewhat to both primary planning objectives, these four plans focus on the objective of increased water supply reliability. As with the previous set of plans that focus on anadromous fish survival, numerous potential measure combinations and sizes exist. The magnitude of enlarging Shasta Dam was important when developing the WSR concept plans because storage capacity is the most influential factor in determining benefits to water supply reliability for this study. Hence, three dam raises were considered in the WSR concept plans: 6.5 feet, 18.5 feet, and 202.5 feet. The concept plans summarized in Table 4-1 and described below are believed to be reasonably representative of the range of potential actions to address the primary planning objective of water supply reliability.

The majority of water supply reliability benefits for all water supply reliability plans consist of increases in south-of-Delta agricultural water deliveries. The remaining benefits are seen in increased water deliveries for south-of-Delta M&I and north-of-Delta agricultural and M&I uses.

WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 Feet)

WSR-1 focuses on the primary planning objective of water supply reliability by increasing the volume of water stored in Shasta Lake with a 6.5-foot dam raise. Major components of this concept plan include (1) raising Shasta Dam by 6.5 feet for the primary purpose of creating 290,000 acre-feet of additional storage available for water supply and (2) revising flood control operations to benefit water supply reliability by managing floods more efficiently.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. This plan is similar to AFS-1, but the additional storage would be operated for water supply reliability as under existing operational guidelines. Similar to AFS-1, this concept plan would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 MAF and extend the existing TCD for efficient use of the expanded cold-water pool.

In addition, WSR-1 includes revisions to the operational rules for flood control such that the facility could potentially be managed more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply. This would be accomplished using advanced weather forecasting tools. A primary constraint of this component of WSR-1 is that the existing level of flood protection provided by Shasta Dam would not be adversely impacted.

Major benefits of WSR-1 include the following:

- **Anadromous Fish Survival –** Although the focus of WSR-1 is on improving water supply reliability, raising Shasta Dam also would increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about half that for AFS-1.

- **Water Supply Reliability –** WSR-1 would increase water supply reliability by increasing critical and dry year yield of the CVP and SWP. This would help reduce estimated future shortages by increasing critical and dry period supplies by at least 72,000 acre-feet per year. This increase in reliability also could help reduce supplies redirected by the CVPIA during drought years by about 13 percent.

- **Other Benefits –** The higher water surface elevation in the reservoir would result in a net increase in power generation. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. WSR-1 does not include any specific measures to address the secondary planning objective of environmental restoration. Similar to the AFS plans, WSR-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 Feet)

WSR-2 focuses on the primary planning objective of water supply reliability by raising Shasta Dam 18.5 feet. The major components of this plan include (1) raising Shasta Dam by 18.5 feet for the primary purpose of creating 634,000 acre-feet of additional storage available for water supply and (2) revising flood control operations to benefit water supply reliability by managing floods more efficiently.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. Although higher dam raises are technically and physically feasible, 18.5 feet is the largest practical dam raise that does not require relocating the Pit River Bridge. The 18.5-foot raise would increase the capacity of the reservoir by 634,000 acre-feet to a total of 5.19 MAF (see Table 4-2). Operations for the added storage in the reservoir would be similar to existing operations. The existing TCD would be extended for efficient use of the expanded cold-water pool. As described for WSR-1, this concept plan would include modifying flood control operation rules to manage the reservoir more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply.

The plan includes constructing a protection dike for I-5 at Lakeshore Drive and the UPRR at Bridge Bay. To offset potential impacts to lake area infrastructure, the plan would include modifications to the Pit River Bridge, replacement of 7 other bridges, acquisition and/or relocation of 130 structures, and relocation of small segments of existing paved and nonpaved roads. In addition, two power transmission lines, several water storage tanks, and three USFS fire stations and ancillary facilities also would be relocated. Portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road would be relocated. To offset potential impacts to seasonal boat traffic under the Pit River Bridge, the plan would need to include features such as boat scheduling assistance and/or financial compensation.

The primary benefits of WSR-2 include the following:

- **Anadromous Fish Survival –** Although the focus of WSR-2 is on improving water supply reliability, raising Shasta Dam by 18.5 feet would increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about 30 percent over AFS-1.

- **Water Supply Reliability** – WSR-2 would increase water supply reliability by increasing the critical and dry year yield of the CVP and SWP. This would help reduce estimated future shortages by increasing critical and dry period supplies by at least 125,000 acre-feet per year. This increase in reliability could also help reduce CVPIA-redirected supplies during drought years by about 20 percent.

- **Other Benefits –** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 44 GWh per year. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. WSR-2 does not include any specific measures to address the secondary planning objective of environmental restoration. The water-oriented recreation experience at Shasta Lake would generally increase due to the increase in lake surface area. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level)

WSR-3 focuses on the primary planning objective of water supply reliability by raising Shasta Dam by 202.5 feet. Major components of this plan include (1) raising Shasta Dam by about 202.5 feet for the primary purpose of creating 9.3 MAF of additional storage available for water supply and (2) major modifications to or replacing dam appurtenances, including hydropower facilities and the TCD.

Raising Shasta Dam by about 202.5 feet is considered to be the largest technically feasible raise without completely reconstructing the existing dam. The 202.5-foot raise would increase the capacity of the reservoir by 9.3 MAF to a total of 13.9 MAF. The magnitude of this raise would require significant modifications or replacement of most facilities associated with the dam (see Table 4-2). The existing TCD would be replaced, and modifications to hydropower facilities would include replacing gates and structural supports for the penstocks, adding generator units to the powerplant, replacing the switchyard, and modifying Keswick Dam and its powerplant. The additional storage in the reservoir would be operated primarily for water supply, but the magnitude of the raise also would significantly increase the cold-water pool and the ability of dam operators to meet both temperature and minimum flow requirements on the upper Sacramento River.

Because of the extensive area impacts associated with WSR-3, the plan would need to include major facilities aimed at offsetting these impacts. At minimum, they would include relocating the Pit River Bridge, replacing 20 other bridges, removing Pit 7 Dam, relocating about 630 structures, and inundating numerous large segments of existing paved and nonpaved roads. About 35 miles of the UPRR, 19 miles of I-5, and numerous associated tunnels, embankments, and other facilities would be relocated. The plan would need to include significant facilities to mitigate for impacts to reservoir area recreation facilities. The plan would include extensive facilities to mitigate impacts to environmental, historical, and other cultural resources around Shasta Lake.

The Pit 7 Dam is located at the existing headwater of Shasta Lake (see Figure 4-2). The dam is 200 feet high and was constructed for hydropower purposes in the mid-1960s by PG&E. The full pool elevation for WSR-3 would be similar to the existing top of the Pit 7 Dam, inundating all facilities at the dam. Electric generation lost at Pit 7 would be replaced from the facilities added at the enlarged Shasta Dam.

Figure 4-2. Pit 7 Dam, Located on the Pit River Upstream from Shasta Lake, is 200 Feet High

Major benefits of WSR-3 include the following:

- **Anadromous Fish Survival –** Raising Shasta Dam by 202.5 feet would substantially increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. Preliminary analyses indicate that improved water temperature conditions could result in a major average increase in salmon population. The additional storage also would provide operators with greater flexibility in meeting minimum flow requirements on the upper Sacramento River. Detailed studies are required to more accurately quantify the increase in anadromous fish populations resulting from such a large increase in the capacity of Shasta Dam and Reservoir.

- **Water Supply Reliability –** WSR-3 would significantly increase water supply reliability for the CVP and SWP systems. This would help reduce estimated future shortages, increasing critical and dry period supplies by over 700,000 acre-feet per year. This increase in reliability would likely offset CVPIA-redirected supplies during drought years.

- **Other Benefits –** The higher water surface elevation in the reservoir would result in a significant net increase in power generation, amounting to almost 2.3 million GWh per year. Much of this increase would be offset, however, by the loss of generation from the Pit 7 Dam, which would be removed. A potential would also exist to significantly increase the ability to control larger flood events in the Sacramento River near Redding. WSR-3 does not include any specific measures to address the secondary planning objective of environmental restoration. The water-oriented recreation experience at Shasta Lake would generally increase because of the increase in lake surface area. The maximum surface area of the lake would increase by about 31,200 acres (roughly twice that of existing conditions), from 29,600 to about 60,800 acres.

WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 Feet) and Conjunctive Water Management

WSR-4 focuses on the primary planning objective of water supply reliability by raising Shasta Dam 18.5 feet in combination with conjunctive water management. Major components of this plan include (1) raising Shasta Dam by 18.5 feet for the primary purpose of creating 634,000 acre-feet of additional storage available for water supply and (2) implementing a conjunctive water management program.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. The 18.5-foot raise would increase the capacity of the reservoir by 636,000 acre-feet to a total of 5.19 MAF (see Table 4-2). Operations for the added storage in the reservoir would be similar to existing operations. The existing TCD would be extended for efficient use of the expanded cold-water pool. As described for WSR-1, this concept plan would include modifying flood control operation rules to manage the reservoir more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply.

The conjunctive water management component would consist largely of contract agreements between Reclamation and certain Sacramento River basin water users. It also would include any additional river diversions, increase in current diversion capacity, and/or transmission facilities to facilitate the exchange.

Major benefits of WSR-4 include the following:

- **Anadromous Fish Survival** – Raising Shasta Dam by 18.5 feet would increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population similar to AFS-1.

- **Water Supply Reliability** – WSR-4 would increase water supply reliability by increasing the critical and dry year yield of the CVP and SWP. The combination of increased storage space in Shasta Reservoir and exchanged surface water for participating Sacramento River water users would result in an increase in water supply reliability of about 146,000 acre-feet per year. This increase in reliability could also help reduce CVPIA-redirected supplies during drought years.

- **Other Benefits**– The higher water surface elevation in the reservoir would result in a net increase in power generation. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. WSR-4 does not include any specific measures to address the secondary planning objective of environmental restoration. The water-oriented recreation experience at Shasta Lake would generally increase because of the increase in lake surface area. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Plans Focused on Combined Objectives

Various concept plans were formulated from the retained management measures to represent a reasonable balance between the two primary planning objectives. Five of the plans are shown in Table 4-1. The CO concept plans shown in the table and described below include measures to actively address the secondary planning objectives, as appropriate. As with previous concept plans, numerous potential sizes and combinations of components are possible. However, for comparison purposes, three CO concept plans described below include raising

Shasta Dam by 18.5 feet and two involve raising Shasta Dam by 6.5 feet. It is believed that they are reasonably representative, although not exhaustively, of the range of potential and applicable actions.

CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet)

CO-1 addresses both primary planning objectives by restoring anadromous fish habitat and raising Shasta Dam by 6.5 feet.

CO-1 includes the following major components:

- Raising Shasta Dam by 6.5 feet for the purposes of expanding the cold-water pool and creating 290,000 acre-feet of additional storage available for water supply.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-1 would use the additional storage created by the 6.5-foot raise to increase water supply reliability, while also improving the ability to meet water temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 290,000 acre-feet to a total of 4.84 MAF, and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for aquatic and floodplain restoration from one or more abandoned gravel mines on the upper Sacramento River (see previous discussion of AFS-3).

Benefits of CO-1 are described below:

- **Anadromous Fish Survival –** CO-1 would increase the ability of Shasta Dam to make cold-water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. Preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 410 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-1 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 72,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** Higher water surface elevations in the reservoir would result in a small net increase in power generation of about 15 GWh per year.

- **Other Benefits –** CO-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating a 6.5-foot raise. The maximum surface area of the lake would increase by about 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)

CO-2 addresses both primary planning objectives by raising Shasta Dam by 18.5 feet and restoration of anadromous fish habitat.

CO-2 includes the following major components:

- Raising Shasta Dam by 18.5 feet for the purposes of expanding the cold-water pool and creating 636,000 acre-feet of additional storage available for water supply.

- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.

- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-2 is similar to CO-1, except Shasta Dam would be raised 18.5 feet instead of 6.5 feet. The additional storage created by the 18.5-foot dam raise would be used to increase water supply reliability, while also improving the ability to meet water temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 636,000 acre-feet to a total of 5.19 MAF, and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for aquatic and floodplain restoration from one or more abandoned gravel mines (see previous discussion of AFS-3).

Benefits of CO-2 are described below:

- **Anadromous Fish Survival –** CO-2 would increase the ability of Shasta Dam to make cold-water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. Preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 1,110 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-2 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 125,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** The higher water surface elevations in the reservoir would result in a net increase in power generation of about 44 GWh per year. The ability to control floods may increase by a small degree.

- **Other Benefits –** CO-2 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)

CO-3 addresses both primary planning objectives by raising Shasta Dam by 18.5 feet, restoring anadromous fish habitat, and improving flow conditions on the upper Sacramento River.

CO-3 includes the following major components:

- Raising Shasta Dam by 18.5 feet, expanding the cold-water pool, and creating 636,000 acre-feet of additional storage available for both water supply and flow regulation.

- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.

- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-3 is similar to CO-2, except a portion of the additional storage created by the 18.5-foot dam raise would be dedicated to managing flows for winter-run salmon on the upper Sacramento River. The additional storage space could be allocated to fisheries and water supply reliability in many different ways; additional investigation would be needed to assess combinations that could best address the two major objectives. For the purpose of this initial analysis, dedicating about 320,000 acre-feet to increasing minimum flows is believed to be a good estimation of the potential benefits of this concept.

Minimum flows on the upper Sacramento River would be increased from 3,250 cfs to about 4,200 cfs between October 1 and April 30 (see previous discussion of AFS-2), consistent with the Anadromous Fish Restoration Program. Suitable areas totaling 150 acres would be chosen for restoration from one or more abandoned gravel mines (see previous discussion of AFS-3). Temperature benefits also would be gained by increasing the size of the cold-water pool.

The existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1).

Benefits of concept CO-3 are described below:

- **Anadromous Fish Survival –** CO-3 would benefit anadromous fish by increasing seasonal minimum flows and improving water temperature conditions in the upper Sacramento River, primarily in dry and critically dry years. Significant additional effort is needed to reliably quantify potential benefits to the anadromous fish population from this concept. However, preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 980 salmon. Habitat restoration and minimum flow increases would add an additional 320 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-3 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 90,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** Higher water surface elevations in the reservoir would result in a net increase in power generation of about 61 GWh per year. The ability to control floods may increase to a small degree.

- **Other Benefits –** CO-3 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise.

CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)

CO-4 addresses the primary and secondary planning objectives through raising Shasta Dam 6.5 feet in combination with conjunctive use, habitat restoration, and environmental restoration in the Shasta Lake area and upper Sacramento River.

CO-4 includes the following major components:

- Raising Shasta Dam by 6.5 feet, expanding the cold-water pool, and creating 290,000 acre-feet of additional storage available for water supply reliability.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Implementing a conjunctive water management program.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek.
- Restoring 500 acres of wetland and riparian habitat along the Sacramento River at one or more sites between Redding and Red Bluff.

CO-4 addresses both primary and secondary objectives of the SLWRI through a combination of measures. It would improve anadromous fish survival by increasing the cold water pool in Shasta Reservoir and restoring 150 acres of valuable aquatic and floodplain habitat on the upper Sacramento River. The concept would improve water supply reliability through increasing the storage space in Shasta Reservoir by 290,000 acre-feet, implementing conjunctive water management, and re-operating the reservoir more efficiently for flood control. The secondary objective of environmental restoration also would be addressed through shoreline and tributary habitat improvements around Shasta Lake, and riparian restoration along the upper Sacramento River.

CO-4 includes restoring (1) resident fish habitat in Shasta Lake and (2) riparian habitat at four locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek (see Figure 4-3).

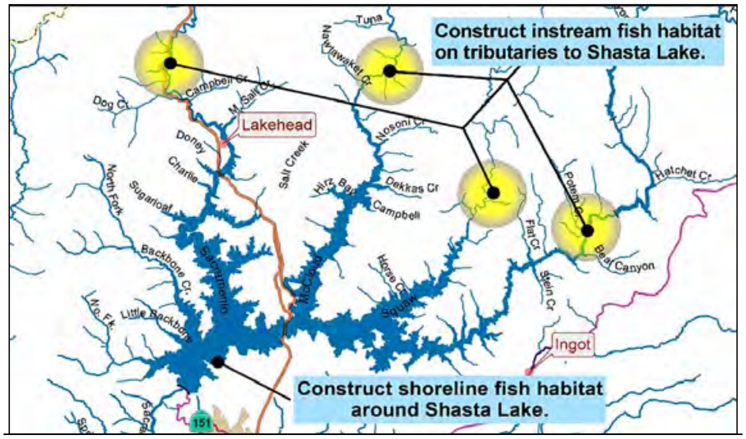

Figure 4-3. Potential Ecosystem Restoration Features in the Shasta Lake Area

This component includes improving shallow, warm-water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. These improvements would help provide favorable spawning conditions; juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Establishing vegetation also could benefit terrestrial species that inhabit the shoreline of Shasta Lake.

This concept also includes improving and restoring instream aquatic habitat along the lower reaches of major tributaries to Shasta Lake using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments could include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that cause scouring and help clean gravel. The lower reaches of perennial tributaries to Shasta Lake would be targeted for aquatic restoration because they provide year-round fish habitat.

Also included in CO-4 is acquisition and restoration of wetland and riparian areas along the upper Sacramento River. The location and total area of potential restoration will be the subject of future studies. However, for initial planning purposes, restoration of 500 acres along the Sacramento River between Keswick and Red Bluff is included in this concept.

Major benefits of CO-4 are described below:

- **Anadromous Fish Survival –** CO-4 would benefit anadromous fish by improving water temperature conditions in the upper Sacramento River, primarily in dry and critically dry years, and increasing the quality and quantity of aquatic habitat. Significant additional effort is needed to reliably quantify potential benefits to the anadromous fish population from this concept. However, preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 410 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-4 would increase average and dry period water supply reliability to the CVP and SWP systems through reservoir expansion and conjunctive water management. This increase corresponds to about 89,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** CO-4 includes restoring resident fish habitat in Shasta Lake and riparian habitat at four locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek. An additional 548 acres of riparian and wetland habitat would be acquired and restored along the upper Sacramento River. The location and total area of restoration in the Shasta Lake and upper Sacramento River areas will be the subject of future studies. Minor increases in hydropower production and flood protection would occur.

- **Other Benefits –** CO-4 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating a 6.5-foot raise.

CO-5 – Multipurpose with Shasta Enlargement (18.5 feet)

CO-5 addresses both primary planning objectives by raising Shasta Dam 18.5 feet in combination with conjunctive water management and anadromous fish habitat restoration.

Major plan components of CO-5 include the following:

- Raising Shasta Dam by 18.5 feet, expanding the cold-water pool, and creating 636,000 acre-feet of additional storage available for water supply.

- Implementing a conjunctive water management program.

- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.

- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek.

- Restoring 500 acres of wetland and riparian habitat at one or more sites between Redding and Red Bluff on the Sacramento River.

CO-5 is similar to CO-4, except Shasta Dam would be raised 18.5 feet instead of 6.5 feet. The additional storage created by the 18.5-foot dam raise would be used primarily to increase water supply reliability, while also improving the ability to meet water temperature objectives for winter-run salmon during drought years. The capacity of the reservoir would increase by 636,000 acre-feet to a total of 5.19 MAF and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revising the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for restoration from one or more abandoned gravel mines (see previous discussion of AFS-3). As with CO-4, the secondary objectives of environmental restoration would be addressed through shoreline and tributary habitat improvements around Shasta Lake, and 500 acres of riparian restoration along the upper Sacramento River.

Major benefits of CO-5 include the following:

- **Anadromous Fish Survival –** CO-5 would increase the ability of Shasta Dam to make cold-water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. Preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 1,110 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-5 would increase average and dry period water supply reliability to the CVP and SWP systems through increasing the capacity of Shasta Lake in combination with conjunctive water management. This increase corresponds to about 146,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** Higher water surface elevations in the reservoir would result in a net increase in power generation of about 44 GWh per year. The ability to control floods may increase by a small degree. An additional 500 acres of riparian and wetland habitat would be acquired and restored along the upper Sacramento River between Red Bluff and Redding. The location and total area of restoration in the Shasta Lake and upper Sacramento River areas will be the subject of future studies.

- **Other Benefits –** CO-5 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Summary Comparison of Concept Plans

To help focus the plan formulation process and select the most appropriate plans to be carried forward for further development, the concept plans were compared considering two basic planning criteria: effectiveness and efficiency. These are two of four criteria identified in the P&G for water resources planning, in addition to completeness, and acceptability. Below is a description of the two criteria and their application. Table 4-3 shows the resulting comparison of the concept plans based on their relative ability to address each of the criteria. As can be seen in the table and described below, each plan was assigned a relative ranking ranging from very low to very high for each criterion. Each comparison criterion for the concept plans in the table received the same weighting and resulted in an overall relative ranking. This overall ranking was used, along with other information, to determine if a concept plan should be considered further in the plan formulation process in the SLWRI.

Effectiveness

Effectiveness is the extent to which a plan alleviates problems and achieves objectives. For the primary planning objective of anadromous fish survival, two major relative ranking factors were considered: (1) increasing salmon survival (decreased salmon mortality) and (2) increasing habitat for spawning. For water supply reliability, ranking was based on the relative amount of new drought period yield that could be derived from each concept plan. For the secondary planning objectives, three relative ranking factors were considered: (1) whether a plan included ecosystem restoration, (2) potential to affect flood peaks downstream from Keswick Dam, and (3) potential to increase net electric energy. Primary planning objectives received 80 percent of the weight and secondary planning objectives received 20 percent of the weight for this criterion.

As indicated in Table 4-3, concept plans with the greatest effectiveness in meeting planning objectives are WSR-3, CO-2, and CO-5. This is primarily because, of the 12 concept plans, these three would generally result in the greatest combined contribution to both primary planning objectives. Each AFS-focused plan, when compared to other concept plans, ranks low primarily because the AFS plans would provide limited benefits to other planning objectives. The same conclusions apply to the larger sizes of raising Shasta Dam.

Table 4-3. Summary Comparison of Concept Plans

Concept Plans	Comparison Criteria		Identified Status and Relative Ranking
	Effectiveness	Efficiency	
AFS-1 – Increase Cold-Water Assets with Shasta Operating Pool Raise (6.5 feet)	Significantly effective in helping benefit anadromous fish survival. Does not significantly contribute to water supply reliability if all storage is dedicated to fisheries purposes. Incidental contribution to flood control and hydropower objectives.	Because contributes to only one primary planning objective (anadromous fish survival), results in greatest cost for that purpose.	Enlarging Shasta only for increasing the cold-water pool is **identified** for further consideration as a stand-alone plan. Although this plan addressed only one primary planning objective, if considered in a larger plan (allocation of space), this plan might be found feasible.
Relative Rank	*Moderate*	*Low*	*Moderate*
AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 feet)	Relatively low increase in fish habitat with uncertain benefit to increased survival. Major trade-off in water supply reliability for relatively minor increased minimum flows. Incidental contribution to flood control and hydropower objectives.	Very high unit costs for increased fish habitat. Also, very high unit cost for water supply reliability. High costs due to dedicating storage space to increasing minimum winter/spring flows with little contribution to water supply.	Enlarging Shasta primarily to increase winter/spring river flows for anadromous fish is **not identified** for further consideration as a stand-alone plan. Very high costs for marginal increases in meeting objectives. Same conclusion for any sized project with similar component measures. However, potential operational changes to increase fish survival are **identified** for further study as part of any plan considered.
Relative Rank	*Low*	*Low*	*Low*
AFS-3 – Increase Minimum Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 feet)	Similar to AFS-2. Increased effectiveness in anadromous fish habitat through gravel mine restoration.	Similar to AFS-2. Very high unit costs to meet primary planning objective.	Similar to AFS-2, **not identified** for further consideration as a stand-alone plan. High costs for marginal increases in meeting objectives.
Relative Rank	*Low*	*Low*	*Low*
WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)	Relatively low potential to effectively increase water supply reliability and improve fish survival. Incidental contribution to flood control and hydropower objectives.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects.	Enlarging Shasta primarily for water supply reliability from sizes 6.5 feet to about 18.5 feet is **identified** for further development primarily because (1) consistent with goals of the 2000 CALFED ROD, (2) high cost-efficiency compared to other new sources, and (3) provides significant incidental benefits to anadromous fish and secondary study objectives.
Relative Rank	*Low*	*Moderate*	*Moderate*

Table 4-3. Summary Comparison of Concept Plans (contd.)

Concept Plans	Comparison Criteria		Identified Status and Relative Ranking
	Effectiveness	**Efficiency**	
WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)	Moderate potential to effectively address primary planning objectives. Significant contribution to water supply reliability. Incidental contribution to flood control and hydropower objectives.	Very high cost-efficiency. Superior to all other known new sources, including potential surface water storage projects.	**Identified** for further development for reasons similar to WSR-1. Also, enlarging Shasta to maximum extent possible without major relocations can maximize cost-efficiency.
Relative Rank	*Moderate*	*Very High*	*High to Very High*
WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level)	High potential to significantly address primary planning objectives. Significantly addresses water supply reliability. Can contribute significantly to cold-water salmon resources. Provides major opportunities to address secondary planning objectives.	Very high implementation cost. Relatively high unit cost for new water supplies.	**Not Identified** for further consideration at this time. High social and environmental impacts in Shasta Lake area. Very high implementation cost.
Relative Rank	*High*	*Low*	*Low*
WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management	Similar to WSR-2 with increased contribution to water supply reliability through conjunctive use management. However, significantly diminishes potential increased fish survival benefits.	High cost-efficiency for water supply reliability. Estimated to result in the lowest unit cost of all plans considered and of all other known potential water supply reliability projects.	Enlarging Shasta to maximum extent possible without major relocations and including conjunctive water management component is **not identified** for further development. Although cost-efficient, it diminishes fish survival benefits to achieve additional water supply reliability. No known active support for a conjunctive use component.
Relative Rank	*Low*	*Very High*	*Moderate to High*
CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet)	Potential to address primary planning objectives with emphasis on spawning habitat restoration. Contributes to cold-water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply.	Unit cost for water supply reliability competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along the upper river.	**Not identified** for further consideration as a stand-alone plan. Major components are redundant with WSR-1 and CO-2, which are recommended for further development.
Relative Rank	*Moderate*	*Moderate*	*Moderate*

Table 4-3. Summary Comparison of Concept Plans (contd.)

Concept Plans	Comparison Criteria		Identified Status and Relative Ranking
	Effectiveness	**Efficiency**	
CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to CO-1, but with increased potential to address primary and several secondary planning objectives due to increased storage space.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along the upper river.	Enlarging Shasta to the maximum extent possible (without major relocations), and including features to increase anadromous fish habitat is **identified** for further development. Recommended primarily because this plan is (1) consistent with goals of the CALFED ROD, (2) highly cost efficient, and (3) addresses most of the planning objectives.
Relative Rank	*High*	*High*	*High*
CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Low to moderate potential to effectively address primary objectives. Potential to significantly benefit salmon resources through restoring fish habitat. Provides major opportunities to address secondary objectives.	Reduced cost-efficiency for water supply reliability due to dedicated increased minimum flows.	For reasons similar to AFS-2 and AFS-3, enlarging Shasta with significant storage space dedicated to increased winter/spring flows for anadromous fish is **not identified** for further consideration as a stand-alone plan at this time. Very high costs for marginal increases in meeting objectives. However, potential operational changes to increase fish survival are recommended for further study as part of any plan considered.
Relative Rank	*Moderate*	*Moderate*	*Moderate*
CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)	Moderate potential to address primary planning objectives, with emphasis on spawning habitat restoration. Contributes to cold-water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	Most cost-efficient plan for a 6.5-foot dam raise. Moderate potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	**Not identified** for further consideration as a stand-alone plan with a 6.5-foot raise, primarily due to reduced effectiveness and efficiency. Major components are redundant with WSR-1 and CO-5, which are recommended for further development.
Relative Rank	*Moderate*	*Moderate*	*Moderate*

Table 4-3. Summary Comparison of Concept Plans (contd.)

Concept Plans	Comparison Criteria		Identified Status and Relative Ranking
	Effectiveness	**Efficiency**	
CO-5 – Multipurpose with Shasta Enlargement (18. 5 feet)	High potential to address primary planning objectives with emphasis on spawning habitat restoration. Significantly contributes to cold-water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	High cost-efficiency for water supply reliability. High potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	Enlarging Shasta to the maximum extent possible (without major relocations), and including features for conjunctive water management, anadromous fish habitat, and ecosystem restoration is **identified** for further development. Recommended primarily because this plan is (1) consistent with goals of the 2000 CALFED ROD, (2) highly cost-efficient, and (3) addresses all planning objectives.
Relative Rank	*High*	*High*	*High*

Key:
AFS = Anadromous Fish Survival
CALFED = CALFED Bay-Delta Program
CO = Combined Objective
ROD = Record of Decision
WSR = Water Supply Reliability

Anadromous Fish Survival This subcriterion is the relative ability of a plan to help increase the survival of anadromous fish populations in the Sacramento River primarily upstream from the Red Bluff Diversion Dam. Included in Table 4-4 is a preliminary estimate of the average annual increase in Chinook salmon populations upstream from the Red Bluff Diversion Dam only, resulting from the increase in the cold-water pool in Shasta Reservoir for three dam enlargements and reservoir operations.

For dam raises of 6.5 feet, the greatest benefit to fish survival would occur with AFS-1 because all additional space would be dedicated to the goal of increasing the cold-water pool. However, AFS-1 would not significantly contribute to the other planning objectives. The next greatest increase in fish survival with a dam raise of 6.5 feet would occur equally with WSR-1, CO-1, and CO-4. The least apparent benefit in increased salmon survival would occur with AFS-2 and AFS-3. This is because increasing minimum flows on the upper Sacramento River would deplete the cold-water pool, which may be needed later in the year for temperature regulation during the warm summer months. Also for these two concept plans, the potential to benefit other objectives would be low. It is expected that similar relationships would occur for larger dam raises but with increasing effectiveness for anadromous fish survival.

As mentioned, AFS-3, CO-1, CO-2, CO-3, CO-4, and CO-5 all included restoration of one or more abandoned gravel mines along the upper Sacramento River downstream from Keswick Dam for anadromous fish survival benefits. Recent evaluations related to the use of the SALMOD model have indicated that restoring these areas may not result in a significant benefit to anadromous fish. Concerns have been expressed ranging from a low likelihood that these areas could be effectively used to increase spawning and rearing habitats to the likelihood for increased predation. Further, during public and stakeholder outreach meetings in late 2005 held primarily for environmental scoping purposes, there was little to no interest expressed for acquisitioning and restoring these areas. At this time, restoration of abandoned gravel mines is not included in further plan formulation activities for the SLWRI.

The estimated difference in increased fish survival benefits between WSR-2 or CO-2 and WSR-4 or CO-5 (dam raises of 18.5 feet) is because including a conjunctive management component in the concept plans would lessen the amount of cold-water available during critical periods compared to operations without the conjunctive management component. Although the relative increase in water supply yield is sizeable, so are the benefits forgone for anadromous fish survival when a conjunctive use component is included. The greatest benefit to anadromous fish from an increase in the cold-water pool would be with WSR-3 (dam raise of 202.5 feet). It is believed, however, that this plan could have adverse impacts not yet defined that would discount the apparent increase in salmon survival.

Table 4-4. Summary of Estimated Costs and Benefits for Concept Plans

Item	Concept Plans											
	Anadromous Fish Survival Focus			Water Supply Reliability Focus				Combined Objective Focus				
	AFS-1	AFS-2	AFS-3	WSR-1	WSR-2	WSR-3	WSR-4	CO-1	CO-2	CO-3	CO-4	CO-5
Raise Shasta Dam (feet)	**6.5**	**6.5**	**6.5**	**6.5**	**18.5**	**202.5**	**18.5**	**6.5**	**18.5**	**18.5**	**6.5**	**18.5**
Total Increased Storage (1,000 acre-feet)[1]	290	290	290	290	636	9340	636	290	636	636	290	636
Accomplishments												
Anadromous Fish												
- Spawning Habitat - Restore Gravel Mines (acres)	-	-	150	-	-	-	-	150	150	150	150	150
- Minimum Flows (acres)	-	170	170	-	-	-	-	-	-	170	-	-
- Average Annual Salmon Increase (1,000 fish)[2]	860	370	370	410	1,110	10,620	1,020	410	1,110	980	410	1,020
Water Supply Reliability (1,000 acre-feet/year)[3]	0	20	20	72	125	703	146	72	125	90	89	146
Ecosystem Restoration (acres)	-	-	-	-	-	-	-	-	-	-	548	548
Hydropower Generation (GWh/yr)[4]	51	32	32	15	44	2,254	44	15	44	61	12	44
Flood Damage Reduction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Construction Cost ($millions)[5]	282	282	292	282	408	5,250	459	292	418	418	356	483

Notes:
[1] Early evaluations estimated the storage capacity increase with a 6.5-foot raise at 290,000 acre-feet as indicated in Table 4-2
[2] Average Annual Salmon Increase numbers are from Initial Alternatives Information Report (simulated using SALMOD), June 2004. Updated modeling results can be found in the Modeling Appendix.
[3] Approximate increased water supply yield based on drought year conditions with Banks Pumping capacity at 6,680 cfs. At 8,500 cfs pumping capacity, yield about 18 percent greater.
[4] Preliminary estimate based on 2003 conditions.
[5] Based on preliminary designs and cost estimates at 2003 price levels.

Key:
AFS = anadromous fish survival
CO = combined objective
GWh/yr = gigawatt hours per year
WSR = water supply reliability

Water Supply Reliability This subcriterion is the relative potential of a plan to help increase water supplies and water supply reliability to the CVP and SWP to help meet current and future water demands, with a primary focus on modifying Shasta Dam and Reservoir. Included in Table 4-4 is an estimate of the increase in drought period water supply reliability for the concept plans. As can be seen, the increase in water supply reliability ranges from about 20,000 acre-feet per year for dam raise of 6.5 feet (including dedication of increased storage to increasing spring fish flows) to over 700,000 acre-feet per year for a dam raise of 202.5 feet. The exception is concept plan AFS-1, which would provide only an incidental amount of water supply yield.

Ecosystem Restoration This subcriterion is a measure of the ability of a plan to address the secondary planning objective of ecosystem restoration. Through pursuit of the primary planning objectives, significant potential is created to implement features to help conserve and restore ecosystem resources, especially in the Shasta Lake area.

Flood Control This subcriterion includes a measure of the ability of a plan to reduce flood damages along the upper Sacramento River near Redding. Each of the concept plans has the potential to incidentally provide increased flood control opportunities. However, for any of the plans other than WSR-3, this possibility is very small, unless the projects were operated (at least in part) specifically for that purpose. However, there does not appear to be sufficient residual need for an additional flood control increment in Shasta Reservoir.

This subcriterion also addresses increases in public safety at Shasta Dam. All of the concept plans include routing the PMF from the top of conservation space in Shasta Reservoir. As mentioned, this results in additional features at Shasta Dam and around Shasta Reservoir to more safely accommodate extremely rare and large flood events such as the PMF.

Hydropower This subcriterion is a measure of the ability of a plan, through pursuit of the primary planning objectives, to help increase hydropower capabilities at Shasta Dam. Each of the plans incidentally provides increased opportunities for hydropower generation. From Table 4-4, based on 2003 conditions, it is estimated that increases in hydropower generation would range from about 15 GWh/year for WSR-1 to over 2,200 GWh/year for WSR-3 (not including loss of generation at the Pit 7 Dam).

Efficiency

Efficiency is the measure of how efficiently a plan alleviates identified problems while realizing specified objectives consistent with protecting the Nation’s environment. Concept plans ranking highest for this criterion are WSR-2, WSR-4, CO-2, and CO-5. This is primarily because each of these plans provides a significant increase in water supply reliability at a relatively low unit cost while significantly contributing to other planning objectives. Each of the AFS-focused concept plans and WSR-3 rank low. For the AFS-focused plans, this is primarily because the increased storage space would be dedicated to either increasing the cold-water pool or instream flows. These plans would provide very little economic benefit to the other planning objectives. However, plans could be simulated to dedicate some of the storage space to water supply and some to anadromous fish, which would result in lowered traditional economic benefits but increased fisheries benefits.

Anadromous Fish Survival Under the efficiency criterion, this is the measure of the potential for a plan to increase the long-term survivability of anadromous fish in the upper Sacramento River at the lowest incremental cost. Through use of SALMOD and by assessment of other features, it is estimated that the most efficient way to significantly and effectively increase the survivability of anadromous fish in the upper Sacramento River is through increases in the cold-water pool in Shasta Lake that would result in cooler water releases during critical periods of the year. Other ways of helping improve the fishery are included in several concept plans such as increased winter/spring minimum flows and habitat restoration. These measures were found to be less effective and had a higher uncertainty for success than increasing the cold-water pool in the lake.

Water Reliability Unit Cost

This is a measure of the potential for a plan to increase the reliability of the CVP and SWP by developing a reliable additional increment of water at the lowest unit cost (dollars per acre-foot of drought period yield). It is estimated that concept plans WSR-2, WSR-4, CO-2, and CO-5 would result in the lowest unit water costs compared to the other plans considered. Excluding AFS-1, concept plans that would result in the highest unit cost for increased water supply reliability are AFS-2, AFS-3, WSR-1, and WSR-3.

Secondary Planning Objective Costs

This is a measure of the potential for a plan to also include benefits for ecosystem restoration, flood control, public safety, and hydropower with the lowest incidental and economically justified additional cost. All dam raise scenarios provide some amount of increased seasonal storage space that can contribute to increased efficiency in flood operations and a higher head for power generation. For public safety, all plans would include added features to increase the certainty of Shasta Dam and Reservoir safely passing the PMF. The relative efficiency of providing flood control and hydropower increases with larger reservoirs and higher dam raises. The efficiency of a plan in providing ecosystem restoration relative to enlarging Shasta Dam and Reservoir will require additional evaluation.

Likelihood for Federal Interest

Potential for Federal interest exists for each of the concept plans, providing the plans are economically feasible and a non-Federal sponsor(s) is capable and willing to share in implementing the cost for a potential project. For those plans with high costs for a specific unit of benefit to the anadromous fishery, ecosystem, or water supply reliability, potential for Federal interest is greatly diminished because of the likely lack of economic feasibility. This is believed to be especially true for concept plans similar to AFS-1, AFS-2, AFS-3, WSR-3, and CO-3.

CALFED Consistency

This is a measure of the relationship of the plan to the overall goals and objectives of the CALFED ROD, or other ongoing projects and programs. To rank high, a plan must neither preclude nor enhance the potential for development of other projects and programs. All of the concept plans, with the exception of AFS-1 and WSR-3, are believed to be fundamentally consistent with the CALFED ROD.

Concept Alternatives Carried Forward

After comparing each concept plan to the planning criteria above, five plans initially appeared superior in Table 4-3 and in supporting analyses. Accordingly, these five plans and the required No-Action plan were recommended for further development in the comprehensive plans phase of the SLWRI. However, although WSR-4 was initially carried forward as an alternative, subsequent analysis of the conjunctive use component indicated tradeoffs between conjunctive use water supply benefits and critical gains in fisheries benefits. The resulting reduction in benefits to fisheries operations in dry and critical years was deemed unacceptable in terms of meeting primary project planning objectives. Thus, WSR-4 and the conjunctive use component of CO-5 were eliminated from further consideration. CO-2 was also initially carried forward, but was subsequently eliminated from further consideration because continued evaluation concluded that restoration of existing gravel mines would have a low likelihood of successfully benefiting salmon resources. Concept plans recommended for further development include the following:

- No-Action
- **WSR-1 –**Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)
- **WSR-2 –** Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)
- **CO-5 –** Multipurpose with Shasta Enlargement (18.5 feet)

Chapter 5
Comprehensive Plans

This chapter provides an overview of the five comprehensive plans, including a discussion of comprehensive plan formulation, management measures common to all comprehensive plans, major components of dam raise scenarios, and costs and benefits of each comprehensive plan. Also included is a general description of the No-Action Alternative and the five comprehensive plans. For each of the five comprehensive plans, major components, benefits, primary effects, and economics are described.

Overview of Comprehensive Plans

The five comprehensive plans include the following:

- **Comprehensive Plan 1 (CP1) – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability –** Raise dam 6.5 feet, enlarge reservoir by 256,000 acre-feet

- **Comprehensive Plan 2 (CP2) – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability –** Raise dam 12.5 feet, enlarge reservoir by 443,000 acre-feet

- **Comprehensive Plan 3 (CP3) – 18.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability –** Raise Dam 18.5 feet, enlarge reservoir by 634,000 acre-feet

- **Comprehensive Plan 4 (CP4) – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability –** Enlarge facilities and modify operations to improve anadromous fish resources

- **Comprehensive Plan 5 (CP5) – 18.5-Foot Dam Raise, Combination Plan –** Combination plan to address all planning objectives

Comprehensive Plans Identification

As described in Chapters 2 and 4, numerous management measures were identified, evaluated, and screened, and from them various initial plans were developed that encompass the scope of potential alternatives focused on addressing the planning objectives. Plans including the following attributes were identified for further development into comprehensive plans. Fundamentally, these plans consist of the following:

- Plan(s) to raise Shasta Dam between 6.5 feet and 18.5 feet, focusing on both water supply reliability and anadromous fish survival but with benefits to various secondary planning objectives (subsequently developed into CP1, CP2, and CP3)
- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on increased anadromous fish survival but also including water supply reliability, and other secondary planning objectives (subsequently developed into CP4)
- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on all planning objectives (subsequently developed into CP5)

Considering results of initial plan formulation efforts, numerous combinations of alternatives were formulated. In addition, features were added to alternatives involving raising Shasta Dam to address maintaining or increasing recreation in the lake area. To develop a significant distinction between the dam-raise-only plans, the approach used for the SLWRI was to first formulate plans focusing on different dam raise heights within the range of 6.5 feet to 18.5 feet. This is generally addressed by the first plan type listed above. A dam raise of 12.5 feet in CP2 was chosen because it represented a midpoint between the smallest and largest likely and practical dam raises. Next, the approach was to identify the most efficient and effective dam raise height and formulate comprehensive plans to focus on anadromous fish survival and other objectives at this height.

Using the general rationale described above, and incorporating input from the public scoping process and continued coordination with resource agencies and other interested parties, five comprehensive plans were developed in addition to the No-Action Alternative.

Management Measures Common to All Comprehensive Plans

Eight of the management measures retained in the alternatives development process (see Chapter 2) are included, to some degree, in all of the comprehensive plans. These measures were included because they (1) would either be incorporated or required with any dam raise, (2) were logical and convenient additions that would significantly improve any alternative, or (3) should be considered with any new water increment developed in California. The eight measures include (1) enlarging the Shasta Lake cold-water pool, (2) modifying the TCD, (3) increasing conservation storage, (4) reducing demand, (5) modifying flood operations, (6) modifying hydropower facilities, (7) maintaining or increasing recreation opportunities, (8) and maintaining or improving water quality.

Enlarge Shasta Lake Cold-Water Pool

Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD. At a minimum, all comprehensive plans include enlarging the cold-water pool by raising Shasta Dam to enlarge Shasta Reservoir. Some alternatives also increase the seasonal carryover storage in Shasta Lake.

Modify Temperature Control Device

For all comprehensive plans, the TCD would be modified to account for an increased dam height and to reduce leakage of warm water into the structure. Minimum modifications to the TCD include raising the existing structure and modifying the shutter control. This measure would increase the ability of operators at Shasta Dam to meet downstream temperature requirements, and provide more operational flexibility to achieve desirable water temperatures during critical periods for anadromous fish.

Increase Conservation Storage

All comprehensive plans include increasing the amount of space available for water conservation storage in Shasta Reservoir by raising Shasta Dam. Conservation storage is the portion of the capacity of the reservoir available to store water for subsequent release to increase water supply reliability for M&I, agricultural, and environmental purposes. The comprehensive plans include a range of dam enlargements and various increases in conservation space.

Reduce Demand

All comprehensive plans include an additional water conservation program for new water supplies created by the project, to augment current water use efficiency practices. The proposed program would consist of a 10-year initial program in which Reclamation would allocate approximately $2.3 million to $3.8 million, proportional to additional water supplies delivered, to fund water conservation efforts. Funding would focus on assisting project beneficiaries (agencies receiving increased water supplies because of the project), with developing new or expanded urban water conservation, agricultural water conservation, and water recycling programs. Program actions would be a combination of technical assistance, grants, and loans to support a variety of water conservation projects such as recycled wastewater projects, irrigation system retrofits, and urban utilities retrofit and replacement programs. The program could be established as an extension of existing Reclamation programs, or as a new program, through teaming with SLWRI cost-sharing partners. Combinations and types of water use efficiency actions funded would be tailored to meet the needs of identified cost-sharing partners, including consideration of cost-effectiveness at a regional scale for agencies receiving funding.

Modify Flood Operations

Physical enlargement of Shasta Reservoir would require alterations to existing flood operation guidelines or rule curves, to reflect physical modifications, such as an increase in dam/spillway elevation. The rule curves would be revised with the goal of reducing flood damage and enhancing other objectives to the extent possible. Potential modification of flood operations would be considered for all comprehensive plans.

Modify Hydropower Facilities

Under each comprehensive plan, physical enlargement of Shasta Dam would likely require various minimum modifications, commensurate with the magnitude of the enlargement, to the existing hydropower facilities at the dam to enable their continued efficient use. These modifications, in conjunction with increased lake surface elevations, may provide incidental benefits to hydropower generation. Although modifications could also be included to further increase the power production capabilities of the reservoir (e.g., additional penstocks and generators), they are believed to be a detail beyond the scope of this investigation and are not considered further at this level of planning.

Maintain and Increase Recreation Opportunities

In addition to the measures described above, all comprehensive plans address, to some extent, the secondary planning objective of maintaining and increasing recreation opportunities at Shasta Lake. Outdoor recreation, and especially recreation at Shasta Lake, represents a major source of enjoyment to millions of people annually and is a major source of income to the northern Sacramento Valley. Shasta Dam and Reservoir are within the Shasta Unit of the Whiskeytown-Shasta-Trinity NRA. Recreation within these lands is managed by USFS. As part of this administration, USFS either directly operates and maintains, or manages through leases, numerous public campgrounds, marinas, boat launching facilities, and related water-oriented recreation facilities. Enlarging Shasta Dam and Reservoir would affect some of these facilities. Consistent with the position of USFS, and planning conditions described in this chapter, all of the comprehensive plans include features to, at a minimum, maintain the overall recreation capacity of the existing facilities. All comprehensive plans also provide for modernization of recreation facilities.

Maintain or Improve Water Quality

All alternatives could contribute to improved Delta water quality conditions and Delta emergency response. Additional storage in Shasta Reservoir would provide improved operational flexibility. Shasta Dam has the ability to provided increased releases and high flow releases to reestablish Delta water quality. Improved Delta water quality conditions could provide benefits for both water supply reliability and ecosystem restoration by potentially increasing Delta outflow during drought years and reducing salinity during critical periods.

Major Components of Comprehensive Plans

Three dam raise options were considered for the comprehensive plans, including 6.5-foot, 12.5-foot, and 18.5-foot raises. Other raise options up to 18.5 feet are possible; however, it is believed that the above three adequately represent the extent of benefits, effects, and costs associated with any raise within the range considered for this feasibility study. Table 5-1 summarizes the physical features associated with the comprehensive plans.

Table 5-1. Physical Features of Dam Raise Scenarios

Main Features	Project Alternatives				
	CP1	CP2	CP3	CP4	CP5
Dam and Appurtenant Structures					
Shasta Dam					
Crest Raise (feet)	6.5	12.5	18.5	18.5	18.5
Full Pool Height Increase (feet) 1	8.5	14.5	20.5	20.5	20.5
Elevation of Full Pool (feet) 2	1,075.5	1,081.5	1087.5	1,087.5	1,087.5
Reservoir Storage Capacity Increase (acre-feet)	256,000	443,000	634,000	634,000	634,000
Wing Dams	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.
Spillway	Raise crest and extend piers. Replace 3 drum gates with 6 sloping wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping wheel gates.
Temperature Control Device	Raise/modify controls.	Raise/modify controls.	Raise/modify controls.	Raise/modify controls.	Raise/modify controls.
Shasta Powerplant	Raise hoists.	Raise hoists.	Raise hoists.	Raise hoists.	Raise hoists.
Pit 7 Dam	Install a tailwater depression system.	Install a tailwater depression system.	Install a tailwater depression system.	Install a tailwater depression system.	Install a tailwater depression system.
Reservoir Area Dikes and Railroad Embankments	Construct 5 new dikes	Construct 6 new dikes	Construct 7 new dikes	Construct 7 new dikes	Construct 7 new dikes
Relocations					
Roadways	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.
Length of Relocated Roadway (linear feet)	17,409	29,054	33,788	33,788	33,788
Number of Road Segments Affected	10	21	30	30	30
Vehicle Bridges	Relocate 4 bridges, Modify 1 bridge.	Relocate 4 bridges, Modify 1 bridge.	Relocate 4 bridges, Modify 1 bridge.	Relocate 4 bridges, Modify 1 bridge.	Relocate 4 bridges, Modify 1 bridge.
Railroad Bridges	Modify 3 bridges.	Modify 3 bridges.	Modify 3 bridges.	Modify 3 bridges.	Modify 3 bridges.
Recreation Facilities	Modify or replace 9 marinas, 6 boat ramps, 6 resorts, 202 campgrounds/day use areas/RV sites, 2 USFS facilities, and 2 trailheads.	Modify or replace 9 marinas, 6 boat ramps, 6 resorts, 261 campgrounds/day use areas/RV sites, 2 USFS facilities, and 2 trailheads.	Modify or replace 9 marinas, 6 boat ramps, 6 resorts, 328 campgrounds/day use areas/RV sites, 2 USFS facilities, and 2 trailheads.	Modify or replace 9 marinas, 6 boat ramps, 6 resorts, 328 campgrounds/day use areas/RV sites, 2 USFS facilities, and 2 trailheads.	Modify or replace 9 marinas, 6 boat ramps, 6 resorts, 328 campgrounds/day use areas/RV sites, 2 USFS facilities, and 6 trailheads. Add 18 miles of new hiking trails.
Utilities	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.
Ecosystem Enhancements	None.	None.	None.	Reserve 378,000 acre-feet of the additional storage for cold-water supply for anadromous fish. Implement adaptive management plan to benefit anadromous fish. Augment spawning gravel in the upper Sacramento River at the rate of up to 10,000 tons per year. Restore 0.8 miles of riparian, floodplain, and side channel habitat along the upper Sacramento River.	Construct shoreline fish habitat around Shasta Lake. Augment spawning gravel in the upper Sacramento River at the rate of up to 10,000 tons per year. Restore 0.8 miles of riparian, floodplain, and side channel habitat along the upper Sacramento River. Enhance aquatic habitat in tributaries to Shasta Lake to improve fish passage.

Notes:

1 The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications, including replacing the three drum gates with six sloping, fixed-wheel gates.

2 Elevation based on National Geodetic Vertical Datum of 1929 (NGVD29).

Key:
CP = Comprehensive Plan
GWh = gigawatt-hour
USFS = U.S. Forest Service

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Potential Benefits of Comprehensive Plans

Major potential benefits of the comprehensive plans, in relation to contributions to the SLWRI planning objectives, are summarized in Table 5-2 and described in the following sections. Quantified benefits in Table 5-2 are based on modeling efforts that are described in several locations of the PDEIS, including Chapter 6, "Hydrology, Hydraulics, and Water Management;" Chapter 11, "Fisheries and Aquatic Resources;" Chapter 23, "Power and Energy;" the Modeling Appendix; and the Economic Valuation Appendix. Additional broad public benefits obtained through pursuing project objectives are summarized in Table 5-3. These benefits are primarily from modernization and upgrades of relocated facilities and increases in overall system capacity.

Table 5-2. Summary of Potential Features and Benefits of SLWRI Comprehensive Plans (Compared to No-Action Alternative)

Item	CP1	CP2	CP3	CP4	CP5
Raise Shasta Dam (feet)	6.5	12.5	18.5	18.5	18.5
Total Increased Storage (TAF)	256	443	634	634	634
Benefits					
Increase Anadromous Fish Survival					
Dedicated Storage (TAF)	-	-	-	378	-
Production Increase (thousand fish)[1]	366	234	607	1,199	607
Spawning Gravel Augmentation (tons)[2]				10,000	10,000
Side Channel Rearing Habitat Restoration (miles)				0.8	0.8
Increase Water Supply Reliability					
Total Increased Firm Water Supplies (TAF/year)[3]	76.4	105.1	133.4	76.4	133.4
Increased Firm Water Supplies NOD (TAF/year)[3]	9.6	19.8	29.6	9.6	29.6
Increased Firm Water Supplies SOD (TAF/year)[3]	66.8	85.3	103.8	66.8	103.8
Increased Water Use Efficiency Funding	Yes	Yes	Yes	Yes	Yes
Increased Emergency Water Supply Response Capability	Yes	Yes	Yes	Yes	Yes
Reduce Flood Damages					
Increased Reservoir Capacity for Capture of High Flood Flows	Yes	Yes	Yes	Yes	Yes
Develop Additional Hydropower Generation					
Increased Hydropower Generation (GWh/year)	42	68	96	138	96
Conserve, Restore, and Enhance Ecosystem Resources					
Shoreline Enhancement (acres)	-	-	-	-	130
Tributary Aquatic Habitat Enhancement (miles)[4]	-	-	-	-	6
Riparian, Floodplain, and Side Channel Habitat Restoration (acres)	-	-	-	2.9	2.9
Increased Ability to Meet Flow and Temperature Requirements Along Upper Sacramento River	Yes	Yes	Yes	Yes	Yes
Maintain or Improve Water Quality					
Improved Delta Water Quality	Yes	Yes	Yes	Yes	Yes
Increased Delta Emergency Response Capability	Yes	Yes	Yes	Yes	Yes
Maintain and Increase Recreation Opportunities					
Recreation (increased user days, thousands)[5]	83	141	224	224	224
Modernization of Relocated Recreation Facilities	Yes	Yes	Yes	Yes	Yes

Notes:

[1] Average annual increase in juvenile Chinook salmon surviving to migrate downstream from the Red Bluff Diversion Dam. Numbers were derived from SALMOD.

[2] Average amount per year for 10-year period.

[3] Total drought period reliability to CVP and SWP. Does not reflect benefits related to water use efficiency actions included in all comprehensive plans.

[4] Tributary aquatic enhancement provides for the connectivity of native fish species and other aquatic organisms between Shasta Lake and its tributaries. Estimates of benefits reflect only connectivity with perennial streams and do not reflect additional miles of connectivity with intermittent streams.

[5] These values do not account for increased visitation due to modernization of recreation facilities associated with all comprehensive plans.

Key:
- = not applicable
CP = comprehensive plan
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
GWh/year = gigawatt-hours per year
NOD = north of Delta
SLWRI = Shasta Lake Water Resources Investigation
SOD = south of Delta
SWP = State Water Project
TAF = thousand acre feet

Table 5-3. Summary of Additional Broad Public Benefits

Category	Benefit Description
System-Wide Water Management Flexibility	All CPs improve system-wide water management flexibility for storage and operations to meet multiple competing public objectives
Air Quality	All CPs would provide for increased clean energy generation potentially reducing GHG emissions
Groundwater	All CPs allow for decreased groundwater pumping and related groundwater overdraft conditions in CVP/SWP water service areas
Reservoir Water Quality	All CPs replace reservoir area septic systems with centralized wastewater treatment plants
Shasta Lake Cold-Water Fisheries	All CPs improve Shasta Lake cold-water fisheries conditions through increasing the cold-water pool
Traffic and Transportation	All CPs modernize relocated roadways and bridges with facilities designed to meet current public safety standards
Public Services	All CPs relocate USFS emergency response facilities to a more centralized location adjacent to interstate transportation corridors

Notes:
[1] Broad public benefits listed above are additional to benefits associated with project objectives.

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
GHG = greenhouse gas
SWP = State Water Project

Estimated Costs

Table 5-4 summarizes estimated construction and average annual costs for each of the Comprehensive Plans. These costs are developed to a feasibility level. Detailed information regarding estimated construction costs for the comprehensive plans is included in the Engineering Summary Appendix. The costs are based on April 2010 price levels. Annual costs are computed by first estimating the total investment cost and then computing the average annual cost from the investment cost and adding estimated annual O&M costs. The investment cost is the sum of the construction cost and the estimate of accrued interest on the construction cost during the construction period. The IDC cost is computed using Reclamation-defined practices. It is sensitive to the construction period, which is estimated to be 4 years for all plans. The current Federal interest rate used in estimating interest and amortization of the total investment cost is 4-1/8 percent and the period of analysis for the annual cost calculation is 100 years.

Table 5-4. Estimated Construction and Average Annual Costs[1]

Item	CP1 6.5 Feet ($ millions)	CP2 12.5 Feet ($ millions)	CP3 18.5 Feet ($ millions)	CP4 18.5 Feet ($ millions)	CP5 18.5 Feet ($ millions)
Construction Costs					
Field Costs					
Relocations					
Vehicular Bridges	$32	$32	$48	$48	$48
Doney Creek Railroad Bridge	$51	$51	$51	$51	$51
Sacramento River Railroad Bridge, Second Crossing	$105	$105	$105	$105	$105
Pit River Bridge Modifications	$15	$21	$28	$28	$28
Railroad Realignment	$7	$7	$7	$7	$7
Roads	$15	$23	$34	$34	$34
Utilities	$23	$24	$29	$29	$29
Buildings/Facilities – Recreation	$120	$135	$153	$153	$153
Dams and Reservoirs					
Main Dam	$49	$58	$69	$69	$69
Outlet Works	$25	$25	$25	$25	$25
Spillway	$95	$98	$100	$100	$100
Temperature Control Device	$26	$27	$28	$28	$28
Powerhouse and Penstocks	$1	$1	$1	$1	$1
Right Wing Dam	$4	$5	$6	$6	$6
Left Wing Dam	$12	$17	$23	$23	$23
Visitor Center	$8	$8	$8	$8	$8
Dikes	$13	$15	$23	$23	$23
Reservoir Clearing	$4	$7	$18	$18	$18
Pit 7 Dam and Powerhouse Modifications	$0.2	$0.2	$0.2	$0.2	$0.2
Environmental Restoration	-	-	-	$6	$17
Recreation Enhancement	-	-	-	-	$1
Total Field Costs	$605	$658	$757	$763	$764
Planning, Engineering, Design, and Construction Management	$121	$132	$151	$153	$153
Lands	$26	$41	$60	$61	$61
Environmental Mitigation	$61	$66	$76	$76	$76
Cultural Resource Mitigation	$12	$13	$15	$15	$15
Water Use Efficiency Actions	$2	$3	$4	$2	$4
Total Construction Cost	**$827**	**$913**	**$1,064**	**$1,070**	**$1,073**
Annual Cost					
Interest and Amortization	$38	$42	$48	$49	$49
Operations and Maintenance	$4.9	$4.8	$5.2	$5.2	$5.2
Total Annual Cost	**$42.6**	**$46.4**	**$53.7**	**$54.0**	**$54.1**

Note:
[1] April 2010 price levels, 100-year period of analysis, and 4-1/8 percent interest rate.
Key:
- = not applicable
CP = Comprehensive Plan

Estimated Economic Benefits

Each of the comprehensive plans will address to some extent most of the planning objectives. In doing so, monetary benefits will be generated. A detailed description of benefits associated with anadromous fish survival, water supply reliability, hydropower generation, ecosystem restoration, and recreation is included in the Economics Appendix. Flood damage reduction benefits associated with all comprehensive plans are not included in the following discussion. All alternatives would provide an incidental increase in flood protection to areas along the upper Sacramento River. The associated economic benefits would, however, be small.

Table 5-5 summarizes the estimated average annual economic benefits for the comprehensive plans. A detailed description of the estimated costs and benefits is included in the Economic Valuation Appendix. To account for the significant uncertainties associated with adequately estimating the value of new water supplies, a sensitivity analysis was done of the value of the increased supplies resulting from the comprehensive plans. The value of water and hydropower was assumed to increase above the inflation rate to account for growing scarcity of available supplies and increasing demands in the future. Increased rates of up to 2 percent were considered, and, accordingly, water supply reliability and hydropower benefits based on a 2 percent rate above inflation are included in Table 5-5. Several reasons for estimating an increased value of new supplies include rapidly increasing population growth resulting in major shifts of water supplies from agricultural to urban uses, sustained demand for reliable supplies of energy and irrigation water, and reductions in supply from impacts of climate change.

Table 5-5. Annual Economic Benefit Summary[1 2]

Item	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Anadromous Fish Survival	15.1	9.6	25.0	49.2	25.0
Water Supply Reliability					
Estimated Benefit (at inflation)[3]	27.0	25.0	26.7	27.0	26.7
Estimated Benefit (2% above inflation)[4]	46.5	43.1	46.1	46.5	46.1
Hydropower					
Estimated Benefit (at inflation)[3]	2.4	3.9	5.4	7.6	5.4
Estimated Benefit (2% above inflation)[4]	4.2	.7	9.4	13.2	9.4
Recreation	3.1	5.2	8.3	8.3	8.4
Flood Control[5]	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified
Water Quality[5]	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified
Total Benefits					
Estimated Value (at inflation)[3 6]	***47.6***	***43.7***	***65.4***	***92.2***	***65.5***
Estimated Value (2% above inflation)[4 6]	***68.8***	***64.6***	***88.7***	***117.2***	***89.3***

Notes:
[1] Any dam raise could provide incidental benefits to secondary objectives.
[2] Benefits have not been monetized for ecosystem restoration including (1) restoring resident fish habitat in Shasta Lake, (2) restoring fisheries and riparian habitat at several locations along the lower reaches of the upper Sacramento River and tributaries to Shasta Lake, (3) augmenting spawning gravel in the upper Sacramento River, and (4) restoring riparian, floodplain, and side channel habitat in the upper Sacramento River.
[3] Assumes the cost of water supplies and hydropower increase at the same rate as inflation.
[4] Includes increase of hydropower and water supply costs at 2 percent above inflation to account for growing scarcity of available supplies in the future. Sensitivity analyses for change in hydropower and water supply benefits are included in the Economic Valuation Appendix.
[5] Benefits for flood control and water quality are minimal and have not been monetized.
[6] Totals may not sum because of rounding.

Key:
CP = comprehensive plan
GWh = gigawatt-hour
HU = habitat unit
TAF = thousand acre-feet

Descriptions of the No-Action Alternative and Comprehensive Plans

In-depth descriptions of the No-Action Alternative and the five comprehensive plans are provided below. Each comprehensive plan description includes the major components, potential benefits, potential primary effects and preliminary economic assessment of the plan.

No-Action Alternative (No Federal Action)

For all Federal feasibility studies of potential water resources projects, the No-Action Alternative is intended to account for existing facilities, conditions, land uses, and reasonably foreseeable actions expected to occur in the study area. Reasonably foreseeable actions include actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete. The No-Action Alternative is considered to be the basis for comparison with potential action alternatives, consistent with the P&G (WRC 1983) and NEPA guidelines.

Under the No-Action Alternative, the Federal Government would continue to implement reasonably foreseeable actions, as defined above, but would not take additional actions toward implementing a plan to raise Shasta Dam to help increase anadromous fish survival in the upper Sacramento River, nor help address the growing water supply and reliability issues in California. The following discussions highlight the consequences of implementing the No-Action Alternative, as they relate to the planning objectives of the SLWRI.

Plan formulation efforts and analysis of the No-Action Alternative and comprehensive plans discussed in this chapter are based on CVP and SWP operational conditions described in the 2004 OCAP BA (Reclamation) and the Coordinated Operations Agreement between Reclamation and DWR for the CVP and SWP, as ratified by Congress. Modeling studies will be updated to reflect changes in water operations in future SLWRI documents.

The accompanying PDEIS Chapters 4 through 25 include detailed descriptions of existing reservoir area infrastructure and study area resource conditions. Anticipated future resources conditions in the study area are also characterized. Detailed information on the study area is contained in the PDEIS and supporting appendices. Table 2-1 of the Modeling Appendix summarizes the existing condition and shows which actions were assumed to be part of the likely future condition (or No-Action /No-Project Alternative).

Anadromous Fish Survival

Much has been done to address anadromous fish survival problems in the upper Sacramento River. Solutions have ranged from changes in the timing and magnitude of releases from Shasta Dam to constructing and operating the TCD at the dam. Actions also include site-specific projects, such as introducing spawning gravel to the Sacramento River and work to improve or restore spawning habitat in tributary streams. However, some of actions have had an adverse effect on Sacramento River habitat, including implementing requirements of the Trinity River ROD, as amended (DOI 2000) which reduced flows from the Trinity River basin into Keswick Reservoir and then into the Sacramento River. Water diverted from the Trinity River is generally cooler than flows released from Shasta Dam. Accordingly, since implementation of the Trinity ROD, some of the benefits derived from flow changes and the Shasta TCD have been offset by the reduction in cooler water from the Trinity River. Increased demand for water for urban, agricultural, and environmental uses is also expected to reduce the reliability of cold water for anadromous fish. Prolonged drought that depletes the cold-water pool in Shasta Reservoir could put populations of anadromous fish at risk of severe population decline or extirpation in the long-term (NMFS 2009b). The risk associated with a prolonged drought is especially high in the Sacramento River, as Shasta Reservoir is operated to maintain only 1 year of carryover storage. Under the No-Action Alternative, after 2 years of drought, Shasta Reservoir storage would be insufficient to provide cold water throughout the winter-run Chinook salmon spawning season. A drought lasting several years would likely result in the extirpation of winter-run Chinook salmon (NMFS 2009b).

Under the No-Action Alternative, it is assumed that actions to protect fisheries and benefit aquatic environments would continue, including maintaining the TCD, and satisfying existing regulatory requirements.

Water Supply Reliability

Demands for water in the Central Valley and throughout California exceed available supplies, and the need for additional supplies is expected to grow. There is growing competition for limited system resources between various users and uses, including urban, agricultural, and environmental. Urban water demand and environmental water requirements have each increased, resulting in greater competition for limited water supplies. As mentioned, the population of California and the Central Valley is expected to increase by more than 60 and 130 percent above 2005 levels, respectively, by 2050. As these population increases occur, and are coupled with the need to maintain a healthy and vibrant industrial and agricultural economy, the demand for water would continue to significantly exceed available supplies. Competition for available water supplies would intensify as water demands increase to support this population growth.

Water conservation and reuse efforts are expected to significantly increase and forced conservation resulting from increasing water shortages would continue. In the past, during drought years, many water conservation measures have been implemented to reduce the effects of the drought. In the future, as more water use efficiency actions become necessary to help meet even average year demands, the impacts of droughts will be much more severe. Besides forced conservation, without developing cost-efficient new sources, the growing urban population would increasingly rely on shifting water supplies from such areas as agricultural production to satisfy M&I demands. It is likely that with continued and deepening shortages in available water supplies, adverse economic impacts would increase over time in the Central Valley and elsewhere in California. One example could include higher water costs, resulting in a further shift in agricultural production to areas outside California and/or outside the United States. Under the No-Action Alternative, Shasta Dam would not be modified and the CVP would continue operating similarly to existing conditions.

The No-Action Alternative would continue to meet water supply demands at levels similar to existing conditions, but would not be able to meet the expected increased demand in California.

Ecosystem Resources, Flood Management, Hydropower Generation, Recreation, and Water Quality

As opportunities arise, some locally sponsored efforts would likely continue to improve environmental conditions on tributaries to Shasta and along the upper Sacramento River. However, overall, future environmental-related conditions in these areas would likely be similar to existing conditions. The quantity, quality, diversity, and connectivity of riparian, wetland, and riverine habitats along the Sacramento River have been limited by confinement of the river systems by levees, reclamation of adjacent lands for framing, bank protection, channel stabilization and land development.

Shasta Dam and Reservoir have greatly reduced flood damage along the Sacramento River. Shasta Dam and Reservoir were constructed at a total cost of about $36 million. During flood events in 1983, 1986, and 1997, Shasta Dam, in combination with the Sacramento River Flood Control Project, prevented an estimated $14 billion in property losses due to flooding. Accordingly, from a flood damage perspective only, Shasta Dam has far more than paid for itself. However, residual risks to human life, health, and safety along the Sacramento River remain. Development in flood-prone areas has exposed the public to the risk of flooding. Storms producing peak flows, and volumes greater than the existing flood management system was designed for, can occur, and result in extensive flooding along the upper Sacramento River. Under the No-Action Alternative, the threat of flooding would continue, and may increase as population growth increases.

California’s demand for electricity is expected to significantly increase in the future. Under the No-Action Alternative, no actions would be taken to help meet this growing demand.

As California’s population continues to grow, demands would grow significantly for water-oriented recreation at and near the lakes, reservoirs, streams, and rivers of the Central Valley. This increase in demand will be especially pronounced at Shasta Lake.

To address the impact of water quality deterioration on the Sacramento River basin and Delta ecosystems and endangered and threatened fish populations, several environmental flow goals and objectives in the Central Valley (including the Delta) have been established through legal mandates aimed at maintaining and recovering endangered and threatened fish and wildlife, and protecting designated critical habitat. Despite these efforts, under the No-Action Alternative, these resources would continue to decline and ecosystems would continue to be impacted. In addition, Delta water quality may continue to decline.

Comprehensive Plan 1 (CP1) – 6.5-Foot Dam Raise, Anadromous Fish and Water Supply Reliability

CP1 was formulated to represent a likely minimum raise of Shasta Dam, and consists of enlarging Shasta Dam by raising the crest 6.5 feet and enlarging the reservoir by 256,000 acre-feet. Major features of CP1 are shown in Figure 5-1.

Major Components of CP1

CP1 includes the following major components:

- Raising Shasta Dam and appurtenant facilities by 6.5 feet.
- Implementing the set of eight common management measures previously described.

As shown in Table 5-1, by raising Shasta Dam 6.5 feet from crest at elevation 1,077.5 to elevation 1,084.0, CP1 would increase the height of the reservoir full pool by 8.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications, including replacing the three drum gates with six sloping fixed-wheel gates. This increase in full pool height would add approximately 256,000 acre-feet of additional storage to the overall reservoir capacity. Accordingly, the overall full pool storage would be increased from 4.55 MAF to 4.81 MAF. Figure 5-2 shows the increase in surface area and storage capacity for each dam raise.

Under CP1, operations for water supply, hydropower, and environmental requirements would be similar to existing operations, with the additional storage retained for water supply reliability and as an expanded cold-water pool for fisheries benefits. Other major features of CP1 are shown in Figure 5-1. As mentioned, CP1 (and all comprehensive plans) includes extending the existing TCD for efficient use of the expanded cold-water pool.

CP1 would also include the potential to revise the operational rules for flood control for Shasta Dam and Reservoir, which could reduce the potential for flood damage, and benefit recreation. Reservoir reoperation would likely include increasing the bottom of the flood control pool elevation based on increased dam height and reservoir capacity. Because of reservoir geometry, this would decrease the depth of the flood control pool, allowing higher winter and spring water levels. Increased reservoir capacity could have further flood damage reduction benefits in years when water levels are below the new flood control pool elevation. There is also limited potential for changes in flood control rules to allow more operational flexibility in reservoir drawdown requirements in response to storms, resulting in a net increase in the rate of spring reservoir filling during some years. The ability to revise the operational rules might result from using advanced weather forecasting tools and enhanced basin monitoring, which may be included during refinement of operational parameters after authorization. Higher spring water levels and associated increases in reservoir surface area would benefit recreation.

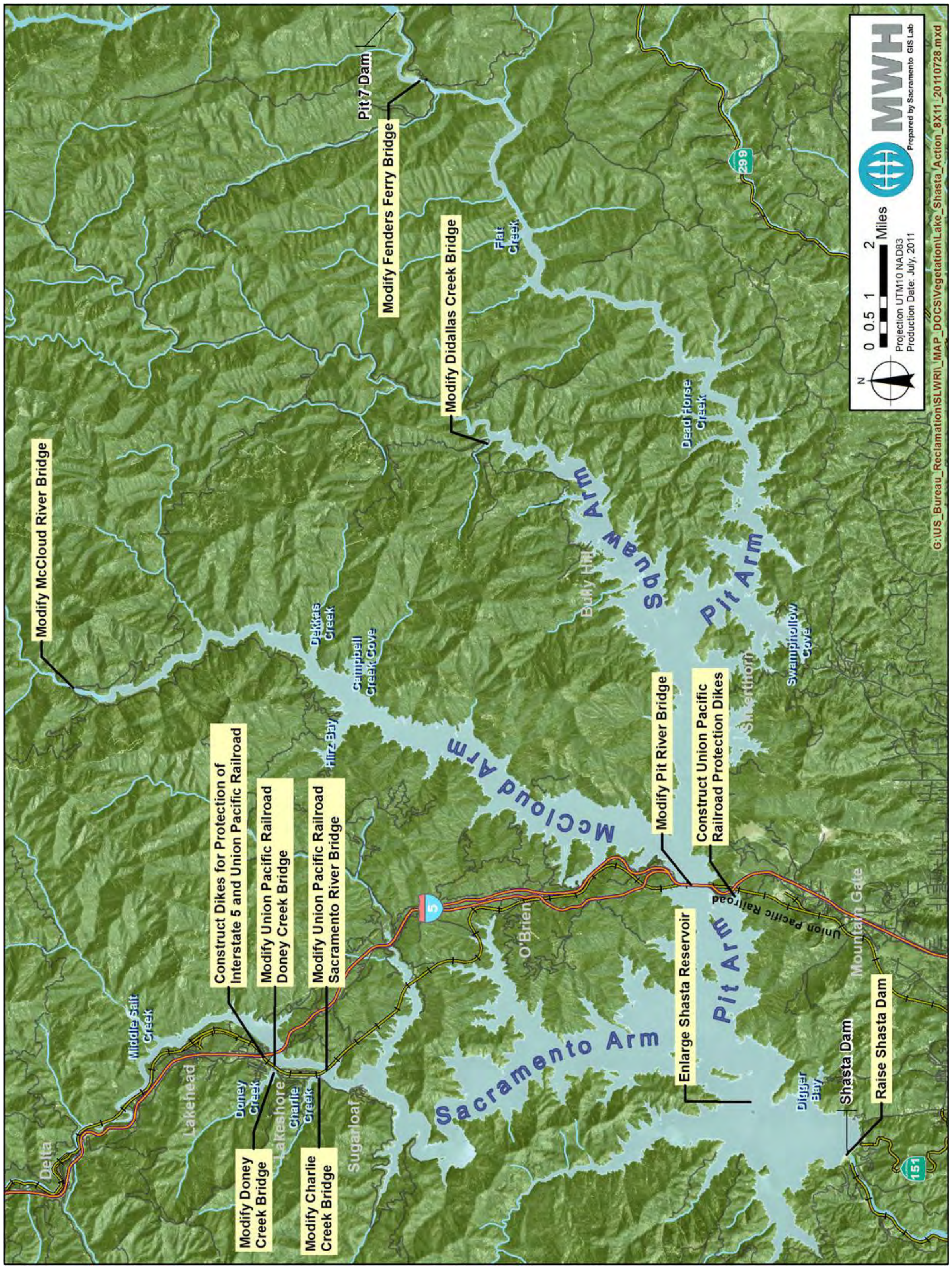


Figure 5-1. Major Features Common to All Comprehensive Plans

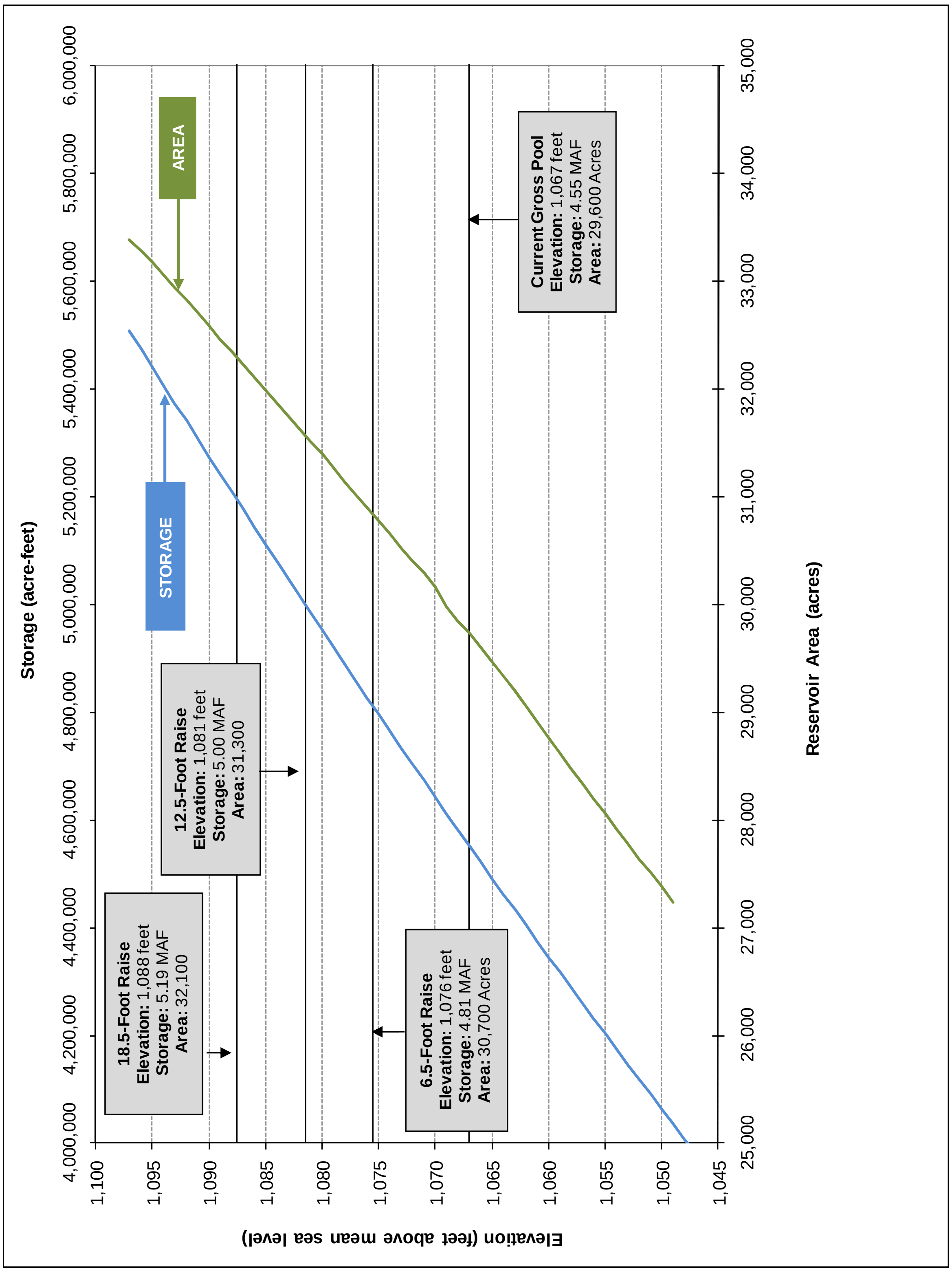


Figure 5-2. Enlarged Shasta Reservoir Area Capacity Relationships

Potential Benefits of CP1

Major potential benefits of CP1, related to the SLWRI planning objectives and broad public services, are summarized in Tables 5-2 and 5-3 and described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. CP1 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critically dry water years. This would be accomplished by raising Shasta Dam 6.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD. Hence, the most significant benefits to anadromous fish would occur upstream from the RBDD. It is estimated that under CP1, improved water temperature conditions could result in an average annual increase in the salmon population of about 366,000 out-migrating juvenile fish per year.

Figure 5-3 shows an exceedence probability relationship of maximum annual storage in Shasta Lake for CP1and other comprehensive plans compared to the No-Action Alternative, illustrating expected increases in storage volumes under each comprehensive plan. Storage volumes for Figure 5-3 were simulated with the CalSim-II model based on the CALFED Common Assumptions for Water Storage Projects 2030 level of development projections as discussed in detail in the Modeling Appendix. Figure 5-4 shows simulated reservoir storage fluctuations for the No-Action Alternative and all comprehensive plans for a representative period of 1972 through 2003.

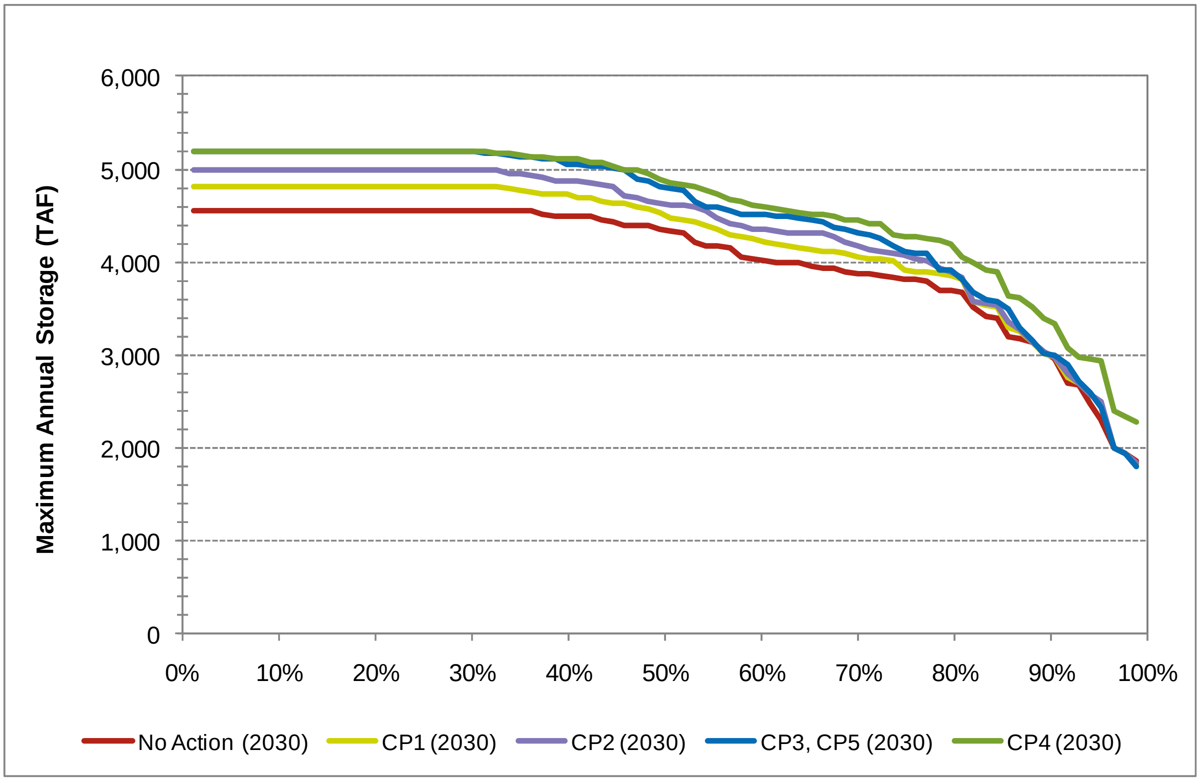


Figure 5-3. Simulated Exceedence Probability Relationship of Maximum Annual Storage in Shasta Lake for a Future Level of Development

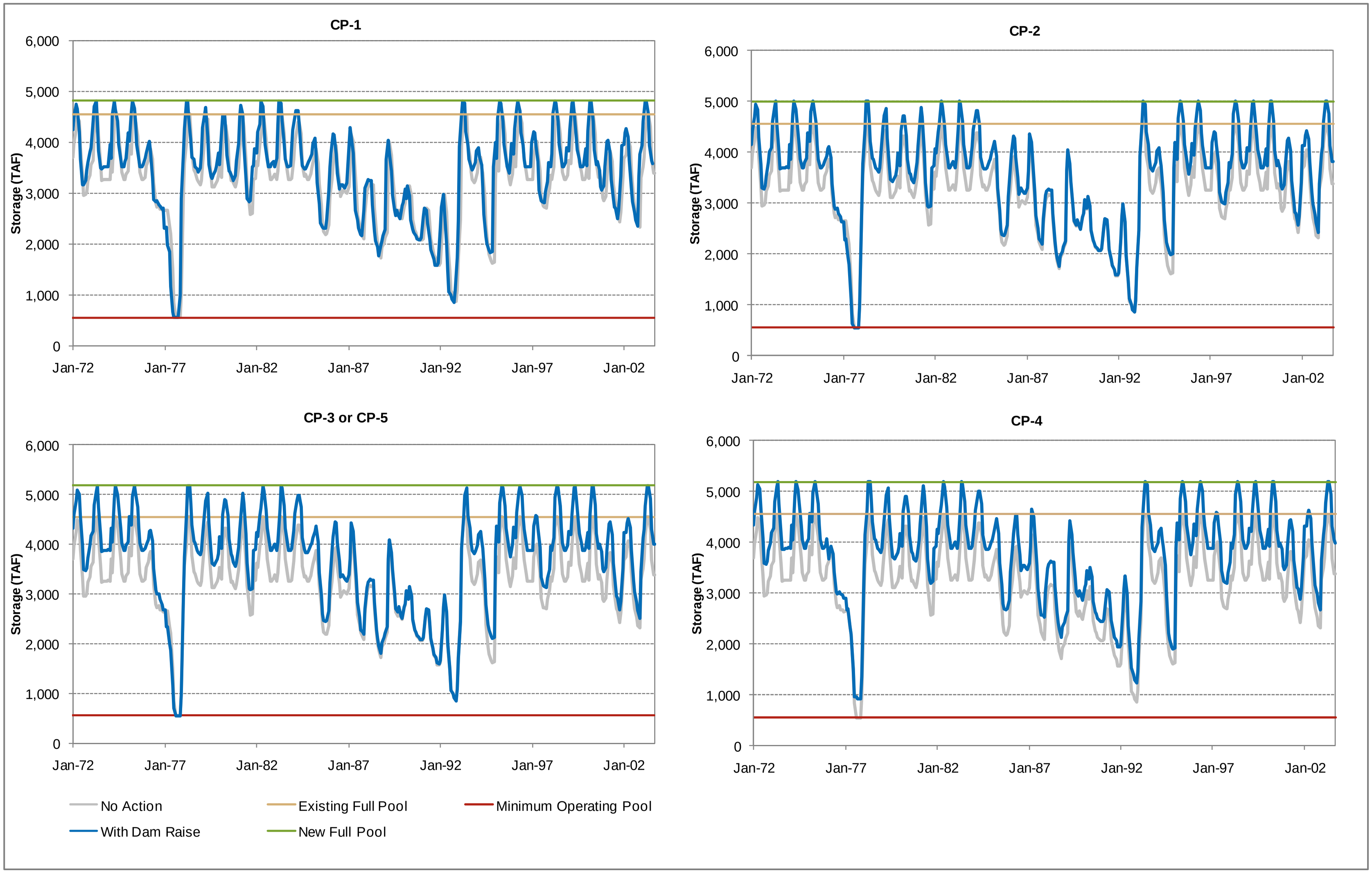
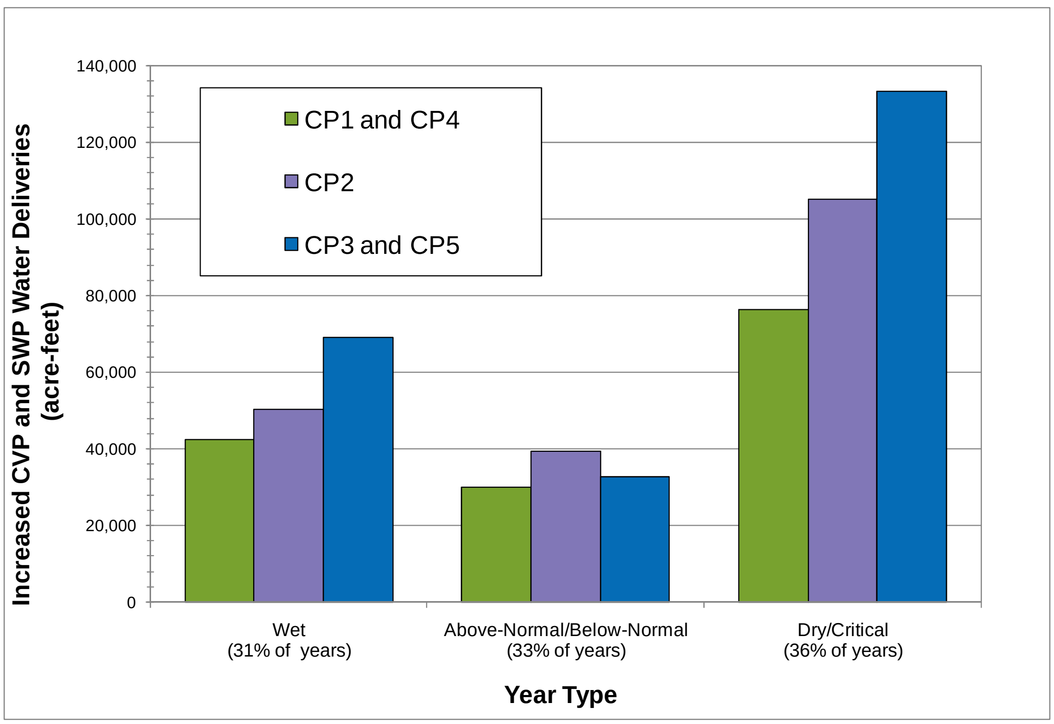


Figure 5-4. Simulated Shasta Reservoir Storage from 1972 to 2003 for the No-Action Alternative and Comprehensive Plans

Increase Water Supply Reliability CP1 would increase water supply reliability by increasing firm water supplies for irrigation and M&I deliveries, primarily during drought periods. Resulting increases in deliveries, based on CalSim-II modeling results, are shown in Figure 5-5 and Table 5-6. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA, which would help reduce estimated future water shortages by increasing firm yield for agricultural and M&I deliveries by at least 76,400 acre-feet per year and an average annual yield of about 46,400 acre-feet per year. For this report, firm yield is considered equivalent to the estimated increase in the reliability of supplies during dry and critically dry periods. As shown in Table 5-6, the majority of increased firm yield, 66,800 acre-feet, would be for south-of-Delta agricultural and M&I deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban areas resulting from water shortages. Under CP1, about $2.3 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.



Note: Deliveries were simulated using CalSim-II and water year types were based on the Sacramento Valley Water Year Hydrologic Classification.

Figure 5-5. Comparison of Increased CVP and SWP Water Deliveries by Year Type for Comprehensive Plans

Table 5-6. Increases in CVP and SWP Water Deliveries for Comprehensive Plans

Total CVP/SWP Deliveries	Average All Years			Dry and Critical Years[2]		
	CP1/CP4 (acre-feet)	CP2 (acre-feet)	CP3/CP5 (acre-feet)	CP1/CP4 (acre-feet)	CP2 (acre-feet)	CP3/CP5 (acre-feet)
North of Delta						
Agriculture	5,200	11,500	16,100	7,800	17,100	25,300
M&I	1,000	1,600	2,300	1,800	2,700	4,300
Total	6,200	13,100	18,400	9,600	19,800	29,600
South of Delta						
Agriculture	22,700	36,200	43,700	42,600	66,900	86,300
M&I	17,500	13,500	13,700	24,200	18,400	17,500
Total	40,200	49,700	57,400	66,800	85,300	103,800
Combined North and South of Delta						
Agriculture[1]	27,900	47,700	59,700	50,400	84,100	111,600
M&I[1]	18,500	15,100	16,000	26,000	21,000	21,800
Total[1]	***46,400***	***62,800***	***75,800***	***76,400***	***105,100***	***133,400***

Note:
[1] Totals may not sum due to rounding.
[2] Based on the Sacramento Valley Water Year Hydrologic Classification
Key:
CP = Comprehensive Plan
CVP = Central Valley Project
M&I = Municipal and Industrial
SWP = State Water Project

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 42 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities.

Maintain and Increase Recreation Opportunities CP1 includes features to at least maintain the existing recreation capacity at Shasta Lake. Although CP1 does not include specific features to further benefit recreation resources, a small benefit would likely occur to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area and modernization of recreation facilities. The maximum surface area of the lake would increase by about 1,110 acres (4 percent), from 29,600 to about 30,700 acres. There is also limited potential for reservoir reoperation to provide additional benefits to recreation by raising the bottom of the flood control pool elevation and allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other SLWRI Planning Objectives CP1 could also provide benefits related to flood damage reduction, ecosystem restoration, and water quality. Enlarging Shasta Dam would provide for incidental increased reservoir capacity to capture flood flows, which could reduce flood damage along the upper Sacramento River. Improved fisheries conditions as a result of CP1, as described above, and increased flexibility to meet flow and temperature requirements, could also enhance overall ecosystem resources in the Sacramento River. Furthermore, CP1 could potentially benefit ecosystem restoration through improved Delta water quality conditions by increasing Delta outflow during drought years and reducing salinity during critical periods. CP1 may also contribute to improving Delta water quality through increased Delta emergency response capabilities. When Delta emergencies occur, additional water in Shasta Reservoir could improve operation flexibility for increasing releases to supplement existing water sources to reestablish Delta water quality. In addition to Delta emergency response, increased storage in Shasta Reservoir could increase emergency response capability for CVP/SWP water supply deliveries.

Additional Broad Public Benefits Additional broad public benefits of CP1 obtained through pursuing project objectives are summarized in Table 5-3. These include benefits to reservoir water quality, traffic and transportation, and public services from modernization and upgrades of relocated facilities. Long-term benefits to air quality, groundwater, Shasta Lake fisheries, and system-wide operations are due to increased overall system capacity, allowing for increases in clean energy production, surface water deliveries, and storage capacity in Shasta Reservoir.

Potential Primary Effects from CP1

Several potential environmental consequences of CP1 are included in this section. A detailed discussion of potential effects and proposed mitigation measures for CP1 are included in Chapters 4 through 25 of the PDEIS and summarized in Table 5-7 below.

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans

Resource Topic/Impact	Alternative	Mitigation Measure
Geology, Geomorphology, Minerals, and Soils		
Impact Geo-2: Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats	CP1 – CP5	Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact
Impact Geo-9: Substantial Increase in Channel Erosion and Meander Migration	CP1 – CP5	Mitigation Measure Geo-9: Implement Channel Sensitive Water Release Schedules
Air Quality and Climate		
Impact AQ-1: Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction	CP1 – CP5	Mitigation Measure AQ-1: Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels
Hydrology, Hydraulics, and Water Management		
No mitigation measures proposed.		
Water Quality		
Impact WQ-1: Temporary Construction-Related Sediment Effects on Shasta Lake and Its Tributaries That Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses	CP1 – CP5	Mitigation Measure WQ-1: Prepare and Implement a Stormwater Pollution Prevention Plan That Minimizes the Potential Contamination of Surface Waters, and Comply with Applicable Federal Regulations Concerning Construction Activities
Impact WQ-4: Long-Term Sediment Effects That Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in Shasta Lake or Its Tributaries	CP1 – CP5	Mitigation Measure WQ-4: Implement Mitigation Measure WQ-1: Prepare and Implement a Stormwater Pollution Prevention Plan That Minimizes the Potential Contamination of Surface Waters, and Comply with applicable Federal Regulations Concerning Construction Activities
Impact WQ-6: Long-Term Metals Effects That Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in Shasta Lake or Its Tributaries	CP1 – CP5	Mitigation Measure WQ-6: Prepare and Implement a Site-Specific Remediation Plan for Historic Mine Features Subject to Inundation in the Vicinity of the Bully Hill and Rising Star Mines

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact WQ-7: Temporary Construction-Related Sediment Effects on the Upper Sacramento River That Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses	CP1 – CP3	Mitigation Measure WQ-7: Implement Mitigation Measure WQ-1: Prepare and Implement a Stormwater Pollution Prevention Plan That Minimizes the Potential Contamination of Surface Waters, and Comply with Applicable Federal Regulations Concerning Construction Activities
	CP4 – CP5	Mitigation Measure WQ-7: Implement Mitigation Measure WQ-1: Prepare and Implement a Stormwater Pollution Prevention Plan That Minimizes the Potential Contamination of Surface Waters, and Comply with Applicable Federal Regulations Concerning Construction Activities and Gravel Augmentation BMPs
Impact WQ-12: Long-Term Metals Effects That Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in the Upper Sacramento River	CP1 – CP5	Mitigation Measure WQ-12: Implement Mitigation Measure WQ-6: Prepare and Implement a Site-Specific Remediation Plan for Historic Mine Features Subject to Inundation in the Vicinity of the Bully Hill and Rising Star Mines
Impact WQ-18: Long-Term Metals Effects That Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in the Extended Study Area	CP1 – CP5	Mitigation Measure WQ-18: Implement Mitigation Measure WQ-6: Prepare and Implement a Site-Specific Remediation Plan for Historic Mine Features Subject to Inundation in the Vicinity of the Bully Hill and Rising Star Mines
Noise and Vibration		
Impact Noise-1: Exposure of Sensitive Receptors in the Primary Study Area to Project-Generated Construction Noise	CP1 – CP5	Mitigation Measure Noise-1: Implement Measures to Prevent Exposure of Sensitive Receptors to Temporary Construction Noise at Project Construction Sites
Hazards and Hazardous Materials and Waste		
Impact Haz-1: Wildland Fire Risk (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Haz-1: Coordinate and Assist Public Services Agencies to Reduce Fire Hazards.
Impact Haz-2: Release Potentially Hazardous Materials or Hazardous Waste (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Haz-2: Reduce Potential for Release of Hazardous Materials and Waste
Impact Haz-4: Expose Sensitive Receptors to Hazardous Materials (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Haz-4: Reduce Potential for Exposure of Sensitive Receptors to Hazardous Materials or Waste

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Agriculture and Important Farmlands		
No mitigation measures proposed.		
Fisheries and Aquatic Ecosystems		
Impact Aqua-4: Effects on Special-Status Aquatic Mollusks	CP1 – CP5	Mitigation Measure Aqua-4: Implement Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact
Impact Aqua-14: Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	CP1 – CP5	Mitigation Measure Aqua-14: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Aqua-15: Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern	CP1 – CP5	Mitigation Measure Aqua-15: Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements
Impact Aqua-16: Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	CP1 – CP5	Mitigation Measure Aqua-14: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Botanical Resources and Wetlands		
Impact Bot-2: Loss of MSCS Covered Species	CP1 – CP5	Mitigation Measure Bot-2: Acquire and Preserve Mitigation Lands; Avoid Populations; Relocate MSCS Plants and Revegetate Affected Areas
Impact Bot-3: Loss of USFS Sensitive, BLM Sensitive, or CRPR Species	CP1 – CP5	Mitigation Measure Bot-3: Acquire and Preserve Mitigation Lands; Avoid Populations; Relocate USFS Sensitive, BLM Sensitive, and CRPR Plants and Revegetate Affected Areas
Impact Bo-4: Loss of Jurisdictional Waters	CP1 – CP5	Mitigation Measure Bot-4: Mitigate Loss of Jurisdictional Waters
Impact Bot-5: Loss of General Vegetation Habitats	CP1 – CP5	Mitigation Measure Bot-5: Acquire and Preserve Mitigation Lands for Loss of General Vegetation Habitats
Impact Bot-6: Spread of Noxious and Invasive Weeds	CP1 – CP5	Mitigation Measure Bot-6: Develop a Weed Management Plan

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact Bot-7: Altered Structure and Species Composition and Loss of Sensitive Plant Communities and Special-Status Plant Species Resulting from Altered Flow Regimes	CP1 – CP5	Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities
Impact Bot-8: Conflict with Approved Local or Regional Plans with Objectives of Riparian Habitat Protection or Watershed Management	CP1 – CP5	Mitigation Measure Bot-8: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities
Impact Bot-11: Loss of Sensitive Natural Communities or Habitats Resulting from Implementing the Gravel Augmentation Program or the Reading Island Restoration Plan, Rehabilitating the Reading Island Boat Ramp, or Constructing a Handicap Fishing Access Area	CP4 – CP5	Mitigation Measure Bot-11: Revegetate Disturbed Areas, Consult with DFG
Impact Bot-12: Loss of Special-Status Plants Resulting from Implementing the Gravel Augmentation Program, Restoring Sacramento River Flow Through Anderson Slough, Rehabilitating the Reading Island Boat Ramp, or Constructing a Handicap Fishing Access Area	CP4 – CP5	Mitigation Measure Bot-12: Conduct Preconstruction Surveys for Special-Status Plants and Avoid Special-Status Plant Populations During Construction
Impact Bot-13: Spread of Noxious and Invasive Weeds Resulting from Implementing the Gravel Augmentation Program, Restoring Sacramento River Flow Through Anderson Slough, Rehabilitating the Reading Island Boat Ramp, or Constructing a Handicap Fishing Access Area	CP4 – CP5	Mitigation Measure Bot-13: Implement Weed Management Measures and Revegetation
Impact Bot-14: Altered Structure and Species Composition and Loss of Sensitive Plant Communities and Special-Status Plant Species Resulting from Altered Flow Regimes on the Lower Sacramento River	CP1 – CP5	Mitigation Measure Bot-14: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities
Impact Bot-15: Conflict with Approved Local or Regional Plans with Objectives of Riparian Habitat Protection or Watershed Management Along the Lower Sacramento River	CP1 – CP5	Mitigation Measure Bot-15: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Wildlife Resources		
Impact Wild-1: Take and Loss of Habitat for the Shasta Salamander	CP1 – CP5	Mitigation Measure Wild-1: Avoid, Relocate, and Acquire Mitigation Lands for Shasta Salamander
Impact Wild-2: Impact on the Foothill Yellow-Legged Frog and Tailed Frog and Their Habitat	CP1 – CP5	Mitigation Measure Wild-2: Avoid, Relocate, and Acquire Mitigation Lands for Foothill Yellow-Legged Frog and Tailed Frog
Impact Wild-3: Impact on the Northwestern Pond Turtle and Its Habitat	CP1 – CP5	Mitigation Measure Wild-3: Avoid, Relocate, and Acquire Mitigation Lands for Northwestern Pond Turtle
Impact Wild-4: Impact on the American Peregrine Falcon	CP1 – CP5	Mitigation Measure Wild-4: Conduct Preconstruction Surveys for the American Peregrine Falcon and Establish Buffers
Impact Wild-5: Take and Loss of Habitat for the Bald Eagle	CP1 – CP5	Mitigation Measure Wild-5: Acquire and Preserve Mitigation Lands; Conduct Protocol-Level Surveys for the Bald Eagle and Establish Buffers
Impact Wild-6: Take and Loss of Nesting and Foraging Habitat for the Northern Spotted Owl	CP1 – CP5	Mitigation Measure Wild-6: Acquire and Preserve Mitigation Lands; Conduct Protocol-Level Surveys for the Northern Spotted Owl and Establish Buffers
Resource Topic/Impact	**Alternative**	**Mitigation Measure**
Impact Wild-7: Impact on the Purple Martin and Its Habitat	CP1 – CP5	Mitigation Measure Wild-7: Conduct a Preconstruction Survey for Purple Martin and Establish Buffers
Impact Wild-8: Impacts on the Willow Flycatcher, Vaux's Swift, Yellow Warbler, and Yellow-Breasted Chat and Their Foraging and Nesting Habitat	CP1 – CP5	Mitigation Measure Wild-8: Acquire and Preserve Mitigation Lands; Conduct a Preconstruction Survey for the Willow Flycatcher, Vaux's Swift, Yellow Warbler, and Yellow-Breasted Chat and Establish Buffers
Impact Wild-9: Impacts on the Long-Eared Owl, Northern Goshawk, Cooper's Hawk, Great Blue Heron, and Osprey and Their Foraging and Nesting Habitat	CP1 – CP5	Mitigation Measure Wild-9: Acquire and Preserve Mitigation Lands; Conduct a Preconstruction Survey for the Long-Eared Owl, Northern Goshawk, Cooper's Hawk, and Great Blue Heron and Establish Buffers
Impact Wild-10: Take and Loss of Habitat for the Pacific Fisher	CP1 – CP5	Mitigation Measure Wild-10: Acquire and Preserve Mitigation Lands; Conduct Preconstruction Surveys for the Pacific Fisher and Establish Buffers

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact Wild-11: Impacts on Special-Status Bats (Pallid Bat, Spotted Bat, Western Red Bat, Western Mastiff Bat, Townsend's Big-Eared Bat, Long-Eared Myotis, and Yuma Myotis), the American Marten, and Ringtails and Their Habitat	CP1 – CP5	Mitigation Measure Wild-11: Acquire and Preserve Mitigation Lands; Conduct a Preconstruction Survey for Special-Status Bats, American Marten, and Ringtails and Establish Buffers
Impact Wild-12: Impacts on Special-Status Terrestrial Mollusks (Shasta Sideband, Wintu Sideband, Shasta Chaparral, and Shasta Hesperian) and Their Habitat	CP1 – CP5	Mitigation Measure Wild-12: Avoid Suitable Habitat; Acquire and Preserve Mitigation Lands for Special-Status Terrestrial Mollusks
Impact Wild-13: Permanent Loss of General Wildlife Habitat	CP1 – CP5	Mitigation Measure Wild-13: Acquire and Preserve Mitigation Lands for Permanent Loss of General Wildlife Habitat
Impact Wild-14: Impacts on Other Birds of Prey (Red-Tailed Hawk and Red-Shouldered Hawk) and Migratory Bird Species (American Robin, Anna's Hummingbird) and Their Foraging and Nesting Habitat	CP1 – CP5	Mitigation Measure Wild-14: Conduct Preconstruction Surveys for Other Nesting Raptors and Migratory Birds and Establish Buffers
Impact Wild-15: Loss of Critical Deer Winter and Fawning Range	CP1 – CP5	Mitigation Measure Wild-15: Acquire and Preserve Mitigation Lands for Permanent Loss of Critical Deer Wintering and Fawning Range
Impact Wild-16: Take and Loss of California Red-Legged Frog	CP1 – CP5	TBD
Impact Wild-17: Impacts on Riparian-Associated Special-Status Wildlife Resulting from Modifications to the Existing Flow Regime in the Primary Study Area	CP1 – CP5	Mitigation Measure Wild-17: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities
Impact Wild-20: Consistency with Local and Regional Plans with Goals of Promoting Riparian Habitat in the Primary Study Area	CP1 – CP5	Mitigation Measure Wild-20: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities
Impact Wild-21: Impacts on Riparian-Associated Special-Status Wildlife Resulting from the Gravel Augmentation Program	CP4 – CP5	Mitigation Measure Wild-21: Conduct Preconstruction Surveys for Elderberry Shrubs, Northwestern Pond Turtle, and Nesting Riparian Raptors and Other Nesting Birds. Avoid Removal or Degradation of Elderberry Shrubs and Avoid Vegetation Removal Near Active Nest Sites.

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact Wild-22: Impacts on Riparian-Associated Special-Status Wildlife Species Resulting from Restoration of Reading Island	CP4 – CP5	Mitigation Measure Wild-22: Implement Mitigation Measure Wild-21: Conduct Preconstruction Surveys for Elderberry Shrubs, Northwestern Pond Turtle, and Nesting Riparian Raptors and Other Nesting Birds. Avoid Removal or Degradation of Elderberry Shrubs and Avoid Vegetation Removal near Active Nest Sites.
Impact Wild-23: Impacts on Riparian-Associated and Aquatic Special-Status Wildlife Resulting from Modifications to Existing Flow Regimes in the Lower Sacramento River and Delta	CP1 – CP5	Mitigation Measure Wild-23: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Wild-26: Consistency with Local and Regional Plans with Goals of Promoting Riparian Habitat Along the Lower Sacramento River and in the Delta	CP1 – CP5	Mitigation Measure Wild-26: Implement Mitigation Measure Bot-7: Develop and Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Cultural Resources		
Impact Culture-1: Disturbance or Destruction of Archaeological and Historic Resources Due to Construction or Inundation	CP1 – CP5	Mitigation Measure Culture-1: Comply with Section 106 of the NHPA
Impact Culture-3: Disturbance or Destruction of Archaeological and Historic Resources near the Upper Sacramento River Due to Construction	CP4 – CP5	Mitigation Measure Culture-3: Implement Mitigation Measure Culture-1: Comply with Section 106 of the NHPA.
Indian Trust Assets		
No mitigation measures proposed.		
Socioeconomics, Population, and Housing		
Impact Socio-14: Potential Temporary Reduction in Shasta Project Water or Hydropower Supplied to the CVP and SWP Service Areas During Construction	CP1 – CP5	Mitigation Measure Socio-14: Secure Replacement Water or Hydropower During Project Construction

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Land Use Planning		
Impact LU-1: Disrupt Existing Land Uses (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure LU-1: Minimize and/or Avoid Temporary Disruptions to Local Communities
Impact LU-2: Conflict with Existing Land Use Goals and Policies of Affected Jurisdictions (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure LU-2: Minimize and/or Avoid Conflicts with Land Use Goals and Policies
Recreation and Public Access		
Impact Rec-1 (CP1–CP5): Seasonal Inundation of Shasta Lake Recreation Facilities or Portions of Recreation Facilities and Public Access at Pool Elevations Above the Current Full Pool Elevation	CP1 – CP5	Mitigation Measure Rec-1: Modify and Relocate Recreation Facilities Inundated by Increases in Shasta Lake Full Pool Elevation
Impact Rec-2 (CP1 – CP5): Temporary Construction-Related Disruption of Recreation Access and Activities at and near Shasta Dam	CP1 – CP5	Mitigation Measure Rec-2: Provide Information About and Improve Alternate Recreation Access and Opportunities to Mitigate the Temporary Loss of Recreation Access and Opportunities During Construction at Shasta Dam
Impact Rec-4 (CP1 – CP5): Increased Hazards to Boaters and Other Recreationists at Shasta Lake from Standing Timber and Stumps Remaining in Untreated Areas of the Inundation Zone	CP1 – CP5	Mitigation Measure Rec-4: Provide Information to Shasta Lake Visitors About Potential Safety Hazards in Newly Inundated Areas from Standing Timber and Stumps
Impact Rec-15 (CP1 – CP5): Increased Difficulty for Boaters and Anglers in Using the Sacramento River and Rivers Below CVP and SWP Reservoirs as a Result of Decreased River Flows	CP1 – CP5	Mitigation Measure Rec-15: Implement Mitigation Measure Aqua-15: Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements
Aesthetics and Visual Resources		
Impact Vis-3: Generation of Increased Daytime Glare and/or Nighttime Lighting (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Vis-3: Minimize or Avoid Visual Impacts of Daytime Glare and Nighttime Lighting

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Transportation and Traffic		
Impact Trans-1: Short-Term and Long-Term Increases in Traffic in the Primary Study Area in Relation to the Existing Traffic Load and Capacity of the Street System	CP1 – CP5	Mitigation Measure Trans-1: Prepare and Implement a Traffic Control and Safety Assurance Plan
Impact Trans-2: Adverse Effects on Access to Local Streets or Adjacent Uses in the Primary Study Area	CP1 – CP5	Mitigation Measure Trans-2: Implement Mitigation Measure Trans-1: Prepare and Implement a Traffic Control and Safety Assurance Plan.
Impact Trans-4: Adverse Effects on Emergency Access in the Primary Study Area	CP1 – CP5	Mitigation Measure Trans-4: Implement Mitigation Measure Trans-1: Prepare and Implement a Traffic Control and Safety Assurance Plan.
Utilities and Service Systems		
Impact Util-1: Damage or Disruption of Public Utility and Service Systems Infrastructure (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Util-1: Implement Procedures to Avoid Damage to or Temporary Disruption of Service
Impact Util-2: Utility Infrastructure Relocation or Modification (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Util-2: Adopt Measures to Minimize Infrastructure Relocation Impacts
Public Services		
Impact PS-1: Disruption of Public Services (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure PS-1: Coordinate and Assist Public Services Agencies
Impact PS-2: Degraded Level of Public Services (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	PS-2: Provide Support to Public Services Agencies
Power and Energy		
No mitigation measures proposed.		
Environmental Justice		
No mitigation measures proposed.		

Table 5-7. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Wild and Scenic Rivers Considerations for McCloud River		
No mitigation measures proposed.		

Key:
Ag = Agriculture and Important Farmlands
AQ = Air Quality and Climate
Aqua = Fisheries and Aquatic Ecosystems
BLM = U.S. Bureau of Land Management
BMP = best management practice
Bot = Botanical Resources and Wetlands
CP – Comprehensive Plan
CRPR = California Rare Plant Rank
Culture = Cultural Resources
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
DFG = California Department of Fish and Game
Geo = Geology, Geomorphology, Minerals, and Soils
Haz = Hazards and Hazardous Materials and Waste
LU = Land Use Planning
MSCS = Multi-Species Conservation Strategy
NHPA = National Historic Preservation Act
Noise = Noise and Vibration
PS = Public Services
Rec = Recreation and Public Access
Socio = Socioeconomics, Population, and Housing
SWP = State Water Project
TBD = to be determined
Trans = Transportation and Traffic
USFS = U.S. Forest Service
Util = Utilities and Service Systems
Vis = Aesthetics and Visual Resources
Wild = Wildlife Resources
WQ = Water Quality

Shasta Lake Area Within the reservoir area, the primary long-term impacts of this and other comprehensive plans would be due to the increased water surface elevations and inundation area and/or indirect effects related to facility access, and O&M. Raising the full pool of the lake would cause direct impacts due to higher water surface elevations and inundation area. General types of impacts would include potential inundation of terrestrial and aquatic habitat, and inundation and resulting relocation of buildings, sections of paved and nonpaved roads, campground facilities (such as parking areas and restrooms), and low-lying bridges. Use of, and access to, recreation facilities also would be impacted, including trails, day-use picnic areas, boat ramps, marinas, campgrounds, resorts, and beaches. Several of the main buildings associated with Bridge Bay Resort and Marina, the largest resort and marina complex on Shasta Lake, are located within a few feet of the existing full pool elevation. Any potential real estate acquisition, or necessary relocations of displaced parties, would be accomplished under Public Law 91-646.

The without-project and with-project relationship of water stored in Shasta Reservoir is shown in Figure 5-2. Figure 5-3 shows the exceedence probability of maximum annual storages in Shasta Reservoir. From these graphics, it can be seen that Shasta Reservoir fills to (or near) full pool levels in the without-project condition about once every 4 years (about 25 percent of the years). In addition, on the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent capacity in about 82 percent of the years over the 82-year period of analysis of the CalSim-II model. With this plan, Shasta would fill to the new full pool storage of 4.81 MAF at the same frequency as under without-project conditions – about 25 percent of the years. Further, Shasta Lake would also fill to 80 percent of the new capacity in about 79 percent of the years. Accordingly, annual operations in the reservoir generally would mirror existing operations except the water surface in the lake would be about 8.5 feet higher. The primary difference in additional reservoir area exposed under without-project versus with-project conditions would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels.

The increased area of inundation for CP1 is 1,110 acres. This equates to an average increase in the lateral zone of about 21 feet. An example of the extent of inundation for the 6.5-foot dam raise (as well as an 18.5-foot dam raise) is shown in Figure 5-6. The figure shows increased inundation of the Sacramento River arm at the community of Lakeshore, the most populated area around the lake. Because of the gently sloping shoreline adjacent to Lakeshore, this area is representative of the maximum lateral increase in inundation that could be expected with dam raises up to 18.5 feet. The community of Sugarloaf would also be impacted.

Figure 5-6. Simulated Maximum Lake Shore Area Inundation for Dam Raises of 6.5 Feet and 18.5 Feet

The duration of inundation at given drawdown levels (e.g., 10 feet from top of full pool) would be similar to existing conditions. Water would inundate the highest levels of the reservoir for periods ranging from several days to about 1 month. Much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, much of the remaining vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the flatter slopes because of the infrequent inundation.

The McCloud River is an area of specific interest. California Public Resources Code 5093.542 (c) and (d) may limit State involvement in studies to enlarge Shasta Dam and Reservoir if that action could have an adverse effect on the free-flowing conditions of the McCloud River or its wild trout fishery. Figure 5-7 illustrates the estimated increase in area of inundation on the McCloud River upstream from the McCloud Bridge for CP1 (6.5-foot dam raise). As shown in Figure 5-7, raising Shasta Dam 6.5 feet would result in inundating an additional 1,470 lineal feet (about 9 acres) of the lower McCloud River compared to existing conditions. Raising Shasta Dam 18.5 feet would result in inundating an additional 3,550 lineal feet (about 27 acres) of the lower McCloud River, compared to existing conditions. This represents a maximum of about 3 percent of the 24-mile-reach of river between the McCloud Bridge and McCloud Dam, which controls flows on the river.

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP1 include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation, and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP1, approximately 355 and 529 historic sites are within the inundation zone and fluctuation, respectively. The local Native American community has also identified several locations they consider to be sacred with potential for inundation under CP1; notable among these are the Winnemem Wintu locations Puberty Rock and the doctoring pools near Nawtawaket Creek. Although Puberty Rock would still be accessible for portions of the year, when lake levels are lower, CP1 would increase the frequency of inundation. Effects to historic properties are regulated under Section 106 of the National Historic Preservation Act, requiring measures to avoid, minimize, or mitigate adverse effects. The Winnemem Wintu will have the opportunity to participate, and continue to provide input, through the Section 106 process as an invited consulting party, and through the NEPA process.

Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related effects are also anticipated in the primary study area.

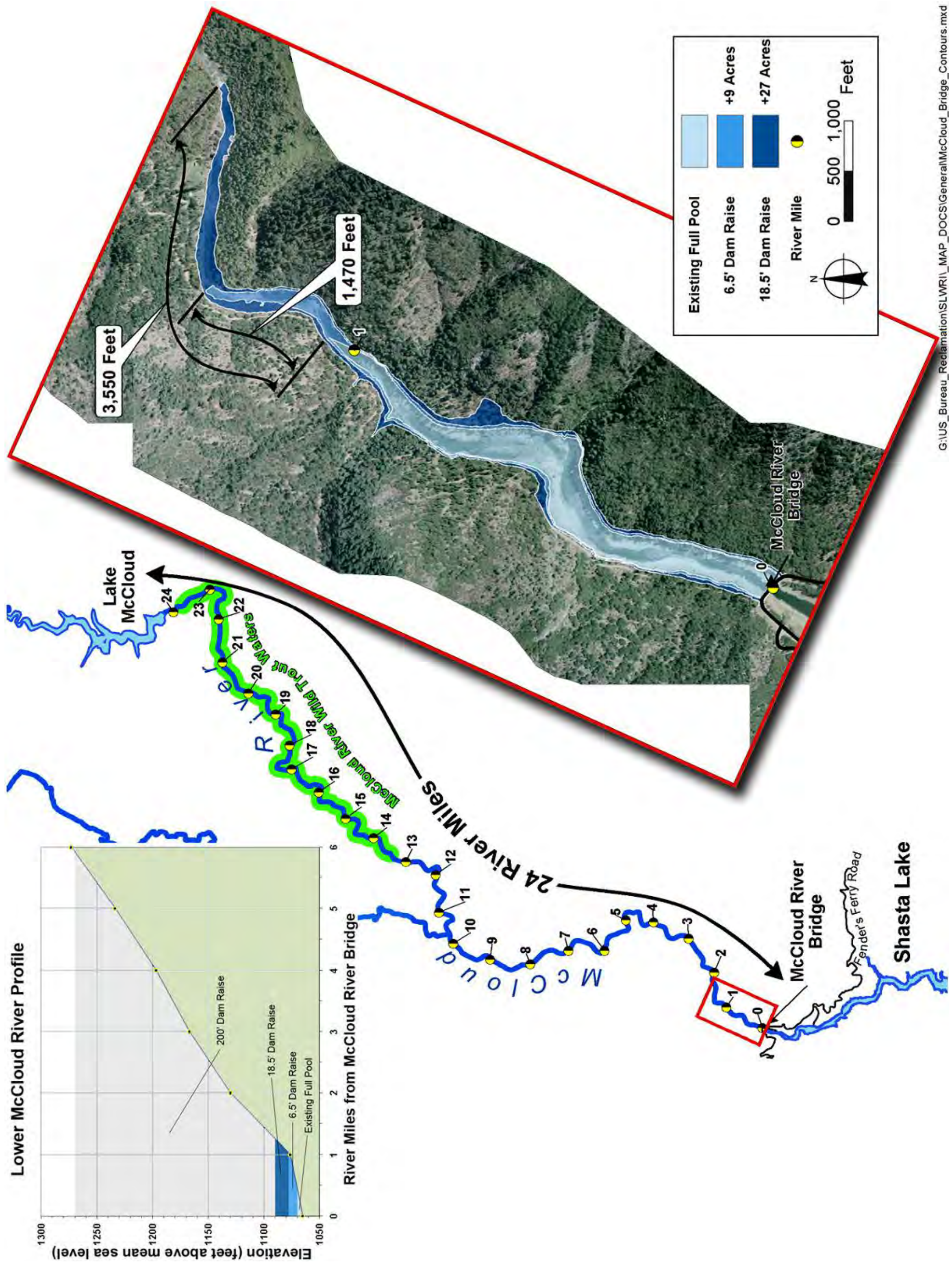


Figure 5-7. McCloud River Maximum Inundation for 6.5-foot and 18.5-foot Dam Raises

Upper Sacramento River Potential effects on flow and stages of the upper Sacramento River from this and other comprehensive plans would be minimal. Included in Figure 5-8 is an estimate of the percent change in river flows at Bend Bridge near Red Bluff for this and other dam raise scenarios under average, wet, and dry year conditions. Figures 5-9, 5-10, and 5-11 show CalSim-II simulated Sacramento River flows below Keswick Dam, Red Bluff Diversion Dam, and Stony Creek, respectively, under wet, above- and below-normal, and dry and critical year conditions for the No-Action Alternative, compared to CP1 and CP4. As can be seen, during most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River, would be relatively unchanged. Also, flows and stages would increase slightly in June and July. Although small, this increase would be most pronounced during dry periods as more water is released from Shasta Dam for water supply reliability purposes. During dry periods, however, there are few to no changes in water flows or changes during the winter and spring periods. Potential noticeable changes in river flows and stages diminish rapidly downstream from Red Bluff. This is primarily because of the significant amount of tributary inflows, especially from the Feather River system.

No effects on cultural resources are expected to occur in the upper Sacramento River region.

Changes in river flows and stages may impact geomorphic conditions along the river, existing riparian vegetation, and other wildlife resources. As mentioned above, the changes in temperatures and flows are, however, expected to have a beneficial effect on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered flow and temperature regime may adversely impact warm-water species in the Sacramento River. This impact is not expected to be significant.

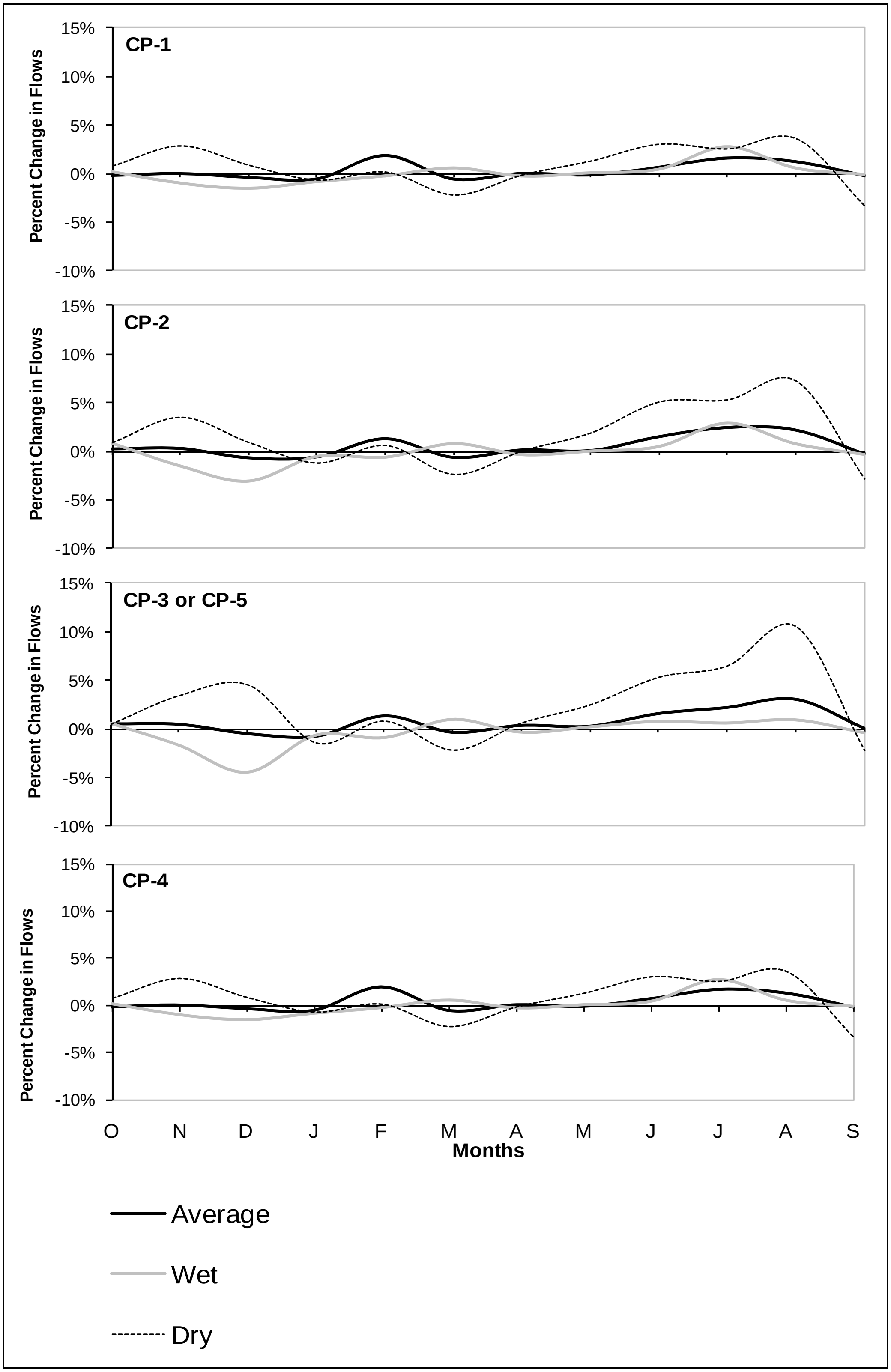


Figure 5-8. Percent Change in Simulated Flows at Bend Bridge for Average, Dry, and Wet Year Conditions

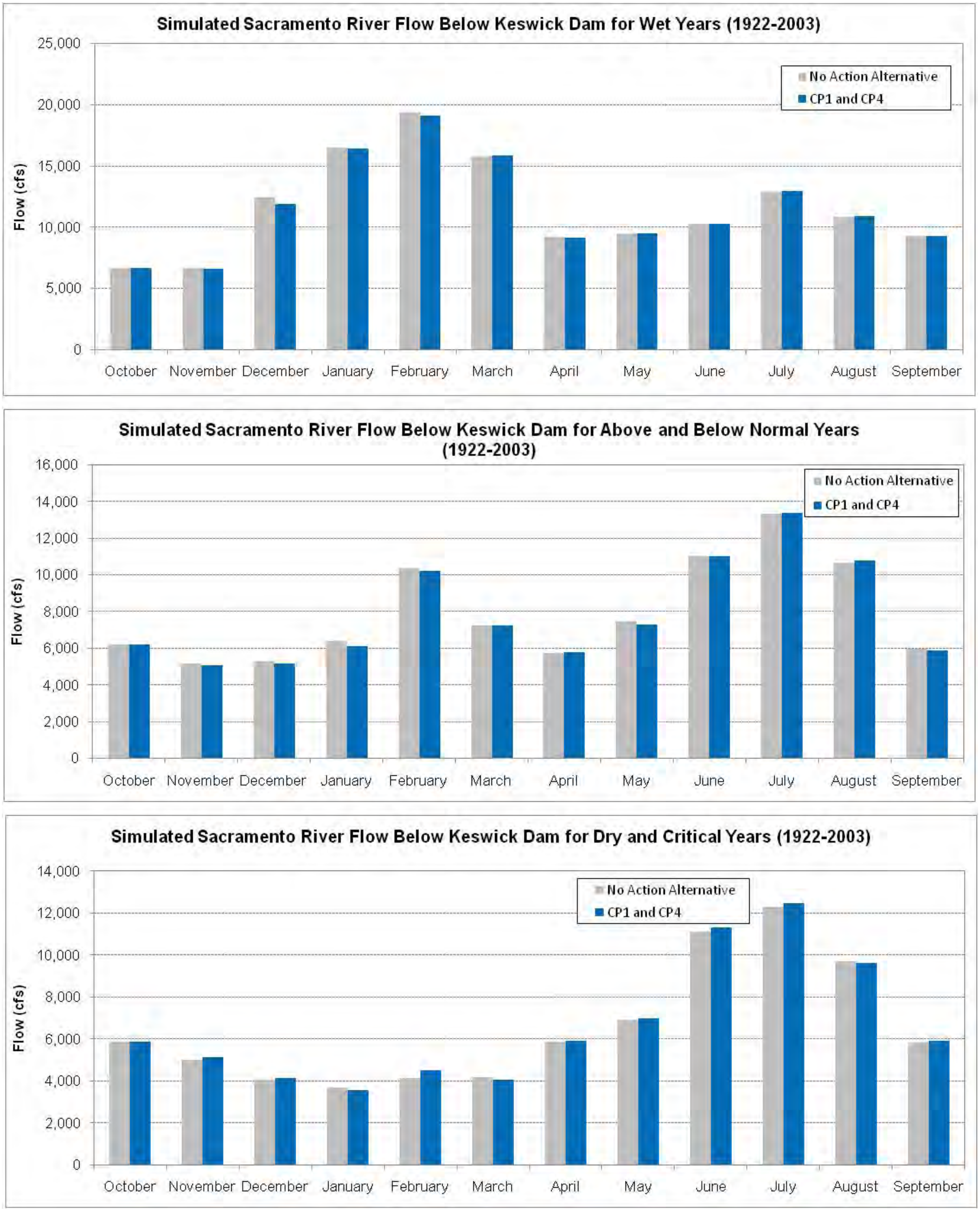


Figure 5-9. Simulated Sacramento River Flow Below Keswick Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP1, and CP4

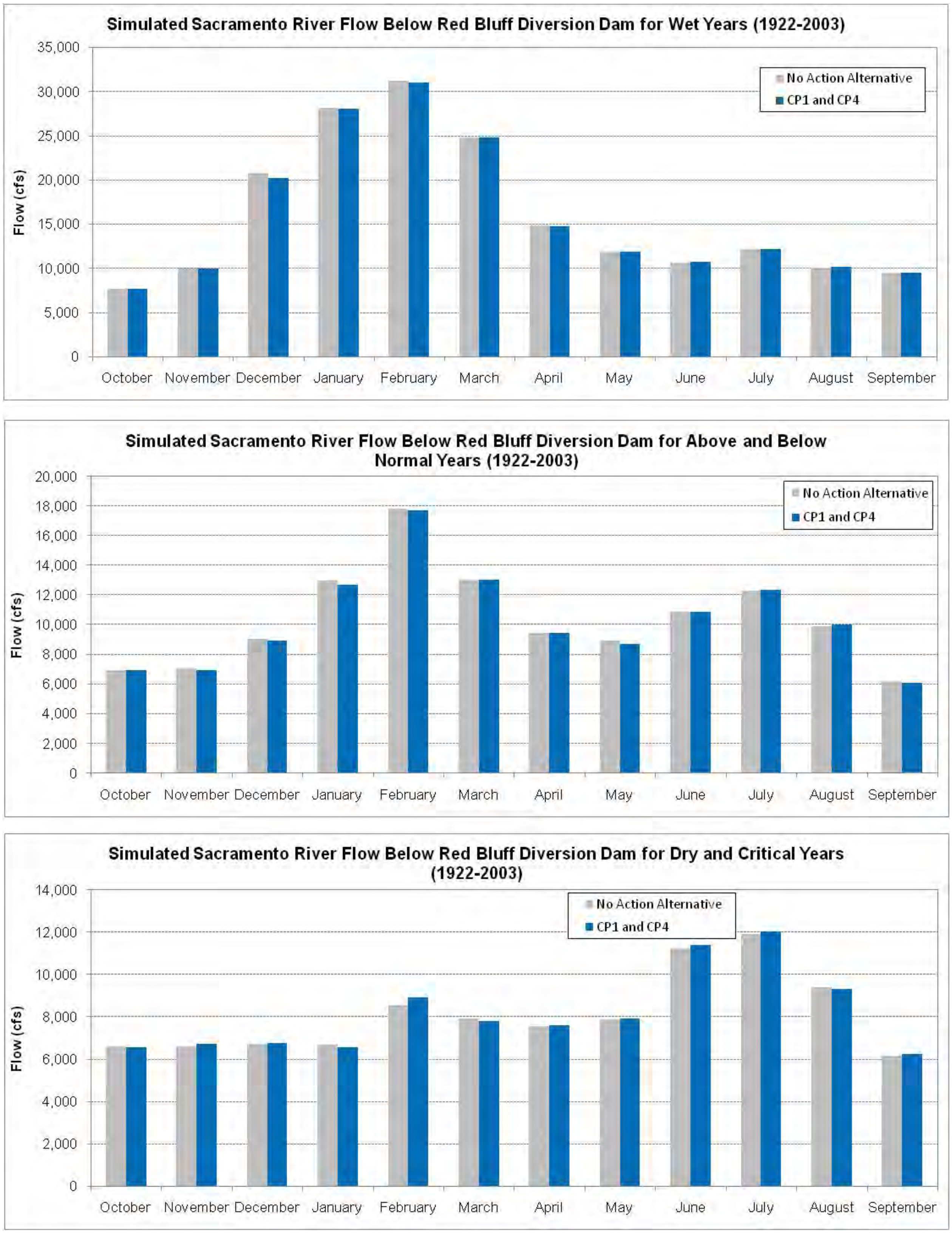


Figure 5-10. Sacramento River Flow Below Red Bluff Diversion Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP1, and CP4

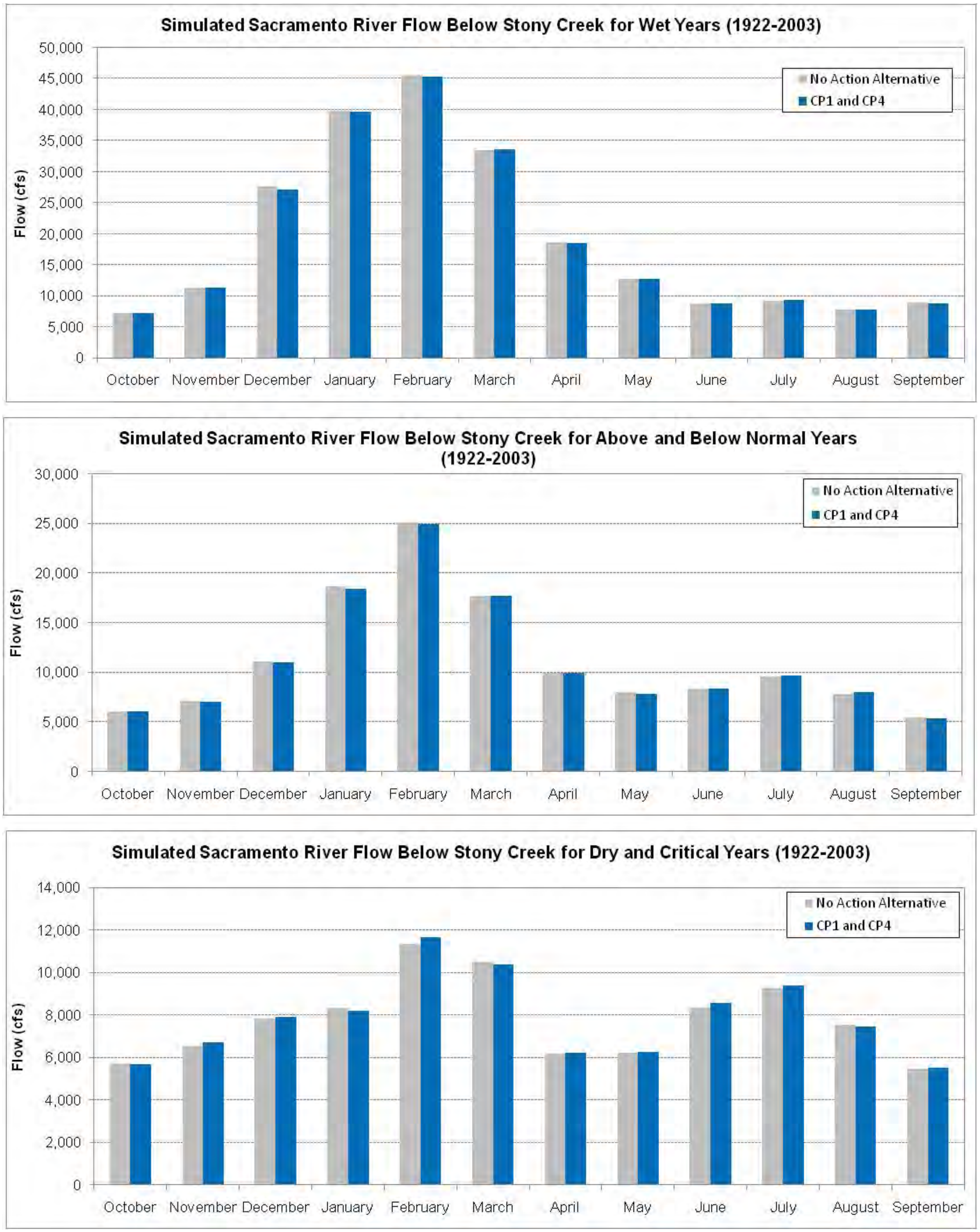


Figure 5-11. Sacramento River Flow Below Stony Creek in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP1, and CP4

Preliminary Economic Assessment of CP1

Estimated Costs As shown in the Table 5-4, the estimated construction cost for CP1 is about $827 million. The estimated total average annual cost of this plan is $42.6 million.

Estimated Economic Benefits As shown in Table 5-5, the total estimated average annual monetary benefit of CP1, assuming the cost of water and energy supplies increase at the same rate as inflation, is about $47.6 million. The largest monetary benefit is increased dry year water supply reliability. Assuming the cost of water supplies and hydropower increases at 2% above inflation, to account for future diminishment of water and energy supplies and increasing demands, the average annual benefit could exceed about $68.8 million per year.

Comprehensive Plan 2 (CP2) –12.5-Foot Dam Raise, Anadromous Fish and Water Supply Reliability

CP2 consists primarily of enlarging Shasta Dam by raising the crest 12.5 feet and enlarging the reservoir by 443,000 acre-feet. Major features of CP2 are shown in Figure 5-1.

Major Components of CP2

CP2 includes the following major components:

- Raising Shasta Dam and appurtenant facilities by 12.5 feet.
- Implementing the set of eight common management measures previously described.

A dam raise of 12.5 feet was chosen because it represents a midpoint between the likely smallest dam raise considered and the largest practical dam raise that would not require relocating the Pit River Bridge. By raising Shasta Dam from a crest at elevation 1,077.5 to elevation 1,090.0, CP2 would increase the height of the reservoir's full pool by 14.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to CP1. This increase in full pool height would add approximately 443,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would increase from 4.55 MAF to 5.0 MAF. Figure 5-2 shows the increase in surface area and storage capacity for CP2.

Under CP2, operations for water supply, hydropower, and environmental requirements would be similar to existing operations, with the additional storage retained for water supply reliability and as an expanded cold-water pool for fisheries benefits. The existing TCD would be extended for efficient use of the expanded cold-water pool.

As described for CP1, this plan would include the potential to revise flood control operational rules, which could potentially reduce flood damage and benefit recreation.

Potential Benefits of CP2

Major potential benefits of CP2, related to the SWLRI planning objectives and broad public services, are summarized in Tables 5-2 and 5-3 and described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. CP2 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critically dry water years. This would be accomplished by raising Shasta Dam 12.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD. Hence, the most significant benefits to anadromous fish would occur upstream from the RBDD. It is estimated that improved water temperature conditions under CP2 could result in an average annual increase in the Chinook salmon population of about 234,000 out-migrating juvenile fish.

Increase Water Supply Reliability CP2 would increase water supply reliability by increasing firm water supplies for irrigation and M&I deliveries, primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA, which would help reduce estimated future water shortages by increasing the reliability of firm water supplies for agricultural and M&I deliveries by at least 105,100 acre-feet per year and an average annual yield of about 62,800 acre-feet per year. For this report, firm yield is considered equivalent to the estimated increase in the reliability of supplies during dry and critically dry periods. As shown in Table 5-6, the majority of increased firm yield, 85,300 acre-feet, would be for south-of-Delta agricultural and M&I deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban areas resulting from water shortages. Under CP2, approximately $3.1 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 68 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities.

Maintain and Increase Recreation Opportunities CP2 includes features to, at a minimum, maintain the existing recreation capacity at Shasta Lake. Although CP2 does not have specific features to further benefit recreation resources, a small benefit would likely occur to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area and modernization of recreation facilities. The maximum surface area of the lake would increase by about 1,750 acres (6 percent), from 29,600 to about 31,300 acres. There is also limited potential for reservoir reoperation to provide additional benefits to recreation by raising the bottom of the flood control pool elevation and allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other SLWRI Study Objectives CP2 could also provide benefits related to flood damage reduction, ecosystem restoration, and water quality, as described for CP1, but to a greater extent because of increased capacity and associated overall system flexibility.

Additional Broad Public Benefits Additional broad public benefits of CP2 obtained through pursuing project objectives are summarized in Table 5-3. Broad public benefits for CP2 are similar to CP1 but amplified due to the higher dam raise further enlarging system capacity and the facility upgrades associated with additional relocations.

Potential Primary Effects of CP2

Following is a summary of the potential environmental effects of CP2. Potential environmental effects are generally comparable between comprehensive plans; some adverse effects would be exacerbated by larger dam raises and the associated scale of those effects, such as expanded construction areas and increased area of inundation around Shasta Lake. Proposed mitigation measures to address potential adverse impacts of CP2 are summarized in Table 5-7. As mentioned, a detailed discussion of potential effects and proposed mitigation measures are included in Chapters 4 through 25 of the PDEIS.

Shasta Lake Area As with CP1, the primary long-term effects of this comprehensive plan would be due to the increased water surface elevations and inundation area. The dam raise scenario under CP2 is greater than under CP1; therefore, anticipated effects under CP2 are expected to be slightly greater. As with the above plan, raising the full pool of the lake would cause direct effects due to higher water levels, and/or indirect impacts related to facility access, operation, and maintenance.

CP2 includes modifying four bridges and replacing four other bridges, inundating a number of small segments of existing paved and nonpaved roads, and relocating a number of potable water facilities, wastewater facilities, gas and petroleum facilities, and power distribution and telecommunications facilities. A number of recreation facilities would also be impacted, including campgrounds, marinas, resorts, boat ramps, day-use areas, and trails. Approximately 21 segments of roadway would be relocated, including portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road. Embankments would be constructed to protect I-5 at Lakeshore and UPRR at Bridge Bay. Any potential real estate acquisitions or necessary relocations of displaced parties would be accomplished under Public Law 91-646.

With CP2, Shasta Reservoir would fill to the new full pool storage of 5.0 MAF at a frequency similar to without-project conditions. On the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent or its current capacity in about 82 percent of the years over the 82-year period of analysis of the CalSim-II model. Figure 5-3 shows an exceedence probability relationship of maximum annual storage in Shasta Reservoir for this and other dam raises. With this alternative, Shasta Reservoir would fill to 80 percent of the new capacity in about 78 percent of the years. Accordingly, annual operations in the reservoir would generally mirror existing operations, but the water surface in the reservoir would be about 12.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels. Figure 5-4 shows the changes from without-project conditions for a dam raise of 12.5 feet for a representative period of 1972 through 2002.

The increased area of inundation for CP2 is 1,850 acres. As with the previous plan, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of the infrequent inundation. The lower reaches of tributaries to Shasta Lake also would experience increased inundation.

Raising Shasta Dam 12.5 feet would result in inundating an additional 2,740 linear feet (about 18 acres) of the lower McCloud River. This represents about 2 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river.

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP2 include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation, and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP2, approximately 371 and 529 historic sites are within the inundation zone and fluctuation, respectively. Effects to traditional cultural properties and sacred sites under CP2 would be similar to CP1.

Although recreation would generally improve under this plan, water in the lake would be drawn down to existing conditions during the late fall and winter periods of some dry years, representing a drawdown 14.5 feet greater than under existing conditions. In addition, clearances for boat traffic under the Pit River Bridge would be restricted to the north end of the bridge during periods of high reservoir levels (at or near full pool). This condition would typically occur in the late spring (May to June) in about 1 out of 4 years, and could last several days to a week. The estimated minimum clearance at the new full pool would be about 20 feet between Piers 6 and 7. This would not be expected to significantly impact boating on the lake.

Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related impacts are also anticipated in the primary study area.

Upper Sacramento River As with the previous plan, potential effects on flow and stages of the upper Sacramento River from CP2 and other comprehensive plans would be minimal. Figures 5-12, 5-13, and 5-14 show CalSim-II simulated Sacramento River flows below Keswick Dam, Red Bluff Diversion Dam, and Stony Creek respectively, under wet, above- and below-normal, dry and critical year conditions for the No-Action Alternative compared to CP2. During most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River, would be relatively unchanged. Also, flows and stages would increase slightly in June and July. Although small, this increase would be most pronounced during dry periods as more water is released from Shasta Dam for water supply reliability purposes. During dry periods, however, there are few to no changes in water flows or changes during the winter and spring periods. All potential noticeable changes in flows and stages would diminish rapidly downstream from Red Bluff.

No effects on cultural resources are expected to occur in the upper Sacramento River region.

Similar to CP1, changes in river flows and stages may impact geomorphic conditions, existing riparian vegetation, and other wildlife resources of the upper Sacramento River. As mentioned above, the changes in temperatures and flows are expected to have a beneficial effect on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered flow and temperature regime may adversely impact warm-water species in the Sacramento River. This effect is not expected to be significant.

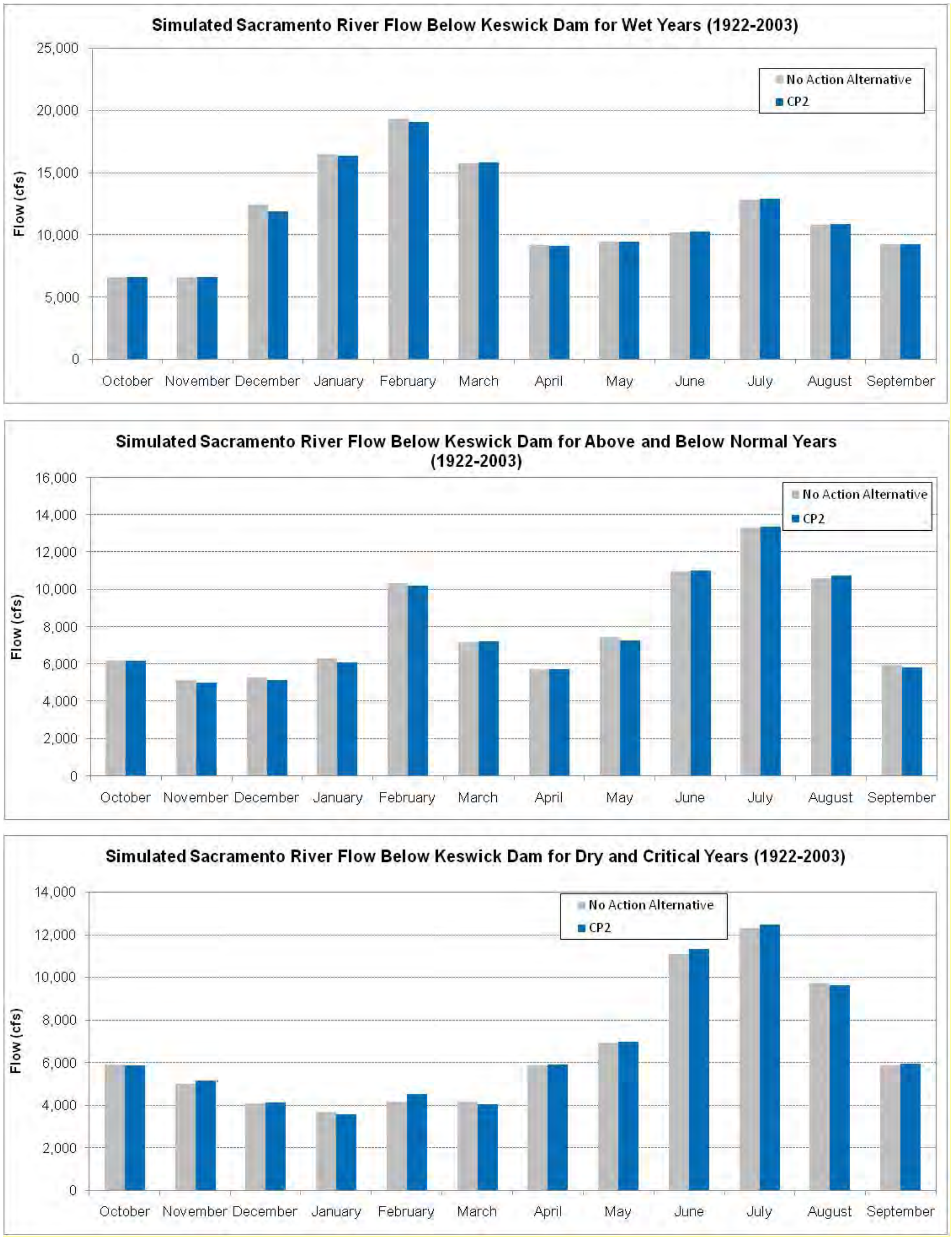


Figure 5-12. Simulated Sacramento River Flow Below Keswick Dam in Wet, Above- and Below-Normal, and Dry and Critical Years CP2

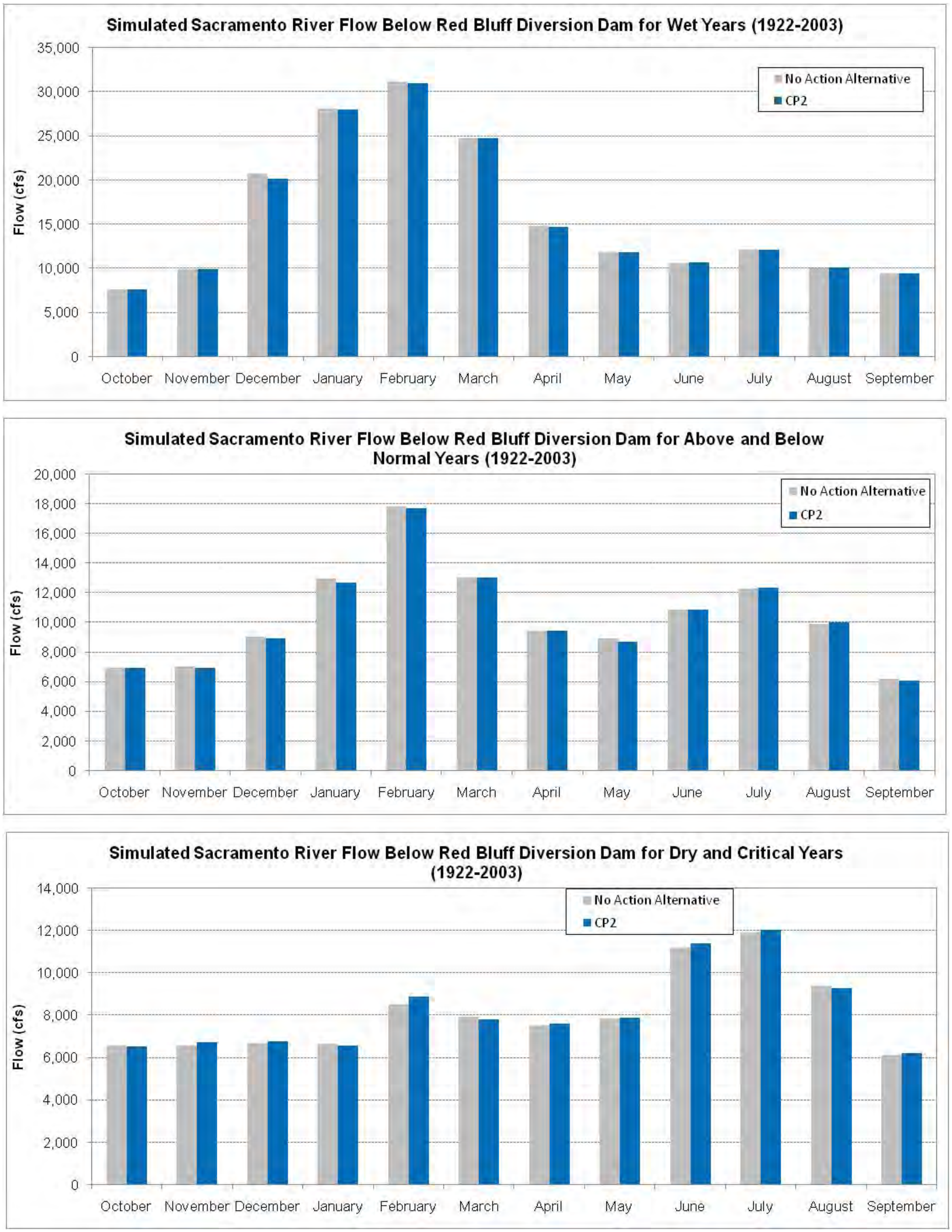
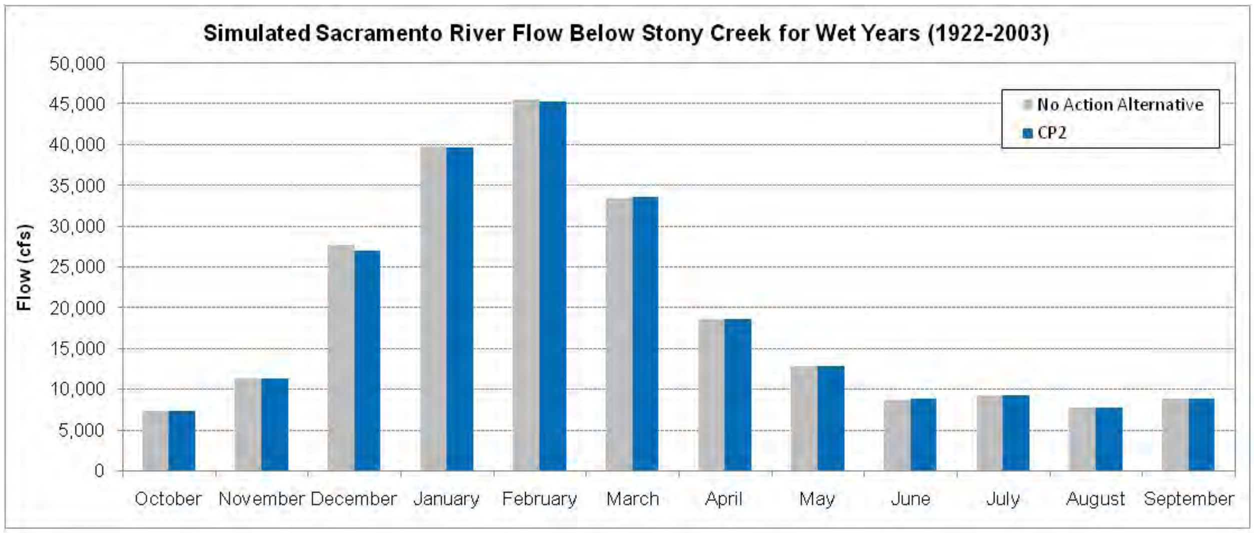
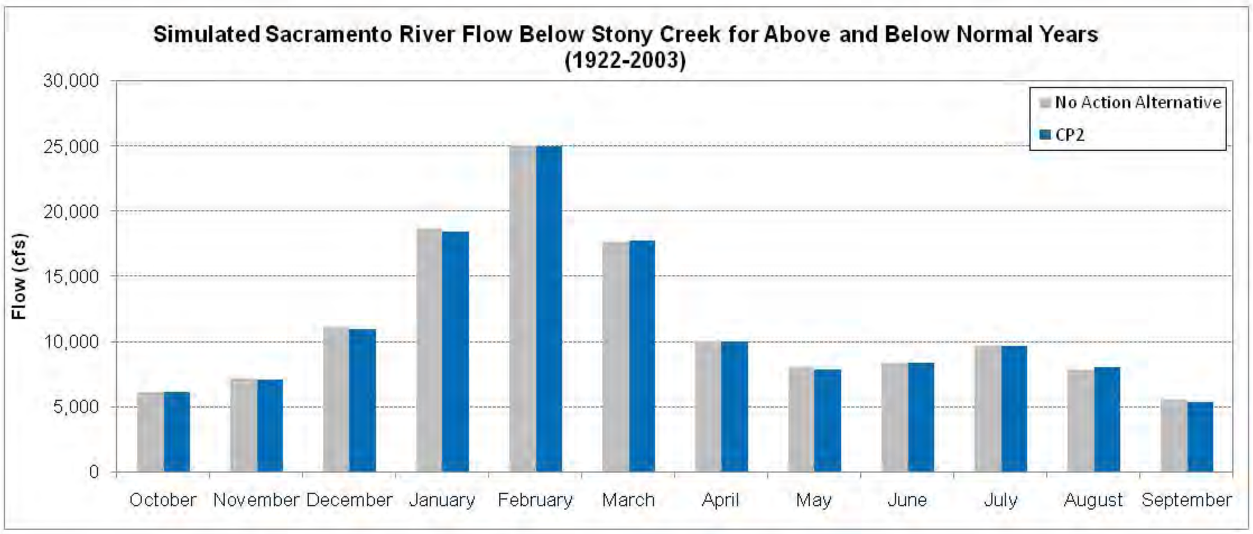


Figure 5-13. Sacramento River Flow Below Red Bluff Diversion Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for CP2





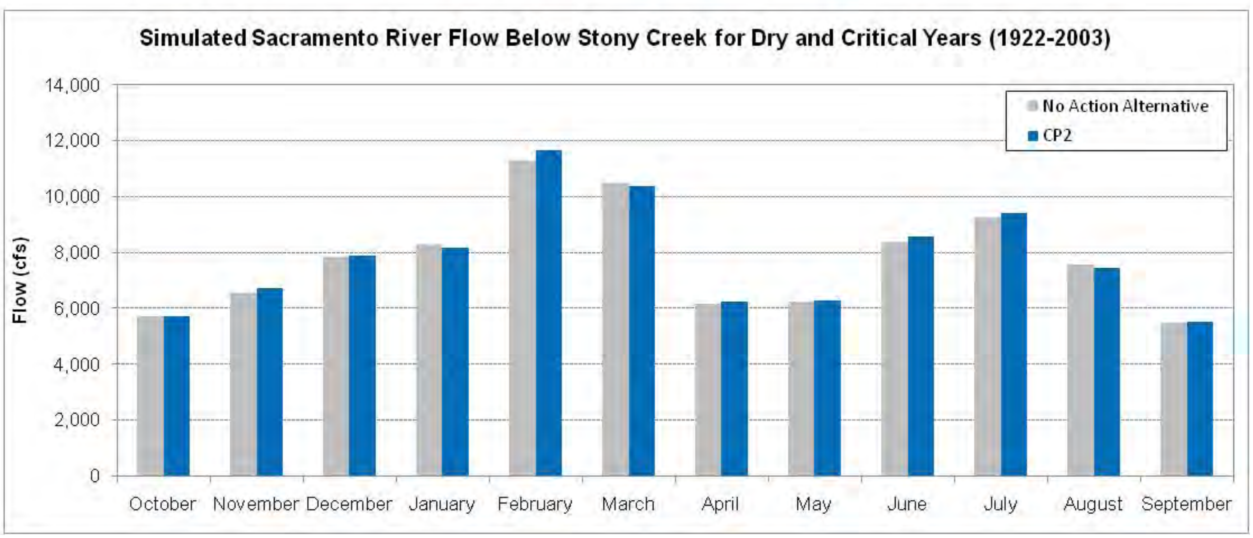


Figure 5-14. Sacramento River Flow Below Stony Creek in Wet, Above- and Below-Normal, and Dry and Critical Years for CP2

Preliminary Economic Assessment of CP2

Estimated Costs Estimated construction cost and annual cost of CP2 are shown in Table 5-4. As shown, the estimated construction cost is about $913 million. The estimated total annual cost of this plan is $46.4 million.

Estimated Economic Benefits As shown in Table 5-5, the estimated average annual monetary benefits of this plan, assuming the cost of water and energy supplies increase at the same rate as inflation, is $43.7 million. The largest monetary benefit is increased dry year water supply reliability. Assuming the cost of water supplies and hydropower increases at 2 percent above inflation, to account for future diminishment of water and energy supplies and increasing demands, the average annual benefit could exceed about $64.6 million per year.

Comprehensive Plan 3 (CP3) – 18.5-Foot Dam Raise, Anadromous Fish and Water Supply Reliability

CP3 consists primarily of enlarging Shasta Dam and Reservoir by raising the dam crest 18.5 feet and enlarging the reservoir by 634,000 acre-feet. Major features of CP3 are shown in Figure 5-1.

Major Components of CP3

Major components of this plan include the following:

- Raising Shasta Dam and appurtenant facilities by 18.5 feet.
- Implementing the set of eight common management measures previously described.

By raising Shasta Dam 18.5 feet from a crest at elevation 1,077.5 to elevation 1,096.0, CP3 would increase the height of the reservoir full pull by 20.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to CP1. This increase in full pool height would add approximately 634,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would increase from 4.55 MAF to 5.19 MAF. Although higher dam raises are technically and physically feasible, 18.5 feet is the largest dam raise that would not require extensive and very costly reservoir area relocations such as relocating the Pit River Bridge, I-5, and the UPRR, as shown in Figure 5-15. Raising the dam 18.5 feet would provide the minimum clearance required (4 feet) at the south end of the Pit River Bridge, while still providing more than 14 feet of clearance at the north end of the bridge. Figure 5-2 shows the increase in surface area and storage capacity for CP3.

Under CP3, operations for water supply, hydropower, and environmental requirements would be similar to existing operations, with the additional storage retained for water supply reliability and as an expanded cold-water pool for fisheries benefits. The existing TCD would be extended for efficient use of the expanded cold-water pool.

As described for the above plans, this plan would include the potential to revise flood control operational rules, which could reduce the potential for flood damage and benefit recreation.

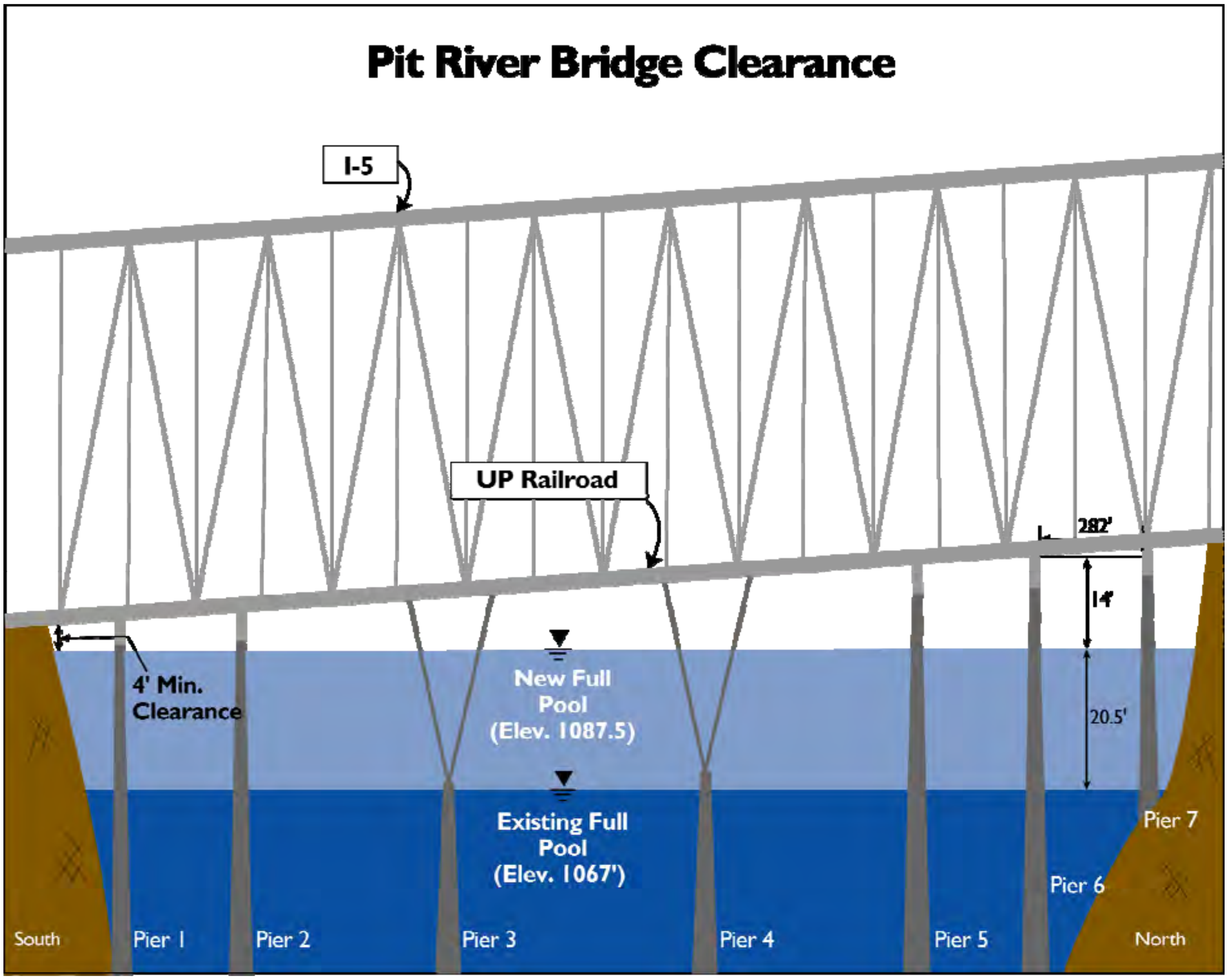


Figure 5-15. Minimum Clearance for Boat Traffic at Pit River Bridge, Full Pool with 18.5-foot Dam Raise

Potential Benefits of CP3

Major potential benefits of CP3, related to the SLWRI planning objectives and broad public services, are summarized in Tables 5-2 and 5-3 and described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. CP3 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critically dry water years. This would be accomplished by raising Shasta Dam 18.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD. Hence, the most significant water temperature benefits to anadromous fish would occur upstream from the RBDD. It is estimated that improved water temperature conditions under CP3 could result in an average annual increase in the Chinook salmon population of about 607,000 out-migrating juvenile fish.

Increase Water Supply Reliability CP3 would increase water supply reliability by increasing firm water supplies for irrigation and M&I deliveries, primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA, which would help reduce estimated future water shortages by increasing the reliability of firm water supplies by at least 133,400 acre-feet per year and an average annual yield of about 75,800 acre-feet per year. For this report, firm yield is considered equivalent to the estimated increase in the reliability of supplies during dry and critically dry periods. As shown in Table 5-6, the majority of increased firm yield, 103,800 acre-feet, would be for south-of-Delta agricultural and M&I deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban areas resulting from water shortages. Under CP3, approximately $3.8 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 96 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities.

Maintain and Increase Recreation Opportunities CP3 includes features to, at minimum, maintain the existing recreation capacity at Shasta Lake. Although CP3 does not include specific measures to further benefit recreation resources, a small benefit would likely occur to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area and modernization of recreation facilities. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres. There is also limited potential for reservoir reoperation to provide additional benefits to recreation by raising the bottom of the flood control pool elevation and allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other SLWRI Study Objectives CP3 could also provide benefits related to flood damage reduction, ecosystem restoration, and water quality, as described for CP1, but to a greater extent because of increased capacity and associated overall system flexibility.

Additional Broad Public Benefits Additional broad public benefits of CP3 obtained through pursuing project objectives are summarized in Table 5-3. Broad public benefits for CP3 are similar to CP1 and CP2 but are amplified due to the higher dam raise further enlarging system capacity and facility upgrades associated with additional relocations.

Potential Primary Effects of CP3

Following is a summary of potential environmental consequences of CP3. Potential environmental effects are generally comparable between comprehensive plans; some adverse effects would be exacerbated by larger dam raises and the associated scale of those effects, such as expanded construction areas and increased area of inundation around Shasta Lake. Proposed mitigation measures to address potential adverse impacts of CP3 are summarized in Table 5-7. As mentioned, a detailed discussion of potential effects and proposed mitigation measures associated with raising Shasta Dam by 18.5 feet are included in Chapters 4 through 25 of the PDEIS.

Shasta Lake Area As with the other comprehensive plans, the primary long-term effects of CP3 would be due to the increased water surface elevations and inundation area. The dam raise scenario under CP3 is greater than under CP1 or CP2; therefore, anticipated effects under CP3 are expected to be slightly greater. As with the above plan, raising the full pool of the lake would cause direct effects due to higher water levels, and/or indirect impacts related to facility access, operation, and maintenance.

CP3 includes modifying four bridges and replacing four other bridges, inundating a number of small segments of existing paved and nonpaved roads, and relocating a number of potable water facilities, wastewater facilities, gas and petroleum facilities, and power distribution and telecommunications facilities. A number of recreation facilities would also be impacted, including campgrounds, marinas, resorts, boat ramps, day use areas, and trails. Approximately 30 segments of roadway would be relocated, including portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road. Embankments would be constructed to protect I-5 at Lakeshore and the UPRR at Bridge Bay. Any potential real estate acquisitions or necessary relocations of displaced parties would be accomplished under Public Law 91-646.

With CP3, Shasta Reservoir would fill to the new full pool storage capacity of 5.19 MAF at a frequency similar to without-project conditions. On the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent of its current capacity in about 82 percent of the years over the 82-year period of analysis of the CalSim-II model. Included in Figure 5-3 is an exceedence probability relationship of maximum annual storage in Shasta Lake for this and other dam raises. Under CP3, Shasta Reservoir would also fill to 80 percent of the new capacity in about 76 percent of the years. Accordingly, the annual operations in the reservoir would generally mirror existing operations, except the water surface in the lake would be about 18.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels. Figure 5-4 shows the changes from without-project conditions for a dam raise of 12.5 feet for a representative period of 1972 through 2002.

The increased area of inundation for this plan is 2,570 acres. As with the previous plans, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of the infrequent inundation. The lower reaches of tributaries to Shasta Lake also would experience increased inundation.

As shown in Figure 5-7, raising Shasta Dam 18.5 feet would result in inundating an additional 3,550 linear feet (about 27 acres) of the lower McCloud River. This represents about 3 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river.

Although it is believed that recreation use would generally improve under this plan because of a larger lake surface area, water in the lake would be drawn down to existing conditions during the late fall and winter periods of some dry years, representing a drawdown 20.5 feet greater than under existing conditions. During these periods, the drawdown zone could increase by about 50 linear feet. In addition, clearances for boat traffic under the Pit River Bridge would be restricted to the north end of the bridge during periods of high reservoir levels (at or near full pool). This condition would typically occur in the late spring (May to June) in about 1 out of 4 years, and could last several days to 1 or 2 weeks. Figure 5-15 illustrates that the minimum clearance at the new full pool would be about 14 feet between Piers 6 and 7. This could impact boating on the lake, as some houseboats exceed 16 feet in height. Since houseboating is a major recreational experience on Shasta Lake, especially around Memorial Day, restrictions on large boat traffic under the Pit River Bridge during maximum pool levels could adversely impact lake area boat rentals, marinas, and other recreation-dependent businesses.

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP3 include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP3, approximately 391 and 529 historic sites are within the inundation zone and fluctuation, respectively. Effects to traditional cultural properties and sacred sites under CP3 would be similar to CP1.

Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related impacts are also anticipated in the primary study area.

Upper Sacramento River As with the previous plan, potential effects on flow and stages of the upper Sacramento River from this and other comprehensive plans would be minimal. Figures 5-16, 5-17, and 5-18 show CalSim-II simulated Sacramento River flows below Keswick Dam, Red Bluff Diversion Dam, and Stony Creek respectively, under wet, above- and below-normal, and dry and critical year conditions for the No-Action Alternative, CP3, and CP5. As can be seen, during most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River, would be relatively unchanged. All potential noticeable changes in flows and stages would diminish rapidly downstream from Red Bluff.

Similar to other comprehensive plans, changes in river flow and stages may impact geomorphic conditions, existing riparian vegetation, and wildlife resources of the upper Sacramento River. As mentioned above, the changes in temperature and flows are expected to have a beneficial effect on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered temperature and flow regime may adversely impact warm-water species in the Sacramento River. This effect is not expected to be significant.

No effects on cultural resources are expected to occur in the upper Sacramento River region.

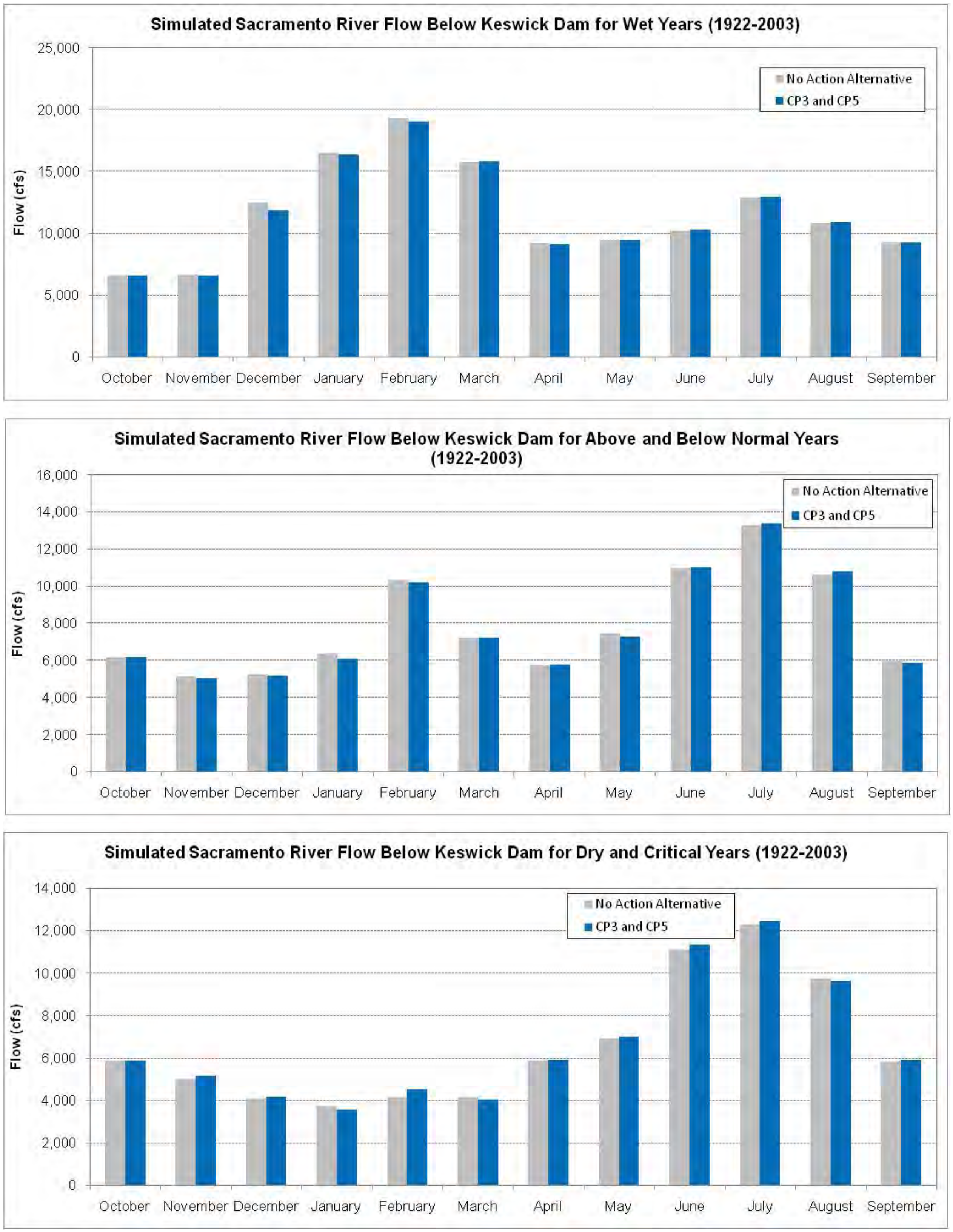
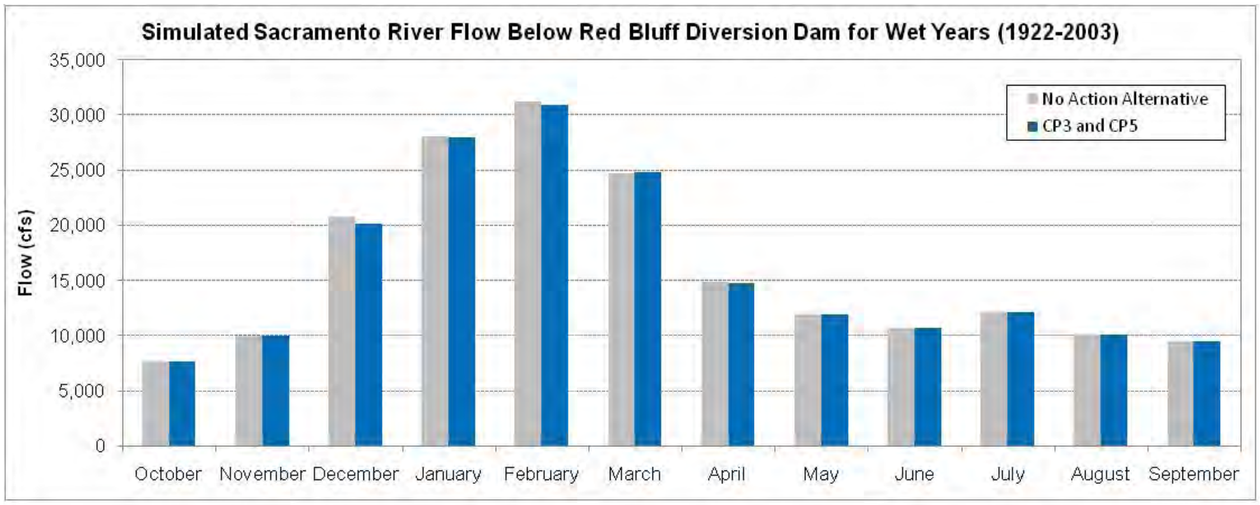
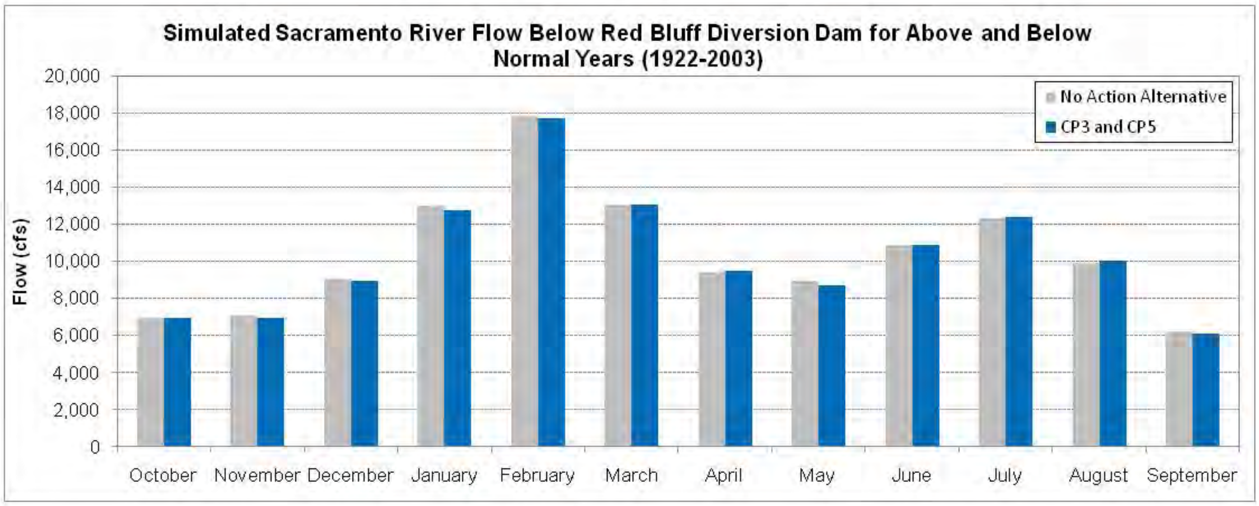


Figure 5-16. Simulated Sacramento River Flow Below Keswick Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP3, and CP5





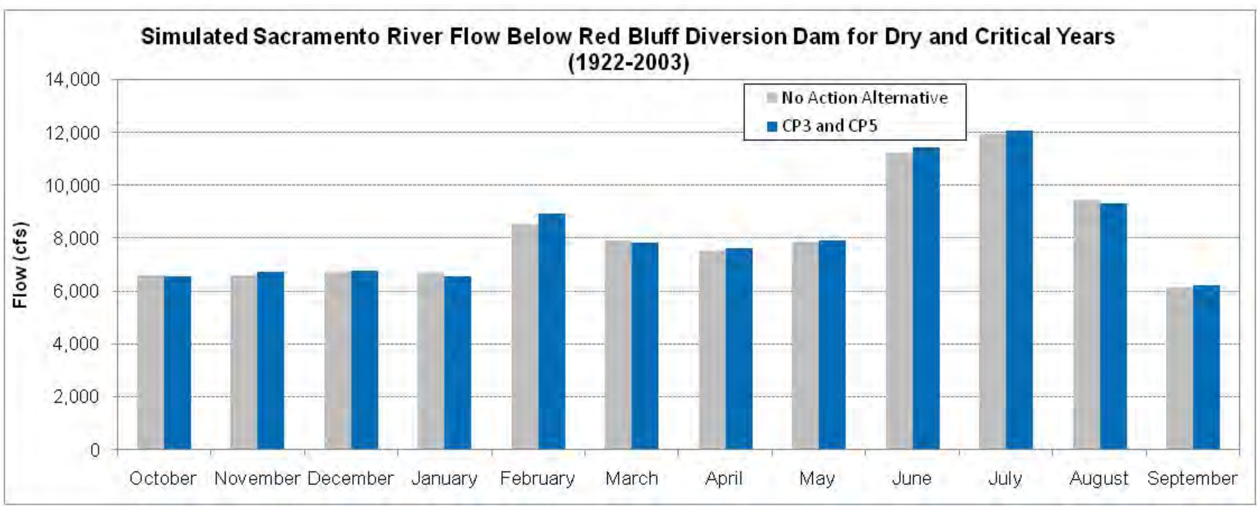


Figure 5-17. Simulated Sacramento River Flow Below Red Bluff Diversion Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP3, and CP5

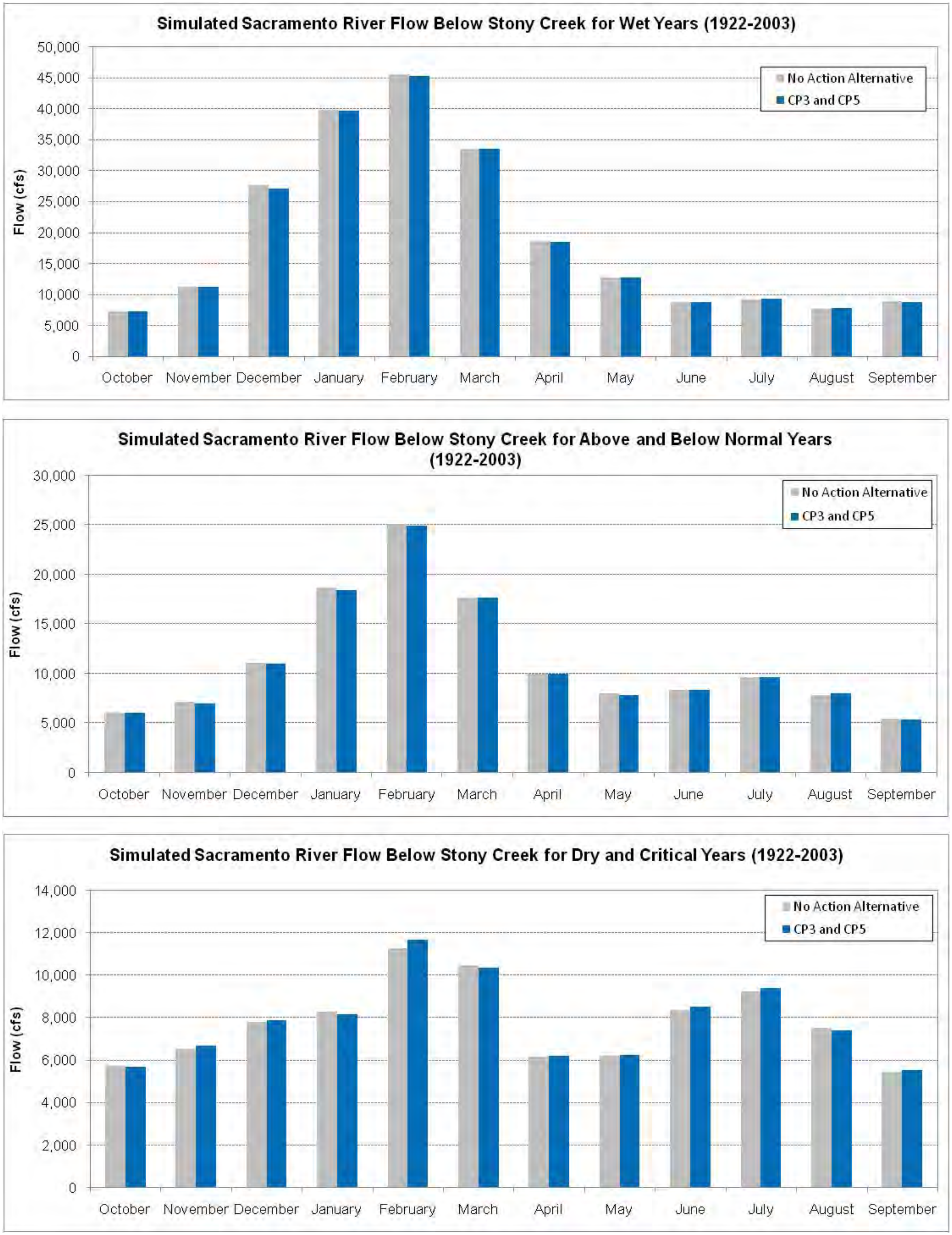


Figure 5-18. Simulated Sacramento River Flow Below Stony Creek in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP3, and CP5

Preliminary Economic Assessment of CP3

Estimated Costs Estimated construction cost and annual costs of CP3 are shown in Table 5-4. As shown, the estimated construction cost is about $1,064 million. The estimated total cost of this plan is $53.7 million.

Estimated Economic Benefits As shown in Table 5-5, the estimated average annual monetary benefit of CP3, assuming the cost of water and energy supplies increase at the same rate as inflation, is about $65.4 million. The largest monetary benefit is increased dry year water supply reliability. Assuming the cost of water supplies and hydropower increases at 2 percent above inflation, to account for future diminishment of water and energy supplies and increasing demands, the average annual benefit could exceed about $88.7 million per year.

Comprehensive Plan 4 (CP4) – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

CP4 focuses on increasing anadromous fish survival by raising Shasta Dam 18.5 feet, while also increasing water supply reliability. Major features of CP4 in the Shasta Lake area are shown in Figure 5-1.

Major Components of CP4

Major components of this plan include the following:

- Raising Shasta Dam and appurtenant facilities by 18.5 feet.
- Reserving 378,000 acre-feet of the increased storage in Shasta Lake for maintaining cold-water volume or augmenting flows as part of an adaptive management plan for anadromous fish survival.
- Augmenting spawning gravel in the upper Sacramento River.
- Restoring riparian, floodplain, and side channel habitat.
- Implementing the set of eight common management measures, previously described.

By raising Shasta Dam 18.5 feet from a crest at elevation 1,077.5 to elevation 1,096.0, CP4 would increase the height of the reservoir full pull by 20.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to CP4. This increase in full pool height would add approximately 634,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would be increased from 4.55 MAF to 5.19 MAF. The additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet temperature objectives for winter-run Chinook salmon and to meet habitat requirements for other anadromous fish during drought years, while increasing water supply reliability. Of the increased reservoir storage space, about 378,000 acre-feet would be dedicated to increasing the cold-water supply for anadromous fish purposes. Figure 5-2 shows the increase in surface area and storage capacity for CP4.

Operations for the remaining portion of increased storage (approximately 256,000 acre-feet) would be the same as in CP1. The existing TCD would be extended to achieve efficient use of the expanded cold-water pool.

As described for the above plans, this plan also would include the potential to revise the operational rules for flood control for Shasta Dam and Reservoir, which could reduce the potential for flood damage and benefit recreation.

CP4 also includes an adaptive management plan for the cold-water pool, augmenting spawning gravel, and restoring riparian, floodplain, and side channel habitat in the upper Sacramento River.

Adaptive Management of Cold-Water Pool This alternative may also include development of an adaptive management plan for the additional 378,000 acre-feet of cold-water pool. The adaptive management plan may include operational changes to the timing and magnitude of releases from Shasta Dam to benefit anadromous fish, as long as there are no conflicts with current operational guidelines or adverse impacts to water supply reliability. These changes may include increasing minimum flows, timing releases from Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional 378,000 acre-feet of water in storage to meet temperature requirements. Reclamation would manage the cold-water pool each year in cooperation with the SRTTG. Because adaptive management is predicated on using best available science and new information to make decisions, a monitoring program would be implemented as part of the adaptive management plan. SRTTG would conduct monitoring, develop monitoring protocols, and set performance standards to determine the success of adaptive management actions.

Augment Spawning Gravel in Upper Sacramento River Gravel suitable for spawning has been identified as a significant influencing factor in the recovery of anadromous fish populations in the Sacramento River (USFWS 2001, NMFS 2009a). Reclamation replenishes spawning gravel in the upper reaches of the Sacramento River, immediately below Keswick Dam and at Salt Creek, as part of the CVPIA. However, the annual gravel budget deficit is estimated to be far greater than what the CVPIA program currently supplies (Hannon 2008). Under CP4, spawning-sized gravel would be injected at multiple locations along the Sacramento River between Keswick Dam and the RBDD.

In December 2008, a workshop was held with Reclamation, USFWS, and DFG to identify the goals and priorities of the SLWRI gravel augmentation program. Input from the resource agencies during the workshop was used to define the program. Gravel augmentation would occur at one to three locations every year, for a period of 10 years, unless unusual conditions or agency requests precluded placement during a single year. This program, in combination with the ongoing CVPIA gravel augmentation program, would help address the gravel debt in the upper Sacramento River, but this reach may continue to be gravel-starved into the future. Therefore, the gravel augmentation program proposed herein would be reevaluated after the 10-year period to assess the need for continued spawning gravel augmentation, and to identify opportunities for future actions or programs to do so.

On average, 5,000 to 10,000 tons of gravel would be placed each year, although the specific quantity of gravel placed in a given year may vary from that range. Gravel would be obtained as uncrushed, rounded river rock, free of debris and organic material from local, commercial sources. To maximize the benefit to anadromous fish, gravel would be washed and sorted to meet specific size criteria. To minimize impacts to salmonid spawning activity, gravel applied to active river channels would be placed between August and September each year, consistent with the time frame for the ongoing CVPIA gravel augmentation.

Input from the resource agencies during the December 2008 led to the identification of 15 potential areas for spawning gravel augmentation in the Sacramento River between Keswick Dam and Shea Island. Selection of specific locations was based on potential benefits to anadromous fish and site accessibility. Gravel placement would provide either immediate spawning habitat or long-term recruitment.

Fifteen preliminary locations for spawning gravel augmentation were identified in the Sacramento River between Keswick Dam and Shea Island. Each site would be eligible for gravel placement one or more times during the 10-year program. Selection of these locations was based on potential benefits to anadromous fish and site accessibility. Gravel placement would provide either immediate spawning habitat or long-term recruitment.

Although preliminary sites have been identified, specific gravel augmentation site(s) and volume(s) would be selected each year in the spring or early summer through discussions among Reclamation, USFWS, DFG, and NMFS. The discussions would include topics such as: avoiding redundancy with planned CVPIA gravel augmentation activities in a given year; identifying hydrology or morphology issues that could impact the potential benefit of placing gravel at any particular site; identifying changes in spawning trends due to previous years' gravel augmentation activities; evaluating potential new sites; and appropriately distributing selected gravel sites along the river reach(es).

Restore Riparian, Floodplain and Side Channel Habitat Under CP4, riparian, floodplain, and side channel habitat restoration would be constructed at a suitable location along the Sacramento River. The exact size, scope, and location of a suitable restoration site are still under development and will be provided in the FEIS. A description of potential riparian, floodplain, and side channel habitat restoration at Reading Island is provided below as an example restoration project. Restoration activities anticipated under CP4 are expected to be similar in size and scope to those described below.

Reading Island lies along the Sacramento River just north of Cottonwood Creek in Shasta County, at River Mile 274. Reading Island is approximately 269 acres in area, with 46 acres on the south end of the island owned by BLM and managed as a day-use park (Figure 5-20). The remaining 223 acres is privately owned. The island is accessible by Adobe Road and a bridge crossing over the Anderson Creek Slough into the BLM day-use park. Historically, the channel that now forms the slough probably supported important habitat for anadromous salmonids, including rearing habitat for winter-run Chinook and spawning habitat for Central Valley steelhead.

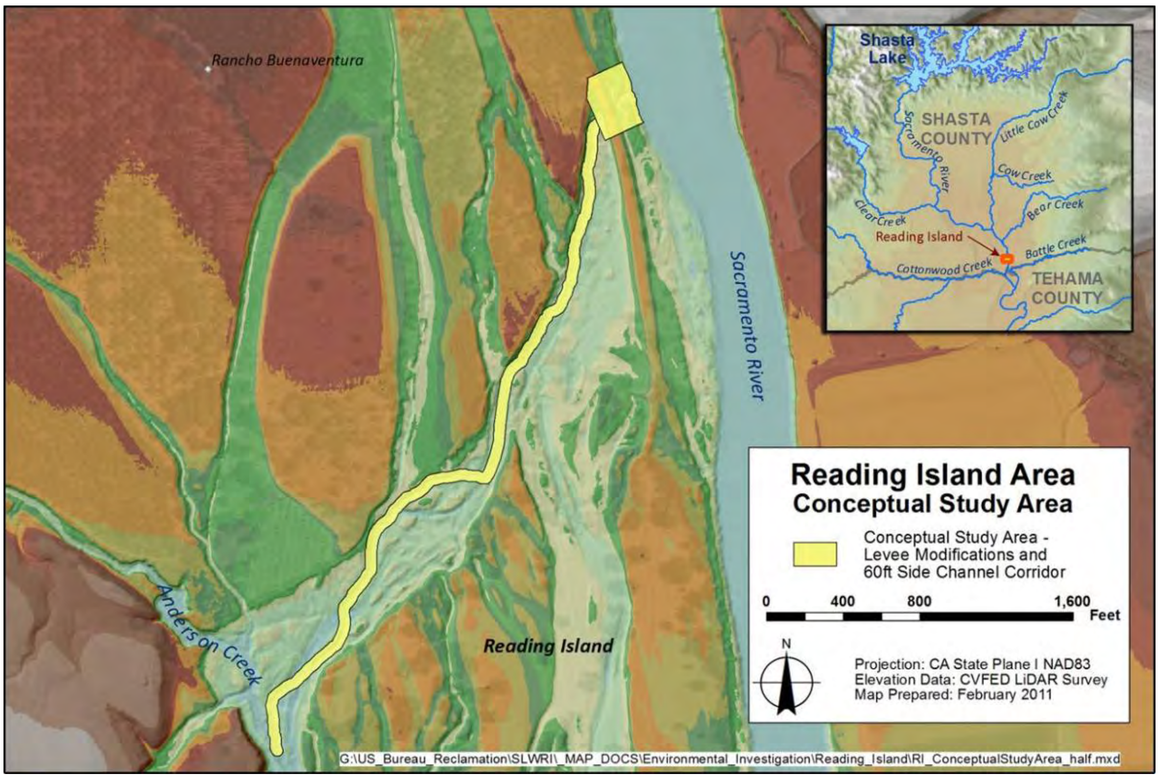


Figure 5-20. Reading Island Conceptual Study Area

At the Reading Island site, an approximately 0.8-mile-long historic Sacramento River channel/floodplain scour channel/side channel (hereafter referred to as “side channel”) drains into the present day Anderson Creek, a remnant Sacramento River channel. Anderson Creek flows approximately 1.5 miles and then enters the Sacramento River about 0.3 miles upstream from Cottonwood Creek. Average channel width of the side channel is approximately 30 feet.

The Anderson Creek Slough, into which Anderson Creek empties, was blocked at the upstream end in the early 1970s by the construction of a levee on the adjoining private property owned by Mr. Greening. Within a few years of the levee construction, the slough became choked with various species of water plants - primarily primrose creeper (Ludwigia peploides). Before levee construction, the Anderson Creek Slough captured a portion of the Sacramento River flow and functioned as side channel habitat.

After the levee construction, water velocity in the channel slowed substantially and water temperatures increased. Primrose creeper and warm-water non-native fish species established within the channel. Currently, the majority of the water entering the slough comes from Anderson Creek and drainage water from irrigation canals. An earthen embankment with two 36-inch diameter culverts now restricts the flow of water into the side channel. The water surface elevation of the Sacramento River with a flow rate of 8,500 cfs is at the approximate elevation of the invert of the culverts, but even when discharge in the Sacramento River increases to approximately 12,000 cfs, there is minimal flow through the culverts into the side channel. Above the slough, Anderson Creek is known to provide rearing habitat for winter-run Chinook and is managed for steelhead spawning habitat.

Floodplain, riparian, and side channel habitat restoration would involve acquiring property on Reading Island and revegetating floodplain terraces and adjacent riparian areas with native plants. In addition, the Reading Island side channel can be activated over a wider range of flows to provide juvenile salmonid rearing habitat in the side channel and Anderson Creek at the downstream end of the side channel. This will be accomplished by breaching the levee at the upstream end of the side-channel to restore connectivity with the Sacramento River at flows greater than 4,000 to 6,000 cfs.

Preliminary analysis indicates that in addition to breaching the levee, side channel clearing and excavation may be necessary to restore flows capable of supporting suitable spawning habitat. Side channel clearing would be performed along the 0.8-mile channel over a maximum average width of 30 feet plus an additional 10 feet for construction equipment access, covering a maximum area of 3.9 acres. Excavation would involve a maximum average width and depth of 20 and 5 feet, respectively, along the length of the channel for a maximum of 15, 560 cubic yards of material removal.

The revegetation planting mix, composition, and density would be determined by a more detailed site analysis but could include native cottonwood, willow, box elder, valley oak, western sycamore, elderberry, and a variety of understory brush species. Temporary irrigation would be provided on an as-needed basis with a temporary well powered from an existing nearby power supply. The revegetated areas are expected to develop into self-sustaining riparian habitats within 1 to 4 years of initial planting, based on results of previous riparian restoration projects along the Sacramento River. Regraded floodplain areas are expected to change over time, depending on hydrologic conditions, but it is anticipated that no elements of this measure would need to be replaced or reapplied during the 50-year project life. The site would be fenced to reduce the potential for access by livestock.

Anadromous Fish Plan Primarily using the SALMOD model, and based on output from the water operations (CalSim-II), reservoir temperature, and river temperature models, a suite of flow-focused and temperature-focused actions (scenarios) were investigated to assess which combination of actions would likely result in the maximum increase in fish populations. These methods are described in the Modeling Appendix.

To formulate CP4, three dam height raises were considered (6.5 feet, 12.5 feet, and 18.5 feet), resulting in 256,000 acre-feet, 443,000 acre-feet, and 634,000 acre-feet of increased storage, respectively. For each of these proposed dam raises, several combinations for allocating the increased storage were analyzed. For instance, assuming a dam raise of 12.5 feet, three options were considered: (1) no increase in the minimum pool, (2) an increase in the minimum pool similar to a 6.5-foot dam raise, and (3) all of the increased space dedicated to increased fisheries. The combinations considered represent scenarios developed to focus on increasing the cold-water pool, and are listed in Table 5-8. Figure 5-21 illustrates the various combinations considered. Obviously, numerous other combinations could be considered. Included in the figure is information about cost (average annual), increased water supply yield, and increased numbers of anadromous fish for the various combinations considered.

Additional scenarios focused on increasing Sacramento River flows with an 18.5-foot raise were also analyzed. The flow combinations were based primarily on flows identified as part of the Anadromous Fish Restoration Plan (USFWS 2001). These scenarios are listed in Table 5-9.

Table 5-8. Scenarios Considered for Cold-Water Storage as Part of Fish Focus Plan

Scenario	Dam Raise (feet)	Enlarged Reservoir	Description
A (CP-1)	6.5	256,000 acre-feet	No increase in minimum pool
B	6.5	256,000 acre-feet	Dedicating 256,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.
C (CP-2)	12.5	443,000 acre-feet	No increase in minimum pool
D	12.5	443,000 acre-feet	Dedicating 187,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
E	12.5	443,000 acre-feet	Dedicating 443,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.
F (CP-3/CP-5)	18.5	634,000 acre-feet	No increase in minimum pool
G	18.5	634,000 acre-feet	Dedicating 191,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
H (CP-4)	18.5	634,000 acre-feet	Dedicating 378,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
I	18.5	634,000 acre-feet	Dedicating 634,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.

Key:
CP = Comprehensive Plan

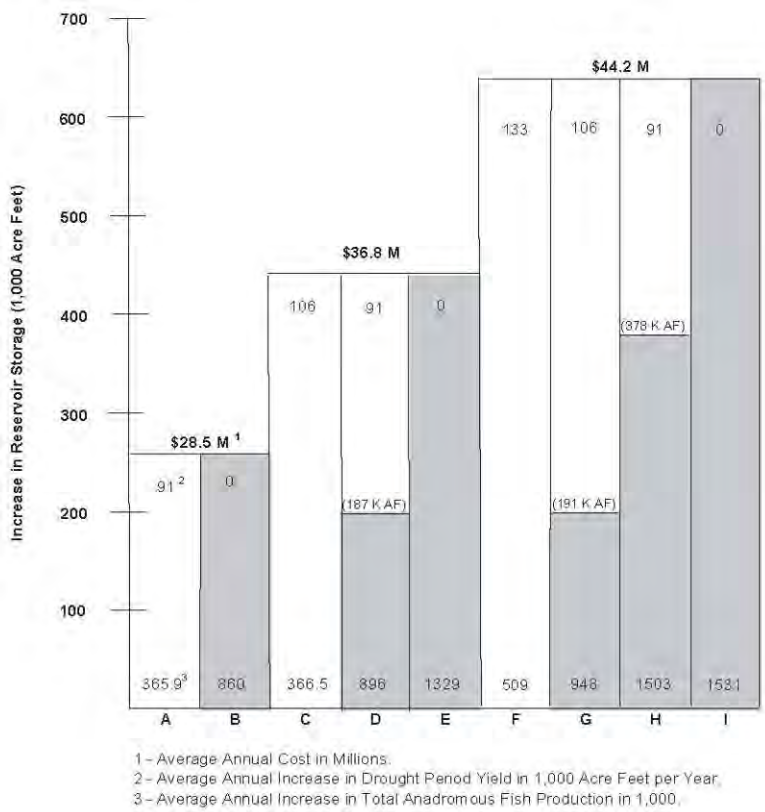


Figure 5-21. Combinations Considered Between Increased Storage Dedicated to Either Water Supply Reliability or Increasing Cold-Water Supply for Fisheries

Table 5-9. Scenarios Considered to Augment Flows as Part of Fish Focus Plan

Scenario	Dam Raise (feet)	Enlarged Reservoir	Description
1	18.5	634,000 acre-feet	October - March Anadromous Fish Restoration Program flows or 500 cfs increase, whichever is lower
2	18.5	634,000 acre-feet	October - March Anadromous Fish Restoration Program flows or 750 cfs increase, whichever is lower
3	18.5	634,000 acre-feet	October - March Anadromous Fish Restoration Program flows or 1,000 cfs increase, whichever is lower
4	18.5	634,000 acre-feet	Increase August flows to 10,000 cfs and September flows to 6,000 cfs for temperature control

Key:
cfs = cubic feet per second

Quantitative analysis indicated that increasing the minimum pool in Shasta Reservoir would have the greatest net fishery benefit. By increasing the minimum pool, the allowable carryover pool storage would increase in the reservoir. This carryover would act to conserve cold water that could be managed to better benefit anadromous fish. Scenarios 1, 2, 3, and 4 (flow augmentation scenarios) showed limited benefits to anadromous fish compared with other scenarios and were eliminated from further analysis.

As can be seen in Figure 5-21, Scenarios B, E, and I would not contribute to increased water supply reliability. Even though CP4 focuses on anadromous fish survival, because these three concepts would not contribute to a primary planning objective, they were deleted from further consideration. Table 5-10 compares the remaining scenarios. Each of the scenarios is assessed against the relative increase in fish production versus the remaining cost between water supply forgone for each scenario and the overall annual cost for the concept. Figure 5-22, is a plot of increased fish production versus remaining cost for each of the scenarios considered from Table 5-10. Included in the figure is an estimate of the "best buy" envelope. As indicated in the figure, it appears that Scenarios D and H are more cost-effective than the other scenarios because they generally lie along the "best buy" envelope.

Table 5-10. Cost Effectiveness Screening for Efficiency of Annualized Preliminary Combined Scenarios

Scenario	Increase in Fish Production[1] (1,000)	Water Supply Benefits		Annual Costs ($1,000)	Remaining Costs ($1,000)
		Yield (1,000 acre-feet/ Year)	Benefit ($1,000)[2]		
NA	-	-	-	-	-
A (CP1)	387	91	13,600	29,800	16,200
C (CP2)	337	106	18,500	38,200	19,700
D	816	91	13,600	38,200	24,600
F (CP3)	627	133	18,500	46,400	27,900
G	816	106	18,500	46,400	27,900
H	1,195	91	13,700	46,400	32,700

Note:
[1] Derived using SALMOD
[2] See Economic Valuation Appendix.
Key:
- = not applicable
CP = Comprehensive Plan
NA = No-Action Alternative

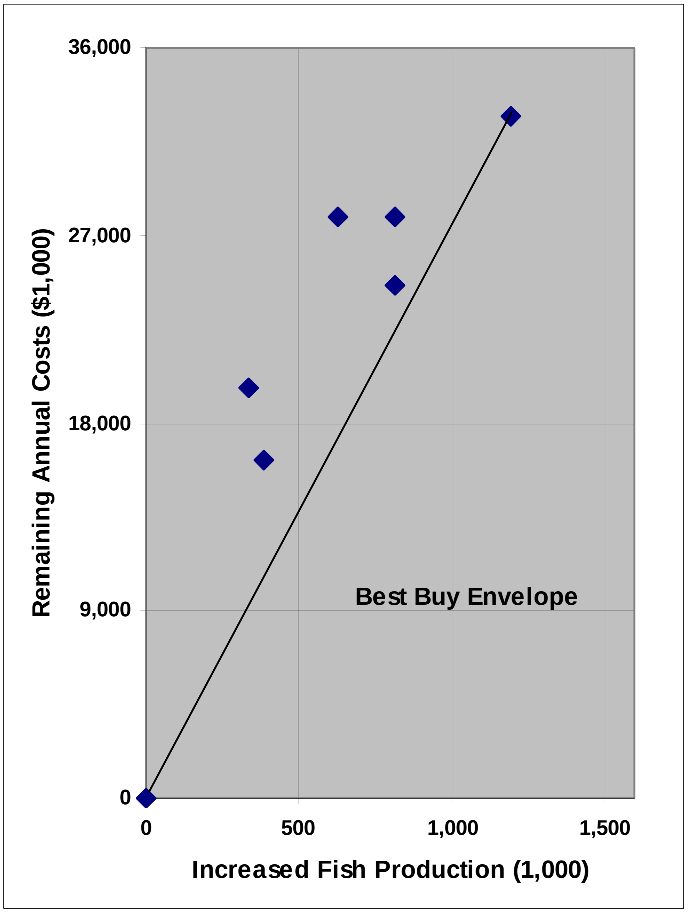


Figure 5-22. Cost-Effectiveness Assessment of Combined Scenarios

Based on numerical modeling results, Scenario H was chosen to represent reservoir operation in CP4 because it provides the greatest benefit to anadromous fish and still meets the primary objective of water supply reliability. Accordingly, CP4 includes raising Shasta Dam 18.5 feet and increasing the storage for cold-water supply in Shasta Reservoir by about 378,000 acre-feet.

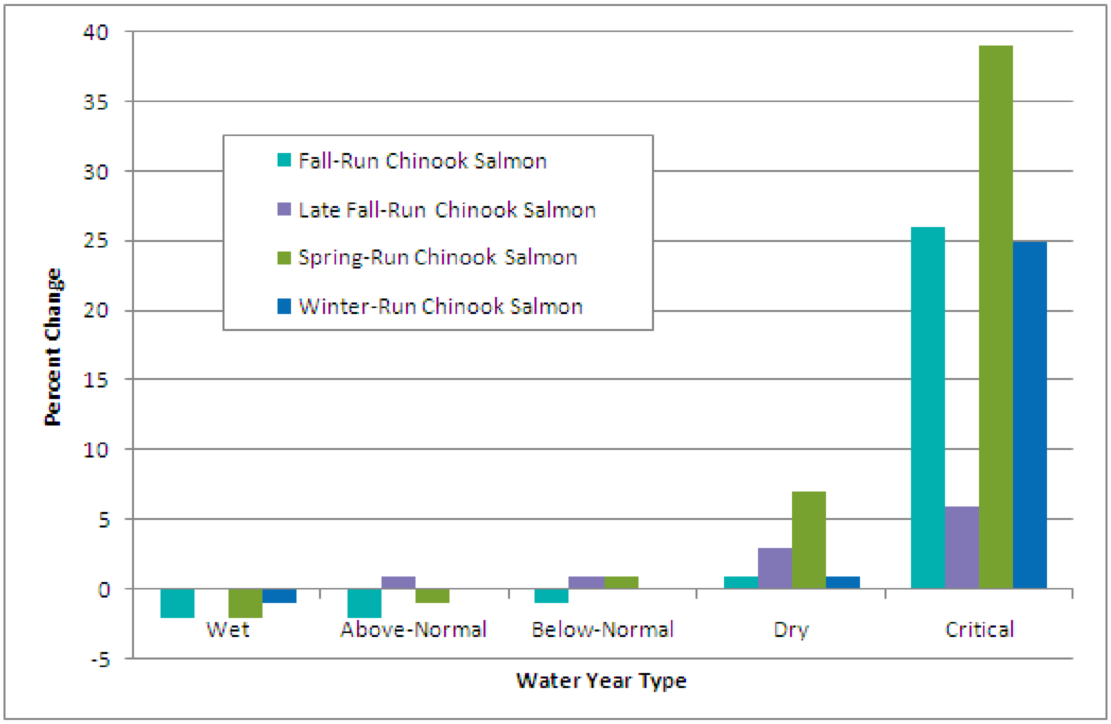
Potential Benefits of CP4

Major potential benefits of CP4, related to the SLWRI planning objectives and broad public services, are summarized in Tables 5-2 and 5-3 and described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. CP4 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critically dry water years. CP4 would significantly increase the ability of Shasta Dam to make cold-water releases and regulate water temperature in the upper Sacramento River. CP4 would benefit anadromous fish by improving temperature conditions in the upper Sacramento River, primarily in dry and critical water years. This would be accomplished by raising Shasta Dam 18.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD. Hence, the most significant water temperature benefits to anadromous fish would occur upstream from the RBDD. It is estimated that improved temperature conditions under CP4 could result in an average annual increase in Chinook salmon population of nearly 1,199,000 out-migrating juvenile fish.

Under CP4, an increase in the cold-water pool would allow Reclamation to operate Shasta Reservoir to provide not only a more reliable source of water during dry and critically dry water years, but also to provide more cool water for release into the Sacramento River to improve conditions for anadromous fish. Of the increased storage space, about 378,000 acre-feet (60 percent) would be dedicated to increasing the cold-water supply for anadromous fish survival purposes. Reclamation would manage the cold-water pool each year based on recommendations from the SRTTG. To assess the effects of operations on Chinook salmon in the upper Sacramento River, the computer model SALMOD was upgraded to evaluate changes in Chinook salmon population between Keswick Dam and the RBDD. In response to changes in Shasta Reservoir operations under CP4 during dry and critically dry water years – the years targeted for improving water reliability for both users and fish – SALMOD modeling showed increases in production of Chinook salmon populations, especially winter-run and spring-run Chinook (Figure 5-23).

In addition, CP4 includes a gravel augmentation program. Gravel augmentation would occur on average at one or more locations in the Sacramento River between Keswick Dam and the RBDD for a period of 10 years, and on average, 5,000 to 10,000 tons of gravel would be placed each year, although the specific quantity of gravel placed in a given year may vary from that range. Spawning gravel augmentation is expected to positively influence anadromous fish populations in the Sacramento River.



Note: Simulated using SALMOD; Water Year Types Based on the Sacramento Valley Water Year Hydrologic Classification

Figure 5-23. Percent Change in Production of Chinook Salmon for CP4

Increase Water Supply Reliability CP4 would increase water supply reliability by increasing firm water supplies for irrigation and M&I deliveries, primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA, which would help reduce estimated future water shortages by increasing the reliability of firm water supplies for agricultural and M&I deliveries by at least 76,400 acre-feet per year and an average annual yield by about 46,400 acre-feet per year. For this report, firm yield is considered equivalent to the estimated increase in the reliability of supplies during dry and critically dry periods. As shown in Table 5-6, the majority of increased firm yield, 66,800 acre-feet, would be for south-of-Delta agricultural and M&I deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban uses resulting from water shortages. Under CP4, approximately $2.3 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 138 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities.

Conserve, Restore, and Enhance Ecosystem Resources In the upper Sacramento River, the addition of spawning gravel and the restoration of riparian, floodplain, and side channel habitat are expected to improve the complexity of aquatic habitat and its suitability for spawning and rearing. Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that increase the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. Restoration would support the goals of the Sacramento River Conservation Area Forum and other programs associated with riparian restoration along the Sacramento River. Side channels can support important habitat for anadromous salmonids, including rearing and spawning habitat. Side channel habitats also provide refuge from predators and productive foraging habitat for juvenile anadromous salmonids. In addition, improved fisheries conditions as a result of cold-water carryover storage in CP4, as described above, and increased flexibility to meet flow and temperature requirements, could also enhance overall ecosystem resources in the Sacramento River.

Maintain and Increase Recreation Opportunities CP4 includes features to, at a minimum, maintain the existing recreation capacity at Shasta Lake. Potential recreation benefits would be as stated for CP3. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres. There is also limited potential for reservoir reoperation to provide additional benefits to recreation by raising the bottom of the flood control pool elevation and allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other SLWRI Study Objectives CP4 could also provide benefits related to flood damage reduction and water quality, similar to CP1.

Additional Broad Public Benefits Additional broad public benefits of CP4 obtained through pursuing project objectives are summarized in Table 5-3. Broad public benefits for CP4 are similar to those for CP3.

Potential Primary Effects of CP4

Anticipated inundation, construction, cultural, and relocation impacts associated with CP4 are similar to CP3, as summarized above. Potential effects on flow and stages of the upper Sacramento River from CP4 are identical to CP1. Figures 5-9, 5-10, and 5-11 show simulated Sacramento River flows below Keswick Dam, RBDD, and Stony Creek, respectively, under wet, average, and dry year conditions for the No-Action Alternative compared to CP1 and CP4. Proposed mitigation measures to address potential adverse impacts of CP4 are summarized in Table 5-7. As mentioned, a detailed discussion of potential effects and proposed mitigation measures associated with raising Shasta Dam by 18.5 feet are included in Chapters 4 through 25 of the PDEIS.

Preliminary Economic Assessment of CP4

Estimated Costs The estimated construction cost and annual costs of CP4 are shown in Table 5-4. As shown, the estimated construction cost is $1,070 million. The estimated total annual cost of this plan is about $54.0 million.

Estimated Economic Benefits As shown in Table 5-5, the estimated average annual monetary benefits of CP4, assuming the cost of water and energy supplies increase at the same rate as inflation, is about $92.2 million. The largest monetary benefit is increased dry year water supply reliability. Assuming the cost of water supplies and hydropower increases at 2 percent above inflation, to account for future diminishment of water and energy supplies and increasing demands, this benefit could exceed about $117.2 million per year.

Comprehensive Plan 5 (CP5) – 18.5-Foot Dam Raise – Combination Plan

CP5 primarily focuses on increasing water supply reliability, anadromous fish survival, Shasta Lake area environmental resources, and increased recreation opportunities. Major features of CP5 are shown in Figure 5-1.

Major Components of CP5

This plan includes the following major components:

- Raising Shasta Dam and appurtenant facilities by 18.5 feet.
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of its tributaries (Sacramento River, McCloud River, and Squaw Creek).
- Constructing shoreline fish habitat around Shasta Lake.
- Augmenting spawning gravel in the upper Sacramento River.
- Restoring riparian, floodplain, and side channel habitat.
- Increasing recreation opportunities at various locations at Shasta Lake.
- Implementing the set of eight common management measures previously described.

By raising Shasta Dam 18.5 feet from a crest at elevation 1,077.5 to elevation 1,096.0, CP5 would increase the height of the reservoir full pull by 20.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to CP5. This increase in full pool height would add approximately 634,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would be increased from 4.55 MAF to 5.19 MAF. Figure 5-2 shows the increase in surface area and storage capacity for CP5.

Under CP5, operations for water supply, hydropower, and environmental requirements would be similar to existing operations, with the additional storage retained for water supply reliability and as an expanded cold-water pool for fisheries benefits. The existing TCD would be extended to achieve efficient use of the expanded cold-water pool.

As described for the above plans, this plan also would include the potential to revise the flood control operational rules for Shasta Dam and Reservoir, which could reduce the potential for flood damage reduction and benefit recreation.

CP5 also includes (1) restoring resident fish habitat in Shasta Lake, (2) restoring fisheries and riparian habitat at several locations along the lower reaches of the tributaries to Shasta Lake, (3) augmenting spawning gravel in the upper Sacramento River, (4) restoring riparian, floodplain, and side channel habitat in the upper Sacramento River, and (5) increasing recreation opportunities at Shasta Lake.

Construct Shoreline Enhancement The ecosystem enhancement goal for the shoreline environment of Shasta Lake is to improve the warm-water fish habitat associated with the transition between the reservoir's aquatic and terrestrial habitats. Shoreline enhancement entails the range of enhancement opportunities along the Shasta Lake shoreline below the full pool elevation (1,090 feet) that would occur with an 18.5-foot dam raise. This area is typically between 0.1 and 1.5 miles upslope from the current full pool elevation of 1,070 feet. The shoreline is defined as the area encompassing nearshore aquatic habitat within the reservoir itself, and vegetation and other habitat components adjacent to the reservoir.

Two categories of potential nearshore warm-water fish habitat enhancement activities are (1) structural enhancements, which entail placing artificial structures in Shasta Lake's littoral zone, and (2) vegetative enhancements, which entail planting and seeding to provide submerged and partly submerged vegetative cover when the reservoir is at full pool capacity during the winter/spring months.

Construction activities common to all action alternatives include stockpiling manzanita for fish habitat. CP5 would include clearing additional manzanita from above the new full pool inundation zone to create further structural enhancements for fish habitat in Shasta Lake's littoral zone.

Vegetative enhancements associated with CP5 include planting willows (Salix) to enhance nearshore fish habitat, and single treatment aerial and hand seeding of annual cereal grains to treat shoreline areas at Shasta Lake. Aerial and hand seeding of annual cereal grains provides only short-term cover but is cost-effective across large areas and can be implemented quickly and efficiently. The annual cereal grain grasses provide cover for young fish and also nutrients for plankton as the grasses decompose. The plankton, in turn, are a valuable food source for juvenile fish.

Construct Tributary Aquatic Habitat Enhancement The primary goal for the enhancement of aquatic habitat in the watershed is to enhance the connectivity for native fish species and other aquatic organisms between Shasta Lake and its tributaries. Two categories of potential aquatic habitat enhancement in tributaries are (1) fish passage enhancements, which entail identifying and correcting barriers to fish passage, particularly at culverts and other human-made barriers, and (2) aquatic habitat enhancements, which entail identifying and implementing feasible habitat improvements intended to conserve or restore degraded aquatic and riparian habitat in tributaries to Shasta Lake.

Fish passage enhancements associated with CP5 includes opportunities to restore and/or enhance five perennial stream crossings. Barriers to fish passage in the watersheds above Shasta Lake are primarily associated with culverts or other types of stream crossings.

Aquatic habitat enhancements associated with CP5 include enhancing aquatic connectivity and reducing sediment related to roads constructed across intermittent streams. The preliminary site survey identified opportunities to enhance 14 intermittent stream crossings. Based on the information obtained in the survey, these crossings provide opportunities for meeting the objectives of enhancing aquatic connectivity and/or reducing the potential for road-related sediment. Two sites have been identified in the Salt Creek watershed, two sites have been identified in the Sugarloaf Creek watershed, and ten sites have been identified in the McCloud Arm watershed.

Augment Spawning Gravel in Upper Sacramento River As part of CP5, spawning-sized gravel would be placed at multiple locations along the Sacramento River between Keswick Dam and the RBDD. Gravel augmentation under CP5 would be identical to the gravel augmentation component of CP4.

Restore Riparian, Floodplain and Side Channel Habitat As described in CP4, riparian, floodplain, and side channel habitat restoration would be constructed at a suitable location along the Sacramento River. This measure is identical to that proposed under CP4.

Recreation Enhancements A total of 18 miles of new hiking trails and 6 trailheads would be constructed to enhance recreation under CP5. Descriptions have been developed for the trails and associated features and are included in the Engineering Summary Appendix.

Potential Benefits of CP5

Major potential benefits of CP5, related to the SLWRI planning objectives and broad public services, are summarized in Tables 5-2 and 5-3 and described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. CP5 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperature in the upper Sacramento River, primarily in dry and critically dry water years. This would be accomplished by raising Shasta Dam 18.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD. Hence, the most significant water temperature benefits to anadromous fish would occur upstream from the RBDD. It is estimated that improved water temperature conditions under CP5 could result in an annual average increase in the Chinook salmon population of about 607,000 outmigrating juvenile fish.

Increase Water Supply Reliability CP5 would increase water supply reliability by increasing firm water supplies for irrigation and M&I deliveries, primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA, which would help reduce estimated future water shortages by increasing the reliability of firm supplies for agricultural and M&I deliveries by at least 133,400 acre-feet per year and an average annual yield of about 75,800 acre-feet per year. For this report, firm yield is considered equivalent to the estimated increase in the reliability of supplies during dry and critically dry periods. As shown in Table 5-6, the majority of increased firm yield, 103,800 acre-feet, would be for south–of-Delta agricultural and M&I deliveries. In addition, increased water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban areas resulting from water shortages. Under CP5, approximately $3.8 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 96 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities.

Conserve, Restore, and Enhance Ecosystem Resources This component includes improving shallow, warm-water fish habitat by using manzanita cleared from above the inundation zone to create structural enhancements, and planting cereal grains to treat shoreline areas. These improvements would help provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Placing manzanita brush structures near the Shasta Lake shoreline would enhance the diversity of structural habitat available for the warm-water fish species that occupy Shasta Lake. Establishing vegetation also could benefit terrestrial species that inhabit the shoreline of Shasta Lake.

The lower reaches of perennial tributaries to Shasta Lake would be targeted for aquatic restoration because they provide year-round fish habitat. Native fish species require connectivity to the full range of habitats offered by Shasta Lake and its tributaries. Improved fish passage addresses the requirement to provide access and/or modify barriers necessary to improve ecological conditions that support these native fish assemblages. Aquatic habitat improvements include enhancing aquatic connectivity and reducing sediment related to roads constructed across intermittent streams.

In the upper Sacramento River, the addition of spawning gravel and the restoration of riparian, floodplain, and side channel habitat are expected to improve the complexity of aquatic habitat and its suitability for spawning and rearing. Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that increase the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. Restoration would support the goals of the Sacramento River Conservation Area Forum and other programs associated with riparian restoration along the Sacramento River. Side channels can support important habitat for anadromous salmonids, including rearing and spawning habitat. Side channel habitats also provide refuge from predators and productive foraging habitat for juvenile anadromous salmonids.

Maintain and Increase Recreation Opportunities CP5 includes features to, at a minimum, maintain the existing recreation capacity at Shasta Lake. In addition, this plan includes construction of 18 miles of new trails and 6 trailheads to enhance recreation opportunities at Shasta Lake. As with the other comprehensive plans, a small benefit would likely occur to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area and modernization of recreation facilities. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 acres to about 32,100 acres. There is also limited potential for reservoir reoperation to provide additional benefits to recreation by raising the bottom of the flood control pool elevation and allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other SLWRI Study Objectives CP5 could also provide benefits related to flood damage reduction and water quality, similar to CP3.

Additional Broad Public Benefits Additional broad public benefits of CP5 obtained through pursuing project objectives are summarized in Table 5-3. Broad public benefits for CP5 are similar to CP3.

Potential Primary Effects from CP5

Anticipated inundation, construction, cultural, and relocation impacts associated with CP5 are similar to CP3 and CP4, as summarized above. Potential effects on flow and stages of the upper Sacramento River from CP5 are identical to those for CP3. Figures 5-16, 5-17, and 5-18 show simulated Sacramento River flows below Keswick Dam, RBDD, and Stony Creek, respectively, under wet, average, and dry year conditions for the No-Action Alternative compared to CP3 and CP5. Some potential exists for impacting existing habitat at environmental restoration sites, but these impacts would likely result from converting present land use back to a more typical riverine environment. Proposed mitigation measures to address potential adverse impacts of CP4 are summarized in Table 5-7. As mentioned, a detailed discussion of potential effects and proposed mitigation measures associated with raising Shasta Dam by 18.5 feet are included in Chapters 4 through 25 of the PDEIS.

Preliminary Economic Assessment of CP5

Estimated Costs Estimated construction cost and annual costs of CP5 are shown in Table 5-4. As shown, the estimated construction cost is $1,073 million. The estimated total annual cost of this plan is $54.1 million.

Estimated Economic Benefits As shown in Table 5-5, the estimated average annual monetary benefit of CP5, assuming the cost of water and energy supplies increase at the same rate as inflation, is about $65.5 million per year. The largest monetary benefit is increased dry year water supply reliability. Assuming the cost of water supplies and hydropower increases at 2 percent above inflation, to account for future diminishment of water and energy supplies and increasing demands, this benefit could exceed $89.3 million per year. Added benefits for ecosystem restoration and recreation enhancements in and around Shasta Lake are estimated to equal to their annual cost.

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Chapter 6 Evaluation and Comparison of Comprehensive Plans

A critically important element of the plan formulation process is the evaluation and comparison of alternative plans. Included in this chapter are the results of an evaluation and comparison of the comprehensive plans described in Chapter 5, and discussions of plan selection rationale, risks and uncertainties, and next steps for the SLWRI feasibility study.

Comprehensive Plan Evaluation

Four accounts are established to display, and facilitate evaluation of, the effects of alternative plans: NED, environmental quality (EQ), regional economic development (RED), and other social effects. These four accounts encompass all significant beneficial and adverse effects of a plan on the human environment, as required by NEPA (42 USC 4321 et seq.). Effects of comprehensive plans are to be displayed as the difference in conditions compared to the No-Action Alternative. Under the P&G (WRC 1983), the NED account is the only required account. The other accounts are only required if by law, or if they will have a material bearing on the decision-making process.

National Economic Development

The objective of NED analysis is to determine the change in net value of the Nation's output of goods and services that would result from implementing each project alternative. Beneficial and adverse effects are evaluated in monetary terms, and measured in terms of changes in national income among the No-Action and various action alternatives. The NED account describes the part of the NEPA human environment that identifies beneficial and adverse effects on the economy. Beneficial effects in the NED account are (1) increases in the economic value of the national output of goods and services from a plan, (2) the value of output resulting from external economies caused by a plan, and (3) the value associated with the use of otherwise unemployed or underemployed labor resources. Adverse effects in the NED account are the opportunity costs of resources used in implementing a plan. These adverse effects include (1) implementation outlays, (2) associated costs, and (3) other direct costs. Specific guidelines, standards, and procedures used in NED analysis are contained in the P&G (WRC 1983).

The NED account may include net benefits to the following categories: irrigation water supply for agriculture, M&I water supply, urban flood damage reduction, power (hydropower), transportation (inland navigation and deep draft navigation), recreation, commercial fishing, unemployed or underemployed labor resources, and other direct benefits. For this analysis, the NED account would include the M&I water supply, irrigation water supply, hydropower, and recreation, as well as the other direct benefits category for anadromous fish survival.

Environmental benefits, including fisheries and ecosystem resources, are typically included in the EQ account if monetary units cannot be attributed to these benefits. However, for this analysis, fisheries benefits were developed as monetary units, and are included in the NED account. The contribution of the various alternatives to anadromous fish survival can be included in the NED account under the "other direct benefits" category.

Monetized Benefits

Estimating the economic benefits of potential effects is critical to establishing economic feasibility and identifying a corresponding NED plan. This section identifies valuation methods and valuation estimates for the benefit categories associated with the SLWRI planning objectives.

Increase Anadromous Fish Survival The method for assessing the economic value of contributions of the SLWRI to anadromous fish survival is through implementing a "cost of the most likely alternative" approach. The underlying premise for the valuation approach is that increasing salmon populations is a socially desirable goal, as indicated by the listing of several species as threatened or endangered and the demonstrated expenditures on salmon restoration projects.

Because the increased potential to reduce water temperatures during critical periods provided by additional surface storage is essential to increasing salmon production, the cost of the most likely alternative was based on the cost of various dam raises operated solely for the purpose of increasing the number of salmon smolt in the Sacramento River. Evaluating the cost of the most likely alternative included analysis of three separate dam raises operated solely for increased anadromous fish production, and was estimated using habitat units. Habitat units were based on 1,000 smolt passing downstream at the location of the Red Bluff Diversion Dam. A cost-per-habitat-unit estimate was calculated for each alternative through dividing annual costs by the expected change in habitat units. The lowest cost-per-habitat-unit estimate was used as a per-habitat-unit benefit estimate. Anadromous fish benefits were computed though multiplying the per-habitat unit benefit estimate by the change in habitat units expected under each of the comprehensive plans (Table 6-1).

Table 6-1. Least Cost Alternative Estimates of Average Annual Salmon Production for Comprehensive Plans

Item	CP1 – 6.5-Foot Raise	CP2 – 12.5-Foot Raise	CP3 – 18.5-Foot Raise	CP4 – 18.5-Foot Raise– Anadromous Fish Focus, with Water Supply Reliability	CP5 – 18.5-Foot Raise - Combination Plan
Change in Average Annual Salmon Production Relative to No-Action Alternative (thousands of fish)	366.4	233.8	607.5	1,198.9	607.5
Total Benefits ($ millions)	15.1	9.6	25.0	49.2	25.0

Notes:
Dollar values are expressed in April 2010 price levels.
Key:
CP = comprehensive plan

Increase Water Supply Reliability The CalSim-II model was used to estimate potential increases in water supply reliability to the CVP and SWP for the comprehensive plans. Table 6-2 shows results of the water operations modeling analyses to determine average year and dry/critically dry year conditions (according to the Sacramento Valley Water Year Hydrologic Classification) north and south of the Delta for the five comprehensive plans.

Irrigation Water Supply This analysis provides preliminary benefit estimates produced through applying the “change in net income” method, as estimated by the Central Valley Production Model (CVPM). In the CVPM, parameters ranging from crop mixes, prices, and yields to irrigation efficiency are modeled for the entire CVP. Then a potential new increment, such as increased storage at Shasta Reservoir is added, and the net increase in the value of increased production is estimated.

Table 6-2. Increases in Irrigation and M&I Yield for Comprehensive Plans and Water Supply Reliability Benefits

Item	CP1	CP2	CP3	CP4	CP5
CVP/SWP Irrigation Water Supply Reliability					
Dry/Critical Years NOD (acre-feet/year)[1]	7,800	17,100	25,300	7,800	25,300
Dry/Critical Years SOD (acre-feet/year)[1]	42,600	66,900	86,300	42,600	86,300
Average – All Years NOD (acre-feet/year)	5,200	11,500	16,100	5,200	16,100
Average – All Years SOD (acre-feet/year)	22,700	36,200	43,700	22,700	43,700
Benefit ($ millions)	***8.3***	***11.0***	***12.9***	***8.3***	***12.9***
CVP/SWP M&I Water Supply Reliability					
Dry/Critical Years NOD (acre-feet/year)[1]	1,800	2,700	4,300	1,800	4,300
Dry/Critical Years SOD (acre-feet/year)[1]	24,200	18,400	17,500	24,200	17,500
Average – All Years NOD (acre-feet/year)	1,000	1,600	2,300	1,000	2,300
Average – All Years SOD (acre-feet/year)	17,500	13,500	13,700	17,500	13,700
Benefit ($ millions)	***18.7***	***14.0***	***13.8***	***18.7***	***13.8***
Total Water Supply Reliability					
Dry/Critical Years[1] (acre-feet/year)	76,400	105,100	133,400	76,400	133,400
Average – All Years (acre-feet/year)	46,400	62,800	75,800	46,400	75,800
Total Benefit					
Estimated Value – At Inflation ($ millions)[2 3]	***27.0***	***25.0***	***26.7***	***27.0***	***26.7***
Estimated Value – 2% Above Inflation ($millions)[2 4]	***46.5***	***43.1***	***46.1***	***46.5***	***46.1***

Notes:
Dollar values are expressed in April 2010 price levels.
[1] Year-types as defined in the Sacramento Valley Water Year Hydrologic Classification Index.
[2] Totals may not sum because of rounding.
[3] Assumes the cost of water supplies increases at the same rate as inflation.
[4] Includes increase of water supply costs at 2 percent above inflation to account for growing scarcity of available supplies in the future. Sensitivity analyses for change in water supply benefits are included in the Economic Valuation Appendix.
Key:
CP = comprehensive plan
CVP = Central Valley Project
M&I = municipal and industrial
SWP = State Water Project
NOD = North of Delta
SOD = South of Delta

Potential increases in water supply reliability developed for the SLWRI are primarily achieved during drought periods when new increments of reliable water supply would be most needed. This is because, under current conditions, there is an increased frequency of water supply shortages in dry and critical years. Similarly, under current conditions, there is greater Delta export capacity in dry years due to less water in the system. Because of data limitations, the CVPM is currently calibrated to a dry year as represented by 2001. The calibration year reflects only moderate drought conditions. As a result, the effects of dry years on cropping decisions and production costs may not be fully represented by the model. The CVPM is run for the long-term average water supply condition to establish the equilibrium crop and technology mix. The model is then run for dry years by considering fixed capital investments established in the long-term run, and allowing groundwater pumping and annual crop idling to occur as a result of reduced water supplies. This analysis uses results from both the long-term average and dry year runs to estimate the annual benefit associated with the SLWRI alternatives. The CVPM was run for the three dam raise scenarios. As can be seen in Table 6-2, average annual benefits ranged from about $8.3 million per year for CP1 to $12.9 million for CP3. Updated CVPM modeling results will be included in future SLWRI documents.

Municipal and Industrial Water Supply The SLWRI alternatives increase water supplies to M&I water users, especially during dry years. Estimates for dry year and average deliveries to M&I water users located north and south of the Delta for CP1 through CP5 are shown in Table 6-2. As shown in the table, M&I water supply benefits largely accrue to CVP and SWP contract holders located south of the Delta. M&I water users have increasingly participated in the water transfer market to augment supplies. M&I water supply reliability benefits were estimated based on the average annual deliveries shown in Table 6-2. This analysis assumes that the next increment of water supply to M&I users would likely be obtained through water transfers. The analysis also relies on values estimated through application of a water transfer pricing model, and through consideration of the costs associated with conveying the water to the M&I service areas. This method is consistent with the "actual or simulated market price" and the "cost of the most likely alternative" methods recommended by the P&G.

Uncertainty As described in Chapter 1, demands for water in California exceed available supplies. It is expected that the difference between available supplies and demands for water will increase significantly in the future, especially during drought periods. Although recent facility improvements have improved delivery capability, no material increases in supply have been added to the CVP or the SWP for nearly 40 years. To date, increases in water demands have primarily been accommodated through operational changes in the existing system. The population of the Central Valley is expected to nearly triple, and that of the State is expected to increase by more than 60 percent by 2050. This rapid increase in population alone, coupled with lack of new sources of supply, is expected to appreciably transform the future of water in California. One of the expected results will be a significant shift in water deliveries from agricultural to urban uses. In addition, major declines are likely in otherwise available supplies for reasons ranging from increased local and regional needs for a number of purposes to ongoing climatic changes.

Certainly the traditional approaches, using the methods above, for estimating water benefits have been adequate as accounting tools and in estimating benefits for increases in reliability today. However, these methods do not account for the growing complexities resulting from increasing demands and dwindling supplies. Current models used to help estimate water benefits are static models and only useful for estimating the increase in production at one point in time, given numerous highly constrained assumptions.

To account for the significant uncertainties associated with adequately estimating the value of new supplies, a sensitivity analysis was performed assuming the value of water increases above the inflation rate (up to 2 percent above inflation). Accordingly, the benefit of the increased supplies resulting from each comprehensive plan, based on a 2 percent rate above inflation, is included in Table 6-2.

Develop Additional Hydropower Generation Increasing the size of Shasta Dam and Reservoir would also result in the ability to increase hydropower generation at Shasta Dam generating facilities. As can be seen in Table 6-3, raising Shasta Dam by 6.5 feet to 18.5 feet would result in increased power generation of 42 to 138 GWh per year. CP4 would result in the largest increase in generation capacity because of greater hydraulic head from more water being held in storage for anadromous fish purposes. In addition, there is a recognized benefit of hydropower generation because it lacks emissions associated with other forms of energy generation. Each unit of energy produced through traditional fossil fuel sources produces emissions, including carbon dioxide. Accordingly, Table 6-3 contains an estimate of the climate exchange market value associated with the increased generation of the five comprehensive plans; however, these values are not included in the NED account totals. As can be seen in Table 6-3, estimated average annual hydropower generation benefits of the five plans range from about $2.5 million for CP1 to about $8.1 million for CP4.

Table 6-3. Summary of Hydropower Generation Benefits of Comprehensive Plans

Item	CP1	CP2	CP3	CP4	CP5
Increased Generation (GWh/year)	42.0	68.0	96.0	138.0	96.0
Value ($ millions)	2.4	3.9	5.4	7.6	5.4
CO_2 Displaced (1,000 metric tons)	37.2	60.1	84.9	122.1	84.9
Value ($ millions)[1]	0.1	0.2	0.3	0.4	0.3
Total Hydropower Benefit[2 3] ($ millions)	2.5	4.1	5.7	8.1	5.7

Notes:
[1] Based on a climate exchange market value of $4.30 per 1,000 metric tons of CO_2 equivalent.
[2] All numbers are rounded for display purposes; therefore, line items may not sum to totals.
[3] Total based on increased generation and CO_2 displacement reduction benefits. CO_2 displacement reduction benefits are not included in total for NED account.
Key:
CO_2 = carbon dioxide
CP = comprehensive plan
GWh/year = gigawatt-hours per year
NED = National Economic Development

Maintain and Increase Recreation Shasta Lake is a major recreational venue in California, and is the centerpiece of the Shasta Unit of the Shasta-Trinity NRA. The combination of large size, plentiful water-based recreation opportunities, favorable climate, and easy access make Shasta Lake one of the most visited recreation destinations in the State and region. A study of recreation sites in Northern California, performed by DWR as part of the Oroville Dam Relicensing project, places the estimated number of annual visitors at over 2.6 million (DWR 2004). Enlarging Shasta Dam alone, including relocating facilities to maintain at least the existing recreation opportunities, would affect recreation participation by providing modernized recreational facilities and increasing the reservoir surface area throughout the year. Table 6-4 compares user days (visitor days) and estimated recreation values for the No-Action Alternative and each of the comprehensive plans. The estimated resulting increase in user values is based on a recreation unit-day value of $37.00, the midpoint between the USFS Region 5 benefit estimate for a unit-day engaged in water travel ($10.00 in 2010 dollars) and a unit-day engaged in fishing ($63.99). The estimated benefit to recreation due to a larger reservoir surface area ranges from about $3.1 million to $8.4 million per year.

Table 6-4. Average Annual Predicted Visitor Days and Recreational Values[1]

Item	No-Action Alternative	CP1	CP2	CP3	CP4	CP5[3]
Visitor Days[2] (1,000)	2,584	2,667	2,725	2,808	2,808	2,808
Change in Visitor Days (1,000)	---	83	141	224	224	224
Total Recreation Value ($ millions)	95.58	98.66	100.79	103.87	103.87	103.87
Change in Value ($ millions)	---	3.1	5.2	8.3	8.3	8.4

Notes:
Dollar values are expressed in April 2010 price levels.
[1] All alternatives include features to, at minimum, maintain the existing recreation capacity at Shasta Lake.
[2] Visitor days and recreation values are at least equal to numbers shown. These values do not reflect increased visitation due to increased annual water surface elevations and reduced water surface elevation fluctuations associated with these plans. These values also do not include increased visitation due to modernization of recreation facilities associated with all comprehensive plans.
[3] For CP5, recreation enhancement benefits are assumed equal to annual costs.
Key:
- = not applicable
CP = comprehensive plan

Benefit Summary Table 6-5 summarizes the estimated annual average economic benefits from Tables 6-1 through 6-4 above.

Table 6-5. Summary of Comprehensive Plan Economic Benefits[1 2]

Item	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Anadromous Fish Survival	15.1	9.6	25.0	49.2	25.0
Water Supply Reliability					
Estimated Benefit (at inflation)[3]	27.0	25.0	26.7	27.0	26.7
Estimated Benefit (2% above inflation)[4]	46.5	43.1	46.1	46.5	46.1
Hydropower					
Estimated Benefit (at inflation)[3]	2.4	3.9	5.4	7.6	5.4
Estimated Benefit (2% above inflation)[4]	4.2	6.7	9.4	13.2	9.4
Recreation	3.1	5.2	8.3	8.3	8.4
Flood Control[5]	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified
Water Quality[5]	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified
Total Benefits					
Estimated Value (at inflation)[3 6]	47.6	43.7	65.4	92.2	65.5
Estimated Value (2% above inflation)[4 6]	68.8	64.6	88.7	117.2	89.3

Notes:
1 Any dam raise could provide incidental benefits to secondary objectives.
2 Benefits have not been monetized for ecosystem restoration including (1) restoring resident fish habitat in Shasta Lake, (2) restoring fisheries and riparian habitat at several locations along the lower reaches of the upper Sacramento River and tributaries to Shasta Lake, (3) augmenting spawning gravel in the upper Sacramento River, and (4) restoring riparian, floodplain, and side channel habitat in the upper Sacramento River.
3 Assumes the cost of water supplies and hydropower increase at the same rate as inflation.
4 Includes increase of hydropower and water supply costs at 2 percent above inflation to account for growing scarcity of available supplies in the future. Sensitivity analyses for change in water supply and hydropower benefits are included in the Economic Valuation Appendix.
5 Benefits for flood control and water quality are minimal and have not been monetized.
6 All numbers are rounded for display purposes; therefore, line items may not sum to totals.

Key:
CP = comprehensive plan
GWh = gigawatt-hour
HU = habitat unit
TAF = thousand acre-feet

Cost Summary Table 6-6 summarizes estimated construction, investment, and annual costs for each of the comprehensive plans. Total investment cost is the sum of total construction costs and IDC cost. The IDC cost is computed using Reclamation-defined practices, and is based on an estimated construction period for all plans of approximately 4 years. Total investment cost is annualized over the project's assumed 100-year lifespan at the Federal interest rate of 4-1/8 percent to compute interest and amortization. Total annual cost is the sum of interest and amortization and estimated annual O&M costs.

Table 6-6. Estimated Construction and Annual Costs of Comprehensive Plans[1]

Item	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Construction Cost					
Field Costs	$605	$658	$757	$763	$764
Noncontract Costs	$222	$255	$306	$307	$309
Total Construction Cost[2]	$827	$913	$1,064	$1,070	$1,073
Investment Cost					
Interest During Construction	$71	$78	$91	$91	$92
Total Investment Cost[2]	$898	$991	$1,154	$1,161	$1,165
Annual Cost					
Interest and Amortization	$38	$42	$48	$49	$49
Operations and Maintenance	$4.9	$4.8	$5.2	$5.2	$5.2
Total Annual Cost[2]	$42.6	$46.4	$53.7	$54.0	$54.1

Notes:
[1] April 2010 price levels, 100-year period of analysis, and 4-1/8 percent interest rate.
[2] All numbers are rounded for display purposes; therefore, line items may not sum to totals..
Key:
CP = comprehensive plan

Net National Economic Development Benefits

The P&G state that the alternative that reasonably maximizes net NED benefits, consistent with the Federal objectives, is identified as the NED plan (WRC 1983). Net NED benefits are calculated by subtracting NED costs from NED benefits. The alternative that generates the maximum net NED benefit is CP4. (Table 6-7). CP4 generates net benefits of $38.2 million annually, assuming water supply costs increase at the same rate as inflation. Under potential future conditions, assuming an increase of water supply and hydropower costs at 2 percent above inflation to account for growing scarcity of available supplies in the future, CP4 generates $63.3 million in net benefits.

Nonmonetized Benefits

Several potential benefit categories associated with comprehensive plans are not quantified under NED, including ecosystem restoration, flood damage reduction, and water quality. One potential benefit category associated with all comprehensive plans that has not been monetized is flood damage reduction. All comprehensive plans would provide an incidental increase in flood protection to areas along the upper Sacramento River. The associated economic benefits would, however, be small. Similarly, all plans would contribute to maintaining or improving water quality in the Sacramento River and the Delta; however, the associated economic benefits would be small and have not been quantified under NED. All comprehensive plans would also increase operational flexibility and improve Delta emergency response.

Ecosystem restoration benefits are not quantified under NED and are included in the EQ account, including (1) restoring resident fish habitat in Shasta Lake, (2) restoring fisheries and riparian habitat at several locations along the lower reaches of the upper Sacramento River and tributaries to Shasta Lake, (3) augmenting spawning gravel in the upper Sacramento River, and (4) restoring riparian, floodplain, and side channel habitat in the upper Sacramento River. Implementing these ecosystem restoration measures does not require implementing other project features (e.g., dam raise, reservoir area relocations). Accordingly, the costs associated with these measures are considered separable from other project features.

Table 6-7. Summary of Annual Costs, Annual Benefits, and Net Benefits for Comprehensive Plans[1]

Item	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Annual Cost					
Total Annual Cost	42.6	46.4	53.7	54.0	54.1
Annual Benefits					
Estimated Value (at inflation)[2]	47.6	43.7	65.4	92.2	65.5
Estimated Value (2% above inflation)[3]	68.8	64.6	88.7	117.2	89.3
Benefit/Cost Ratio					
Estimated Value (at inflation)[2]	1.12	0.94	1.22	1.71	1.21
Estimated Value (2% above inflation)[3]	1.62	1.39	1.65	2.17	1.65
Net Benefits					
Estimated Value (at inflation)[2 4]	5.0	-2.7	11.7	38.2	11.4
Estimated Value (2% above inflation)[3 4]	26.2	18.1	35.1	63.3	35.2

Notes:
[1] April 2010 price levels, 100-year period of analysis, and 4-1/8 percent interest rate.
[2] Assumes the cost of water supplies and hydropower increases at the same rate as inflation.
[3] Includes increase of hydropower and water supply costs at 2 percent above inflation to account for growing scarcity of available supplies in the future. Sensitivity analyses for change in water supply and hydropower benefits are included in the Economic Valuation Appendix.
[4] All numbers are rounded for display purposes; therefore, line items may not sum to totals.
Key:
CP = comprehensive plan

Environmental Quality

The EQ account is a means of integrating information about the EQ resource and NEPA human environment effects (as defined in 40 Code of Federal Regulations 1507.14) of alternative plans into water resources planning. This is essential to a reasoned choice among alternative plans.

A thorough evaluation of the EQ accounts was performed as part of the NEPA environmental documentation process. Table S-1 in the PDEIS summarizes impacts and mitigation measures; Chapter 2, Section 2.4.3, of the PDEIS describes the environmental commitments common to comprehensive plans. Also, Chapter 26 of the PDEIS describes short-term use of the human environment and the maintenance and enhancement of long-term productivity. In addition, Chapter 26 of the PDEIS presents potential irreversible or irretrievable commitments of resources for the comprehensive plans.

Table 6-8 summarizes key effects for all resource categories for the EQ account. All comprehensive plans are similar in terms of their potential environmental effects, although some adverse effects are exacerbated by larger dam raises and by the associated scale of the effects, such as expanded construction areas and increased area of inundation around Shasta Lake. Generally, the adverse effects would be mitigated to less-than-significant levels with prescribed mitigation measures. Some adverse effects for all of the action alternatives – the short-term generation of construction-generated emissions in excess of Shasta County Air Quality Management District thresholds, and the temporary exceedence of Shasta County noise level standards — would remain unavoidable despite mitigation measures. Altered flow regimes, changes to the areas inundated by the Sacramento River and Shasta Lake, and disturbances associated with construction activities have the potential to affect environmental resources. However, these adverse effects would be mitigated to the extent practicable.

CP1 and CP2 would have less of an adverse effect on land uses within the dam inundation area than the other comprehensive plans because CP1 and CP2 would raise the dam by 6.5 feet and 12.5 feet, respectively, compared to the 18.5-foot increase that CP3, CP4, and CP5 propose. However, the benefits associated with improved anadromous fish survival and increased water supply reliability would offset the localized adverse effects of the larger raise.

Table 6-8. Summary of Potential Environmental Effects Under Environmental Quality Account

Resource Area/ Alternatives	Primary Study Area		Extended Study Area			Key Considerations
	Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBDD)	Sacramento River (RBDD to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Geology, Geomorphology, Minerals, and Soils CP1 – CP5	[orange]	[green]	[green]	[green]	[green]	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation. Long -term adverse effects associated with operations reduced through mitigation.
Air Quality and Climate CP1 – CP5	[orange]	[green]	[purple]	[purple]	[purple]	Long-term benefits related to reduced emissions due to increased hydropower generation. Short-term unavoidable adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Hydrology, Hydraulics, and Water Management CP1-CP5	[green]	[green] [blue]	[green] [blue]	[green] [blue]	[green] [purple] [blue]	Beneficial effects to groundwater levels in CVP/SWP service areas. Long-term beneficial effects related to water supply reliability and flood damage reduction included in NED account.
Water Quality CP1 – CP5	[green] [purple]	[green] [blue]	[green] [blue]	[green] [blue]	[green] [blue]	Long-term beneficial effects to reservoir water quality due to replacement of reservoir area septic systems with centralized wastewater treatment plants. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation. Long-term beneficial water quality effects in Sacramento River and Delta included in NED account.
Noise and Vibration CP1 – CP5	[green]	[green]	[green]	[green]	[green]	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Hazards and Hazardous Materials and Waste CP1 – CP5	[green]	[green]	[green]	[green]	[green]	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Agriculture and Important Farmland CP1 – CP5	[orange]	[green]	[green]	[green]	[green] [blue]	Long-term beneficial effects from improved agricultural water supply reliability included in NED account. Long-term adverse effects due to conversion of forest lands.

Table 6-8. Summary of Potential Environmental Effects under Environmental Quality Account (contd.)

Resource Area/ Alternatives	Primary Study Area		Extended Study Area			Key Considerations
	Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBDD)	Sacramento River (RBDD to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Fisheries and Aquatic Ecosystems CP1 – CP5						Long-term beneficial effect on cold-water fisheries habitat in Shasta Lake. CP4 and CP5 provide ecosystem restoration benefits for fisheries and aquatic habitat through (1) augmenting spawning gravel in the upper Sacramento River, and (2) restoring riparian, floodplain, and side channel habitat in the upper Sacramento River. CP5 provides ecosystem restoration benefits for fisheries and aquatic habitat, including (1) restoring resident fish habitat in Shasta Lake, and (2) restoring fisheries and riparian habitat at several locations along the lower reaches of tributaries to Shasta Lake. Long-term beneficial effects on anadromous fisheries included in NED account.
Botanical Resources and Wetlands CP1 – CP5						CP4 and CP5 provide ecosystem restoration benefits for botanical resources through restoring riparian, floodplain, and side channel habitat in the upper Sacramento River. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Wildlife Resources CP1 – CP5						CP4 and CP5 provide ecosystem restoration benefits for wildlife resources through restoring riparian, floodplain, and side channel habitat in the upper Sacramento River. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Cultural Resources CP1 – CP5						Adverse effects due to construction in primary study area; adverse effects reduced through mitigation. Adverse effects due to operations in the primary study area are unavoidable.
Socioeconomics, Population, and Housing CP1 – CP5						Long-term beneficial effects from improved agricultural water supply reliability included in NED account. Short-term beneficial effects of construction activities included in RED account.
Land Use and Planning CP1 – CP5						Long-term adverse effects to land use in reservoir area are unavoidable; adverse effects reduced through mitigation.

Table 6-8. Summary of Potential Environmental Effects under Environmental Quality Account (contd.)

Resource Area/ Alternatives	Primary Study Area		Extended Study Area			Key Considerations
	Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBDD)	Sacramento River (RBDD to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Recreation and Public Access CP1 – CP5	[green] [blue]	[green]	[green]	[green]	[green]	Long-term beneficial effects on recreation included in NED account. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Aesthetics and Visual Resources CP1 – CP5	[orange]	[orange]	[green]	[green]	[green]	Long-term adverse effects to aesthetics in reservoir area are unavoidable; adverse effects reduced through mitigation.
Transportation and Traffic CP1 – CP5	[green] [purple]	[green]	[green]	[green]	[green]	Long-term beneficial effects due to modernized roadway/bridge relocations. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Utilities and Service Systems CP1 – CP5	[green] [purple]	[green]	[green]	[green]	[green]	Long-term beneficial effects due to replacing and modernizing utilities. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Public Services CP1 – CP5	[green]	[green]	[green]	[green]	[green]	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Power and Energy CP1 – CP5	[blue]	[blue]	[green]	[green]	[blue]	Long-term beneficial effects from increased hydropower generation included in NED account.
Environmental Justice CP1 – CP5	[orange]	[green]	[green]	[green]	[green]	Not disproportionately high and adverse effects to minority and low income populations in the vicinity of Shasta Lake and upper Sacramento River. Disproportionately high and adverse effects to Native American populations in vicinity of Shasta Lake. Not disproportionately high and adverse effects to Native American populations in the vicinity of the upper Sacramento River.

Table 6-8. Summary of Potential Environmental Effects under Environmental Quality Account (contd.)

Resource Area/ Alternatives	Primary Study Area		Extended Study Area			Key Considerations
	Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBDD)	Sacramento River (RBDD to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Wild and Scenic Rivers CP1 – CP5	[orange]	[green]	[green]	[green]	[green]	Long-term adverse effects to McCloud River are unavoidable.

Key:
- [green] No effect, minimal effect, not disproportionately high and adverse (environmental justice), and/or minimal effect after mitigation.
- [orange] Unavoidable and/or disproportionately high and adverse (environmental justice).
- [purple] Beneficial effect .
- [blue] Beneficial effects associated with anadromous fish survival, water supply reliability, flood damage reduction, hydropower, and recreation accounted for in NED. Beneficial effects to regional economics (including jobs and income) included in RED accounts.

CP = comprehensive plan
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
NED = National Economic Development
RBDD = Red Bluff Diversion Dam
RED = Regional Economic Development
SWP = State Water Project

Regional Economic Development

The RED account registers changes in the distribution of regional economic activity that result from each alternative plan considered in an implementation study. According to the P&G, two measures of regional effects are considered: regional income and regional employment. A region is generally defined as an area that encounters “significant” income and employment effects. Income and employment effects are further divided into “positive” and “negative” effects. Each of the four categories (positive income, positive employment, negative income, and negative employment) is equal to the sum of the NED effects that accrue in a region, plus transfers between the region and outside the region (i.e., positive income effects equal the NED benefits in the region plus the transfers of income to the region from outside the region). Transfers can come from implementation outlays, transfers of basic economic activity, indirect effects, and induced effects. The positive (and negative) effects on regional employment are directly parallel to effects on income; therefore, typically the analysis of regional employment effects is organized in the same categories as regional income effects. Regional employment effects are also analyzed according to relevant service, trade, industrial, and other sectors as well as skill levels (unskilled, semiskilled, and highly skilled).

Employment and income effects of the proposed alternatives were determined through the use of IMPLAN (IMpact analysis for PLANning) modeling. Reclamation economists completed this modeling, which was based on an input/output analysis. Input/output models are essentially accounting tables that trace the linkages of inter-industry purchase and sales within a given region and year. In addition to inter-industry data, the IMPLAN model used several assumptions to analyze the RED of all alternatives regarding construction duration, origin of the labor force, size of labor force, payroll costs as a percent of total construction costs, and origin of construction materials. For specific assumptions, see Chapter 7 of the Economic Valuation Appendix. The IMPLAN model yields “multipliers” that are used to calculate the total direct, indirect, and induced effects on employment and income, among other factors. The resulting benefits can be seen in Table 6-9.

Increased levels of income are expected to accompany the increase in employment (Table 6-10). The level of increased income is directly related to the quantity of employment opportunities and the duration of the project. Construction activity associated with each of the alternatives will take place over 3 to 5 years, depending on the alternative selected. Because economic impacts are typically measured and reported in annual terms, costs were converted to average annual expenditures for the duration of the construction period.

Table 6-9. Summary of Annual Employment Benefits for RED Account

Item	CP1	CP2	CP3	CP4	CP5
Construction Duration (years)	3	4	5	5	5
Short-Term Employment[1]					
New Direct Jobs	450	370	350	350	350
Local Labor Force	450	370	350	350	350
Construction	450	370	350	350	350
External Labor Force	0	0	0	0	0
Indirect and Induced Jobs	1,370	1,140	1,060	1,070	1,070
Construction Support	580	480	450	450	460
Total Direct, Indirect, and Induced Employment[2]	1,820	1,510	1,410	1,410	1,420
Long-Term Employment					
Long-Term Maintenance Positions	2	2	2	2	2

Note:
[1] Results showing jobs per year for the construction duration are based on application of IMPLAN model.
[2] All numbers are rounded for display purposes; therefore, line items may not sum to totals.
Key:
CP = comprehensive plan
RED = Regional Economic Development

Table 6-10. Summary of Annual Income Effects for RED Account

Item	CP1	CP2	CP3	CP4	CP5
Construction Duration (years)	3	4	5	5	5
Income[1]					
Direct ($ millions)	126.1	104.4	97.4	97.9	98.2
Indirect/Induced ($ millions)	57.4	47.6	44.3	44.6	44.7
Total Income[2] ($ millions)	183.6	152.0	141.7	142.5	142.9

Note:
[1] Results showing personal income per year for the construction duration are based on application of IMPLAN model and area expressed in April 2010 price levels.
[2] All numbers are rounded for display purposes; therefore, line items may not sum to totals.
Key:
CP = comprehensive plan
REC = Regional Economic Development

In addition to employment and income benefits, all comprehensive plans would also provide additional benefits due to implementation outlays for construction activities. Construction activities would primarily occur in the immediate vicinity of Shasta Lake in Shasta County. RED effects due to implementation outlays are estimated to affect primarily the four-county region surrounding Shasta Lake, including Shasta, Tehama, Trinity, and Siskiyou counties. Effects to both regional employment and regional income are expected to be beneficial during the project construction period and would be approximately proportional to construction costs of the comprehensive plans.

Other Social Effects

The other social effects account is a means of displaying, and integrating into water resources planning, information on alternative plan effects from perspectives that are not reflected in the other three accounts. Categories of effects in the other social effects account include the following: urban and community impacts; life, health, and safety factors; displacement; long-term productivity; and energy requirements and energy conservation. Both the beneficial and adverse effects in the other social effects account are expected to be similar across all comprehensive plans, but generally proportional to the respective dam enlargement and newly inundated areas.

Threats to people, for loss of life and injury from flood events, must be addressed for public safety. Enlarging Shasta Dam and Reservoir has the potential to reduce flood flows in the upper Sacramento River. The comprehensive plans would reduce the frequency, magnitude, and duration of some potential future flood events, as for those that have affected structures and residents in this part of the primary study area in the past. As a result of greater reservoir capacity, the overall risk of flooding and its related consequences below Shasta Dam is expected to be reduced. The potential for loss of life would also be reduced. Flood control benefits of the dam enlargement would not be expected to change the existing floodplain or Federal Emergency Management Agency flood zone designations; therefore, the comprehensive plans would not remove an obstacle to development. Thus, flood protection benefits are not considered growth inducing.

Environmental justice review is required to determine if a disproportionate share of a proposed project’s adverse socioeconomic and other environmental impacts are borne by low-income and minority communities. Analyses have shown the disturbance or loss of resources associated with locations considered by the Winnemem Wintu and Pit River Madesi Band members to have religious and cultural significance. These disturbances would result in an unmitigable, disproportionately high and adverse effect on Native American populations in the vicinity of Shasta Lake.

All comprehensive plans would provide beneficial effects on health and safety in the Shasta Lake area and downstream along the Sacramento River. Additionally, all comprehensive plans are estimated to displace people and businesses in the Shasta Lake area because of expanded reservoir inundation areas.

Comparison of Comprehensive Plans

Four evaluation criteria based on the Federal P&G for water resources planning were introduced in Chapter 1: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability. Chapter 4 includes an evaluation of concept plans based on the effectiveness and efficiency criteria. In this chapter, all four evaluation criteria are applied below to the Comprehensive Plans described in Chapter 5, as summarized in Table 6-11.

Completeness

Completeness is a determination of whether a plan includes all elements necessary to realize planned effects and the degree that intended benefits of the plan depend on the actions of others. Several subfactors that are important in measuring this criterion include (1) authorization, (2) the spectrum of objectives being addressed, (3) reliability, (4) physical implementability, and (5) environmental effects and mitigation.

Table 6-11 is a summary comparison of the No-Action Alternative and each comprehensive plan. As can be seen, the No-Action Alternative rates very low for completeness, and each of the comprehensive plans rates from high to very high. Two distinguishing subfactors of the completeness criterion are (1) objectives being addressed and (2) reliability. CP1, CP2, and CP3 primarily address anadromous fish survival and water supply reliability; however, each of these comprehensive plans indirectly contributes to each of the other planning objectives, with the exception of ecosystem restoration. Further, the likely reliability and certainty of each of these three comprehensive plans to meet its intended objectives is very high. These comprehensive plans do not significantly rely on any other actions. However, CP4 specifically focuses on anadromous fish survival through increasing the minimum carryover storage space in Shasta Reservoir each year, and CP5 focuses on additional ecosystem restoration and recreation. With both CP4 and CP5, O&M requirements would increase. Accordingly, overall reliability would be reduced for each alternative.

Table 6-11. Summary Comparison of No-Action Alternative and Comprehensive Plans

Comprehensive Plans	Comparison Criteria				Relative Ranking
	Completeness	Effectiveness	Efficiency	Acceptability	
No-Action Alternative	Although the No-Action Alternative requires no future action, it addresses none of the planning objectives.	Water supply reliability and hydropower needs will continue to increase. High survival, ecosystem restoration, and recreation needs will remain unchanged.	Highly cost inefficient. By taking no action, and as problems and needs continue and grow, either other significantly more costly actions will be undertaken, especially to address water supply and power needs, or problems and needs will continue unabated.	Neither addresses nor meets any CALFED or CVPIA goal.	*Very Low*
Relative Rank	*Very Low*	*None*	*None*	*Very Low*	
CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability	Can be implemented with minimum impact and would not require future elements. Does not preclude future action at Shasta Dam and Reservoir or elsewhere in CVP. Addresses primary planning objectives.	Relatively low potential to effectively increase water supply reliability and improve fish survival. Contributes to hydropower and recreation planning objectives.	Low cost efficiency. Unit cost for water supply reliability is likely superior to other new sources.	Meets goals of CALFED and consistent with plan in 2000 CALFED ROD. High potential for avoiding perceived impacts.	*Moderate*
Relative Rank	*Very High*	*Low*	*Low*	*High*	
CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability	Similar to CP1. Significant potential for avoiding/mitigating potential increased impacts.	Moderate potential to effectively address primary objectives. Significant contribution to water supply reliability. Contribution to hydropower and recreation planning objectives.	Moderate cost efficiency. Unit cost for water supply reliability is likely superior to other new sources.	Consistent with goals of CVPIA, CALFED, and other related programs. Significant potential for avoiding perceived impacts.	*Moderate to High*
Relative Rank	*Very High*	*Moderate*	*Low*	*Moderate*	

Table 6-11. Summary Comparison of No-Action Alternative and Comprehensive Plans (contd.)

Comprehensive Plans	Comparison Criteria				Relative Ranking
	Completeness	Effectiveness	Efficiency	Acceptability	
CP3 – 18.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability	Similar to CP1. Significant potential for avoiding/mitigating potential increased impacts.	High potential to effectively address primary planning objectives. Contribution to hydropower and recreation objectives.	High cost efficiency. Unit cost for water supply reliability is likely superior to other new sources.	Consistent with goals of CVPIA, CALFED, and other related programs. Significant potential for avoiding perceived impacts.	*High*
Relative Rank	*Very High*	*High*	*High*	*High*	
CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability	Significant potential for avoiding/mitigating potential increased impacts. Moderate degree of uncertainty about permanently implementing changed operation for anadromous fish.	Major increases in benefits to anadromous fish but relatively lower potential to effectively increase water supply reliability.	Overall cost efficiency very high. Moderate cost efficiency for water supply reliability.	Consistent with goals of CVPIA, CALFED, and other related programs. Higher acceptability by fishery resource agencies.	*High*
Relative Rank	*High*	*Moderate*	*Very High*	*Moderate to High*	
CP5 – 18.5-Foot Dam Raise, Combination Plan	Can be implemented with minimum impact and would not require future elements. Does not preclude future action at Shasta Dam and Reservoir or elsewhere in CVP. Addresses all planning objectives.	High potential to address primary planning objectives with emphasis on ecosystem restoration and recreation.	Similar to CP3. High potential for helping restore ecosystem resources and additional recreation at and near Shasta Lake.	Consistent with goals of CVPIA, CALFED, and other related programs. Consistent with the goals of CALFED for various programs, including water supply reliability and ecosystem restoration.	*High*
Relative Rank	*High*	*High*	*High*	*Moderate to High*	

Key:
CALFED = CALFED Bay-Delta Program
CP = comprehensive plan
CVP = Central Valley Project
ROD = Record of Decision

Another significant subfactor is environmental effects and mitigation. Anticipated impacts are generally comparable between alternatives; some impacts are exacerbated by larger dam raises and the associated scale of those impacts, such as a prolonged construction period and increased area of inundation around Shasta Lake. A detailed description and assessment of the effects to environmental resources within the primary study area and appropriate mitigation measures are included in the PDEIS.

Authorization/Objectives

This subcriterion is an estimate of a plan's consistency with the basic study authorization and whether it addresses each of the primary planning objectives and provides opportunities to address the secondary planning objectives. All of the Comprehensive Plans are believed to address the authorization and objectives.

Reliability

Reliability is a measure of a plan's capability to provide, over the life of a project, the specific and sustained benefits for which the plan was intended. It also includes a determination of whether other projects, programs, or actions are necessary to implement the project and develop the full level of benefit for which the plan was intended. It includes determining whether future actions, other than normal and identified O&M, are required for full and successful implementation of the plan. Alternatives that require future and ongoing action specific for success (CP4 and CP5) have a higher uncertainty than other plans.

Physical Implementability

Physical implementability is the potential for an alternative to be constructed or implemented within the study area, with disclosure of any unusual construction challenges potentially impacting project construction. All of the alternatives have a high potential for physical implementability.

Environmental Resources

This subcriterion estimates the relative ability of a plan to either avoid potential adverse environmental effects or successfully mitigate for unavoidable adverse effects. All alternatives are believed to have a high potential to either avoid or successfully mitigate environmental impacts (see also Hydraulic Conditions, below).

Water and Related Resources This subcriterion is a determination of whether a plan can be implemented to mitigate any unavoidable impacts to water, power, recreation, flood control, and/or related resources. All alternatives are believed to have a high potential for implementation with minimum effects to water and related resources. Alternatives with dam raises greater than 6.5 feet would negatively affect near-lake recreation facilities and hydropower generation at Pit 7 Dam.

Hydraulic Conditions This subcriterion measures the ability of a plan to avoid potentially adverse hydraulic effects to other areas or to mitigate any unavoidable impacts. Since all alternatives include increasing the water surface of Shasta Reservoir, each would inundate greater areas than without-project conditions – between 1,100 and 2,500 acres for the 6.5- and 18.5-foot dam raises, respectively. Once full, the range for the reservoir in annual inundation would be similar to without-project conditions for all alternatives considered, except during dry and critically dry years. Little can be done to avoid effects associated with increased areas of inundation. Mitigation would include working to reduce the effects of the inundation with soil erosion control measures and introducing water-tolerant vegetation plantings. Acquisition and management of other areas to mitigate impacts also would be considered. The ability to successfully mitigate effects from the dam raises would be high.

All alternative plans would result in relatively minor changes in flow conditions downstream from Keswick Dam. Each would tend to reduce flows in the river from about December through March annually, and increase flows in spring and summer from about May through August. Average annual peak winter and spring/summer releases from Keswick Dam are about 10,000 and 14,000 cfs, respectively. Estimated maximum decreases in winter flows would range from about 5,700 and 11,000 cfs for the 6.5- and 18.5-foot dam raises (35 to 42 percent of without-project flows), respectively. For the 6.5- and 18.5-foot dam raises, average maximum spring and summer increases in flows would range from about 3,000 and 2,300 cfs (25 to 20 percent of the without-project flows) respectively. These changes in flows become less significant farther downstream from Keswick Dam due to the influence of tributaries to the Sacramento River.

Cultural Resources This subcriterion measures the ability of an alternative plan to avoid potential adverse effects to present or historical cultural resources or to successfully mitigate for adverse unavoidable impacts. Each of the Comprehensive Plans would have similar effects on reservoir area cultural resources as described previously in Chapter 5. A more detailed description and assessment of the impacts to cultural resources, and appropriate mitigation measures, are included in the Chapter 14 of the PDEIS.

Effectiveness

Effectiveness is the extent to which an alternative plan alleviates problems and achieves objectives. For the primary planning objective of anadromous fish survival, two major relative ranking factors were considered: (1) increasing salmon survival (decreased salmon mortality) and (2) increasing habitat for spawning. For the primary planning objective of increasing water supply reliability, ranking was based on the relative amount of new drought period yield that could be derived from each comprehensive plan. For the secondary planning objectives, four relative ranking factors were considered: (1) whether a comprehensive plan included ecosystem restoration, (2) potential to affect flood peaks downstream from Keswick Dam, (3) potential to increase net power generation, and (4) amount of increased recreation opportunities at Shasta Lake.

As indicated in Table 6-11, comprehensive plans with the greatest effectiveness in meeting planning objectives appear, at this time, to be CP3, CP4 and CP5. This is primarily because CP3 and CP5 would provide the largest contribution toward water supply reliability and CP4 would provide the largest contribution toward anadromous fish survival. All three plans provide benefits to ecosystem restoration (via improved fisheries conditions), flood damage reduction, hydropower generation, recreation, and water quality.

Efficiency

Efficiency is the measure of how efficiently an alternative alleviates identified problems, while realizing specified objectives consistent with protecting the Nation’s environment. The relative rankings in Table 6-11 for efficiency are based primarily on likely net benefits obtained under each plan. Table 6-12 includes an estimate of the monetary costs and benefits, as well as net benefits, for each of the comprehensive plans under conditions assuming – (1) the cost of water supplies and hydropower increases at the same rate as inflation, and (2) the cost of water supplies and hydropower increases at 2 percent above inflation to account for increasing value of water and energy supplies due to demand increases and supply reductions. As shown, assuming the cost of water and energy supplies increases at the same rate as inflation, CP1, CP3, CP4, and CP5 would be economically feasible and under future conditions, all plans would be economically feasible. As mentioned, at this stage of analysis under either condition, it appears that CP4 has the potential to provide the greatest net economic benefits. This is primarily because of the higher potential increase in anadromous fish survival.

Anadromous Fish Survival

This is a measure of the potential for an alternative to increase the long-term survivability of anadromous fish in the upper Sacramento River. As described in Chapter 5 and shown in Table 6-12, the plan likely to result in the largest number of increased salmon is CP4, followed by CP3 and CP5.

Water Supply Reliability

This is a measure of the potential for an alternative to increase water supply reliability for both irrigation and M&I purposes by developing a reliable additional increment of water at the lowest unit cost. Additional information on this benefit category is included in the Economic Valuation Appendix.

Table 6-12. Summary of Potential Benefits and Estimated Costs of Comprehensive Plans

Item	CP1	CP2	CP3	CP4	CP5
Raise Shasta Dam (feet)	**6.5**	**12.5**	**18.5**	**18.5**	**18.5**
Total Increased Storage (TAF)	256	443	634	634	634
Benefits					
Increase Anadromous Fish Survival					
Dedicated Storage (TAF)	-	-	-	378	-
Production Increase (thousand fish)[1]	366	234	607	1,199	607
Spawning Gravel Augmentation (tons)[2]				10,000	10,000
Side Channel Rearing Habitat Restoration (miles)				0.8	0.8
Increase Water Supply Reliability					
Increased Firm Water Supplies (TAF/year)[3]	76.4	105.1	133.4	76.4	133.4
Increased Firm Water Supplies NOD (TAF/year)[3]	9.6	19.8	29.6	9.6	29.6
Increased Firm Water Supplies SOD (TAF/year)[3]	66.8	85.3	103.8	66.8	103.8
Increased Water Use Efficiency Funding	Yes	Yes	Yes	Yes	Yes
Increased Emergency Water Supply Response Capability	Yes	Yes	Yes	Yes	Yes
Reduce Flood Damages					
Increased Reservoir Capacity for Capture of High Flows	Yes	Yes	Yes	Yes	Yes
Develop Additional Hydropower Generation					
Increased Hydropower Generation (GWh/year)	42	68	96	138	96
Conserve, Restore, and Enhance Ecosystem Resources					
Shoreline Enhancement (acres)	-	-	-	-	130
Tributary Aquatic Habitat Enhancement (miles)[4]	-	-	-	-	6
Riparian, Floodplain, and Side Channel Habitat Restoration (acres)	-	-	-	2.9	2.9
Increased Ability to Meet Flow and Temperature Requirements Along Upper Sacramento River	Yes	Yes	Yes	Yes	Yes
Maintain or Improve Water Quality					
Improved Delta Water Quality	Yes	Yes	Yes	Yes	Yes
Increased Delta Emergency Response Capability	Yes	Yes	Yes	Yes	Yes
Maintain and Increase Recreation					
Recreation (increased user days, thousands)[5]	83	141	224	224	224
Modernization of Relocated Recreation Facilities	Yes	Yes	Yes	Yes	Yes

Table 6-12. Summary of Potential Benefits and Estimated Costs of Comprehensive Plans (contd.)

Item	CP1	CP2	CP3	CP4	CP5
Economics ($millions)[6]					
Cost					
Construction Cost	$827	$913	$1,064	$1,070	$1,073
Annual Cost	$42.6	$46.4	$53.7	$54.0	$54.1
Annual Economic Benefits [7]					
Estimated Value (at inflation)[8]	$47.6	$43.7	$65.4	$92.2	$65.5
Estimated Value (2% above inflation)[9]	68.8	64.6	88.7	117.2	89.3
Net Economic Benefits[7]					
Estimated Value (at inflation)[8]	$5.0	($2.7)	$11.7	$38.2	$11.4
Estimated Value (2% above inflation)[9]	26.2	18.1	35.1	63.3	35.2

Notes:
[1] Average annual increase in juvenile Chinook salmon surviving to migrate downstream from the Red Bluff Diversion Dam. Numbers were derived from SALMOD.
[2] Average amount per year for 10-year period.
[3] Total increased deliveries during dry and critical years based on the Sacramento Valley Water Year Hydrologic Water Classification to CVP and SWP. Does not reflect benefits related to water use efficiency actions included in all comprehensive plans.
[4] Tributary aquatic enhancement provides for the connectivity of native fish species and other aquatic organisms between Shasta Lake and its tributaries. Estimates of benefits reflect only connectivity with perennial streams and do not reflect additional miles of connectivity with intermittent streams.
[5] These values do not account for increased visitation due to modernization of recreation facilities associated with all comprehensive plans.
[6] Based on April 2010 price levels, 4-1/8 discount rate, and 100-year period of analysis.
[7] Economic benefits reflect increases in anadromous fish production, firm water supplies, hydropower generation, and recreation (increased user days). Does not include monetized annual benefits for ecosystem restoration, flood damage reduction, or water quality.
[8] Assumes the cost of water supplies and hydropower increases at the same rate as inflation.
[9] Includes increase of hydropower and water supply costs at 2 percent above inflation to account for growing scarcity of available supplies in the future. Sensitivity analyses for changes in water supply and hydropower benefits are included in Economic Valuation Appendix.

Key:
- = not applicable
CP = comprehensive plan
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
GWh/year = gigawatt-hours per year
NOD = north of Delta
SOD = south of Delta
SWP = State Water Project
TAF = thousand acre-feet

Secondary Planning Objective Costs

This is a measure of the potential for an alternative to also include benefits for ecosystem restoration, flood damage reduction, and hydropower, with the lowest incidental and economically justified additional cost. All dam raise scenarios provide some amount of increased seasonal storage space that can contribute to increased hydropower, recreation, and regional employment. In addition, although small, each alternative could also contribute to increases in flood control. The relative benefits to those objectives increases with larger reservoirs and higher dam raises.

Acceptability

Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local government agencies, and public interest groups and individuals. This evaluation criterion will be very important following completion of the Final Feasibility Report and endorsement by a non-Federal sponsor of the comprehensive plan recommended for implementation. It appears that all of the comprehensive plans would be similarly ranked with respect to acceptability. Each of the plans needs to be coordinated with other agencies and public interests.

Summary of Comparisons

Each of the comprehensive plans is estimated to be complete and each appears to be effective in achieving its intended objectives. All comprehensive plans except CP2 are cost-efficient. Table 6-11 compares the No-Action Alternative and five comprehensive plans overall and Table 6-12 compares the costs and benefits for each of the comprehensive plans.

Comprehensive plans involving a 6.5-foot and 12.5-foot raise of Shasta Dam require the majority of the construction and annual costs associated with an 18.5-foot dam raise, as shown in Figure 6-12, as well as a majority of the environmental effects from reservoir area relocations, but provide only a portion of the increased storage capacity of an 18.5-foot raise. Based on studies to date, the three comprehensive plans involving a dam raise of 18.5 feet (CP3, CP4, and CP5) best address the planning objectives. This is primarily because of (1) a high certainty (completeness) that the plans could achieve their intended benefits, and (2) relatively high effectiveness and economic efficiency.

Rationale for Selection of a Recommended Plan

A plan recommending Federal action is to be the plan that best addresses the targeted water resources problems in considering public benefits relative to costs. The basis for selecting the recommended plan is to be fully reported and documented, including the criteria and considerations used in selecting a recommended course of action by the Federal Government. When the Feasibility Report and EIS are finalized, the Secretary of the Interior will use both documents and supporting information to provide a recommendation to Congress. This recommendation will be documented in a ROD and used by the U.S. Congress, along with the finalized Feasibility Report and EIS, to determine interest in, and the form of, project authorization if a plan is recommended for implementation. It is recognized that most of the activities pursued by the Federal Government require assessing of trade-offs and that in many cases, the final decision will require judgment regarding the appropriate extent of monetized and nonmonetized effects.

The needed rationale to support Federal investment in water resources projects is well described by the 2009 *Draft Proposed National Objectives, Principles, and Standards for Water and Related Resources Implementation Studies* (CEQ):

> *The presentations shall summarize and explain the decision rationale leading from the identification of need through the recommendation of a specific alternative. This shall include the steps, basic assumptions, analysis methods and results, criteria and results of various screenings and selections of alternatives, peer review proceedings and results, and the supporting reasons for other decisions necessary to execute the planning process. The information shall enable the public to understand the decision rationale, confirm the supporting analyses and findings, and develop their own fully-informed opinions and/or decisions regarding the validity of the study and its recommendations.*
>
> *Opportunities shall be provided for public reaction and input prior to key study decisions, particularly the tentative and final selection of recommended plans. The above information shall be presented in a decision document or documents, and made available to the public in draft and final forms. The document(s) shall demonstrate compliance with NEPA and other pertinent Federal statutes and authorities.*

At this stage of the Federal planning and NEPA processes (as described in this Draft Feasibility Report and the Preliminary Draft EIS), the potential effects of the comprehensive plans have been evaluated and compared based on established criteria. As a result, an 18.5-foot raise of Shasta Dam has been identified as the preliminary proposed plan at this time because it appears feasible under a variety of operations.

Operation of the existing CVP and SWP may change as a result of the ongoing OCAP reconsultation, and the proposed plan for operating an enlarged dam and reservoir is uncertain. Operations of the preliminary proposed plan are still being refined based on updates to modeling studies and input from agencies, stakeholders, and the public. Major components, benefits, and effects of the preliminary proposed plan would be similar to CP3, CP4, and CP5, as described in Chapter 5, but it is recognized that changes may occur to the comprehensive plans with changes in water operations and other relevant water resources projects and programs, including, potentially, BDCP/DHCCP efforts. Ultimately, the alternative that best meets the stated planning objectives, maximizes net public benefits, and is determined to be technically, environmentally, economically, and financially feasible, will be identified in the Final Feasibility Report and FEIS with supporting rationale and documentation.

If determined to be feasible, the plan recommended for implementation will meet all pertinent Federal, State, and local laws, policies, regulations, and other requirements so that it may be ideally recognized as the "Environmentally Preferable Alternative" consistent with NEPA, the "NED Plan" consistent with the P&G, the "Least Environmentally Damaging Practicable Alternative " consistent with the Clean Water Act, and the "Environmentally Superior Alternative" consistent with California Environmental Quality Act.

Risk and Uncertainty

With each aspect of this report, certain assumptions were made based on engineering and scientific judgment. Careful consideration was given to the methodologies and evaluations for hydrology and system operations, cost estimates, and biological analyses. Analyses were developed with advanced modeling and estimating tools using historical data and trends. While this is effective in helping predict outcomes for future operations, costs, and biological conditions, many uncertainties could affect the findings of this study. Various risks and uncertainties associated with the SLWRI are discussed below.

Hydrology and Climate Change

Potential climate change could possibly produce conditions that are different from those for which current water management operations were designed. The potential for, and magnitude of, climate change is widely debated. The State is investing significant resources in studying how global climate changes could affect the way California receives and stores water. Results indicate that climate changes in the State could affect hydrology, water temperatures for fish, and future operations for both flood management and water supply deliveries.

According to the 2009 *California Water Plan Update*, California could experience changes in temperature, precipitation, and snow level (DWR). Any measurable change in these climate indicators could affect future water operations in California. It is unlikely that changes in snow levels would significantly affect Shasta Reservoir because the reservoir is primarily filled by direct rainfall runoff, as opposed to snowmelt. However, changes in water management operations downstream and in the Delta could affect Shasta Reservoir operations. If precipitation increases, it may further enhance the benefits of increased reservoir capacity. According to the California Water Plan Update (DWR 2005), more studies are needed before definitive answers can be given:

> *In general, while modeling of projected temperature changes is broadly consistent across most modeling efforts, there are disagreements about precipitation estimates. Considerable uncertainties about precise impacts of climate change on California hydrology and water resources will remain until we have more precise and consistent information about how*

precipitation patterns, timing, and intensity will change. Further work is in progress to extend and improve these modeling efforts, and to use watershed-scale hydrological models that will be of more direct value to planners.

Water Supply Reliability and Demands

Water supplies and demand will continue to be subject to annual variability. Demands are expected to exceed supplies in the future, but predicting expected future water supply and/or shortages in the Central Valley of California can be challenging. There are numerous variables and, just as important, numerous opinions regarding these variables, depending on the growth scenarios anticipated. The *California Water Plan* (DWR 2009) estimates demand for different growth scenarios, ranging from "slow and strategic growth," that is slower than currently projected, to "expansive growth", which assumes that population growth will be faster than currently projected, with nearly 70 million people living in California in 2050.

Potential for an overall reduction in future demands for agricultural water supplies has been predicted. Reasons for this are conversion from agricultural to urban land uses and implementation of more efficient irrigation water applications.

Future Land Use

Population growth is a major factor in California's future water picture. California's population is expected to increase by just over 60 percent by 2050. Population growth could force some of the existing water supplies currently identified for agricultural uses to be redirected to urban uses. Certainly, some portion of increased population growth in the Central Valley would occur on lands currently used for irrigated agriculture. Therefore, water that would have been needed for these lands for irrigation would instead be used to serve replaced urban demands. However, this would only partially offset the required agricultural-to-urban water conversion, since much of the growth would occur on nonirrigated agricultural lands. If it was assumed that all of the urban growth in the Central Valley would occur on lands currently under irrigation, this would only account for up to about 40 percent of expected future conversion needs. The remainder of the agricultural-to-urban water conversion would be required to help sustain urban growth primarily in other areas of the State.

Efficiency in Water Use

While agricultural interests are ever improving in irrigation efficiencies, technology is also being used to be more efficient with all of the supplies that can be acquired. Challenges are greatest during dry years and droughts, because in drier years, water dedicated to the environment is curtailed and less water is available for agriculture. Users who have already increased efficiency may find it more challenging to achieve additional water use reductions during droughts.

Anadromous Fish Populations

Anadromous fish are highly affected by changes in their surrounding conditions. Trying to predict fish survival is difficult because of the many influencing factors. The SALMOD model used to predict fish survival for this feasibility study contains assumptions with varying levels of uncertainty. A key uncertainty stems from using the same number of returning spawners in each year of the SALMOD simulation. This does not allow for population growth over time; benefits are seen only in the number of survivors in a given year. Independent of the model, uncertainty is also related to water conditions outside the area of influence of the dam raise. These include conditions downstream from the modeled reach of the Sacramento River, in the Delta, and in the Pacific Ocean. Lastly, potential climate change could also influence fish survival. All models are subject to uncertainty; SALMOD was chosen as the best available model for performing population comparisons on the Sacramento River for two reasons. First, SALMOD has been applied previously on the Sacramento River (Kent 1999, Bartholow 2003, Reclamation 2008b. Second, the U.S. Geological Survey has completed a thorough review and update of model parameters and techniques on the Klamath River, enabling a smooth transfer of relevant model parameters to Sacramento River modeling for the SLWRI (Bartholow and Henriksen 2006).

Adaptive Management

Adaptive management of system operations could reduce uncertainty in anadromous fish survival. Adaptive management is a deliberate, iterative, and scientific process of designing, implementing, monitoring, and adjusting an action, measure, or project to reduce uncertainty and maximize one or more goals over time. If applied appropriately, this approach would allow for flexible operations based on best available science and new information as it becomes available. For this project, an adaptive management plan may include operational changes to the timing and magnitude of releases from Shasta Dam primarily to improve the quality and quantity of aquatic habitat. These changes could include increasing minimum flows, timing releases from Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining additional storage to meet temperature requirements to improve conditions supporting anadromous fish survival.

Water System Operations

Water operations modeling performed for this feasibility study was based primarily on operational constraints described in the 2004 OCAP BA (Reclamation) and the Coordinated Operations Agreement between Reclamation and DWR for the CVP and SWP, as ratified by Congress.

Federal planning policies were used to help estimate which future projects may or may not be implemented; projects were deliberately either included or excluded from water operations models and evaluations. Some of the projects included in the without-project condition, if not implemented, could influence the findings of this feasibility study. Also, some projects not accounted for in the models could change the findings of the feasibility study if they are implemented. Changes in Delta exports could also influence future water operations. In addition, changes in hydrology could produce conditions that are different than current water operations were designed for.

Although recent model upgrades have been made based on mandated operations changes due to species declines, drought conditions, and subsequent BOs, the SLWRI used existing modeling studies as the basis of the No-Action Alternative. These studies reflect water operations conditions described in the 2004 OCAP BA and the Coordinated Operations Agreement.

The legal challenges and changing environmental conditions result in uncertainty with regard to both current and future operations. These operational uncertainties are likely to continue, and current and future water operation conditions may be different because operational constraints governing water operations are likely to change with release of a revised USFWS and NMFS BOs. The existing SLWRI modeling analysis is being used for comparison purposes, and reflects expected variation among the comprehensive plans, including the type and relative magnitude of anticipated impacts and benefits. Because of the lingering uncertainty about future water operations, the Draft Feasibility Report and PDEIS are based on existing studies.

Modeling studies will be updated to reflect changes in water operations resulting from ongoing OCAP reconsultation and other relevant water resources projects and programs, including, potentially, BDCP/DHCCP efforts. The results of these updated studies will be incorporated into future SLWRI documents.

Implementation of the 2008 USFWS and 2009 NMFS RPAs and/or a BDCP alternative could affect the estimated benefits of SLWRI comprehensive plans. The discussion below describes the nature of potential effects.

Analysis of 2008 USFWS BO and 2009 NMFS BO Reasonable and Prudent Alternatives

Several lawsuits were filed challenging the validity of the 2008 USFWS BO and 2009 NMFS BO and Reclamation's acceptance of the RPA included with each BO (*Consolidated Salmonid Cases, Delta Smelt Consolidated Cases*). Both BOs were found to be unlawful and were remanded to the respective resource agencies, leaving significant uncertainty in future water operations of the CVP and SWP. However, these BOs and associated RPAs contain the most recent estimate of potential water operations changes that could occur in the near future. Implementation of the RPAs and potential effects on SLWRI comprehensive plans are discussed below.

If the RPAs associated with the 2008 USFWS BO and the 2009 NMFS BO were implemented, the following actions could affect water operations of the CVP and SWP and infrastructure at Shasta Dam:

- Maintenance of additional carryover storage in Shasta Reservoir for the cold-water pool, measured at the end of September and end of April
- Year-round management of Keswick Dam releases to meet temperature compliance points
- Seasonally reduced south-of-Delta (SOD) exports, December through June
- Increased Delta outflow (September through October) for salinity management
- Studies to investigate fish passage above Shasta Dam

The following discussion describes how implementation of the RPAs could affect the existing system, and how the estimated benefits of comprehensive plans could change if the RPAs were in place.

Anadromous Fish Survival Certain RPA actions and all SLWRI comprehensive plans were formulated specifically to benefit anadromous fish in the upper Sacramento River. Implementing the RPAs is anticipated to increase survival of anadromous fish in the upper Sacramento River primarily through improved water temperature regimes. If an enlarged Shasta Dam and Reservoir were constructed in combination with implementation of the RPAs, it is anticipated that the combined fisheries benefits would be greater than those attributed to the RPAs alone, through both temperature management and changes in flow regimes associated with the SLWRI comprehensive plans. However, there is significant uncertainty related to the magnitude of the combined benefits. Some SLWRI comprehensive plans also include improvements to fisheries habitat along the upper Sacramento River, and could further increase anticipated RPA fisheries benefits.

Water Supply Reliability If implemented, the RPAs are anticipated to reduce CVP and SWP water deliveries, especially SOD, due to pumping restrictions and the commitment of water to environmental purposes (e.g., temperature management and Delta outflow). All SLWRI alternative plans were formulated specifically to increase CVP and SWP water deliveries and water supply reliability. Implementing an enlarged Shasta Dam and Reservoir in combination with implementation of the RPAs would provide net water supply benefits, but because the RPAs would restrict Delta pumping, water supply benefits, especially south of the Delta, may be more limited than could be achieved without RPA implementation.

Secondary Planning Objectives Implementation of the RPAs and the comprehensive plans would affect benefits associated with the secondary planning objectives less than the primary planning objectives. Effects to hydropower as a result of RPA implementation are uncertain because the trade-off between increased head and flows through the powerhouse resulting from higher end-of-September storage is unknown. However, it is anticipated that hydropower generation would be similar for the SLWRI comprehensive plans with or without RPA implementation. As described under the primary planning objective of anadromous fish survival, ecosystem restoration along the upper Sacramento River with certain comprehensive plans could present synergistic benefits with the RPA implementation. SLWRI-related benefits for recreation, flood, water quality, and reservoir area ecosystem restoration would be similar for the SLWRI comprehensive plans with or without the RPA implementation.

Analysis of Potential BDCP Alternatives

The BDCP is being prepared collaboratively by Federal, State, and local agencies, environmental organizations, and other interested parties. The BDCP is intended as a comprehensive conservation strategy for the Delta, designed to advance the coequal planning goals of restoring ecological functions of the Delta and improving water supply reliability for large portions of the State of California. To provide support for the BDCP environmental review process, DWR formed the DHCCP in 2008 as a partnership with Reclamation.

A range of alternatives for providing species/habitat protection and improving water supply reliability as part of the BDCP are being evaluated through development of an EIS/EIR. Currently, several alternative Delta conveyance facilities are being evaluated. Among these alternatives is a through-Delta facility and an isolated facility that would convey water around the Delta for local supply and export through a hydraulically isolated channel or tunnel. Isolated facility capacities under consideration range from 3,000 cfs to 15,000 cfs.

The following discussion describes how implementation of the BDCP could affect the existing system, and how the estimated benefits of SLWRI comprehensive plans could change if a BDCP alternative was implemented.

Anadromous Fish Survival All BDCP alternatives are anticipated to improve habitat conditions in the Delta for anadromous fish species; however, effects of BDCP alternatives on habitat conditions and anadromous fish survival in the upper Sacramento River are uncertain at this time. All SLWRI comprehensive plans were formulated specifically to benefit to anadromous fish in the upper Sacramento River, with a specific focus on increasing out-migration of salmonids downstream of RBDD. Improved habitat conditions in the Delta through implementation of any BDCP alternative are anticipated to further increase the survival in the Delta of out-migrating salmonids resulting from an enlarged Shasta Dam and Reservoir included in all SLWRI comprehensive plans. However, there is significant uncertainty related to the magnitude of these benefits.

Water Supply Reliability All SLWRI comprehensive plans were formulated specifically to increase CVP and SWP water deliveries and water supply reliability. An isolated facility implemented as part of the BDCP could increase water deliveries to CVP and SWP water users south of the Delta and improve water quality for urban and agricultural water users. Implementation of an enlarged Shasta Dam and Reservoir in combination with any BDCP alternative would likely provide greater water supply benefits than implementing either proposed project independently. If an enlarged Shasta were constructed in combination with any BDCP alternative, it is anticipated that the combined water supply benefits would be greater than those attributed to the BDCP alternative alone. Modifications of Shasta Dam and Reservoir could increase system flexibility and potential use of new Delta conveyance facilities, providing for even greater water supply reliability. However, the magnitude of the combined benefits is dependent upon type and size of conveyance facilities included in BDCP alternatives.

Secondary Planning Objectives SLWRI benefits for ecosystem restoration, hydropower generation, flood damage reduction, recreation and water quality are anticipated to be similar for the SLWRI comprehensive plans whether or not BDCP is implemented.

Cost Estimates

Cost estimates developed for comprehensive plans included in this report are based on April 2010 price levels and a 100-year period of analysis. Varying uncertainties are associated with the material and unit costs used to develop the estimates. Unknowns include the price of construction materials and labor costs. In particular, the construction market has experienced extreme price volatility in the last several years. A significant market anomaly occurring from 2002 to 2009 skews the calculation of forward cost trends using short-term linear regression techniques.

Although the recent economic downturn has resulted in price decreases, it is expected that prices will continue to escalate over the long-term. While future inflation trends are difficult to predict, new market forces (e.g., higher material commodity pricing, energy costs, lack of competition) will likely continue to have significant impacts on heavy civil infrastructure construction costs for the foreseeable future. Because of uncertainty and variability among the short-term regressions, a longer view of the market is preferred. Consequently, while forward cost trends are always difficult to predict, there is some basis to believe that cost escalation is normalizing back to historical levels at approximately 3 percent per year. Future studies and coordination should be undertaken to determine an appropriate escalation factor to be used for budgetary approval.

Next Steps for the Feasibility Study

As the SLWRI progresses, Reclamation will continue to address unresolved issues and concerns, including issues related to comprehensive plan refinement, economic evaluations, Native American and cultural resources, and water rights. Additional refinement of the comprehensive plans is expected based on public and stakeholder input on the Draft Feasibility Report and PDEIS and updates to modeling studies.

Solicit Input on Draft Feasibility Report and PDEIS

Reclamation will solicit public input on the Draft Feasibility Report and Preliminary Draft EIS. Comments received during the public review period will be considered in further project development and documentation.

Comprehensive Plan Refinement

As the SLWRI progresses, Reclamation will continue to refine and evaluate comprehensive plans identified measures to respond to public comments and reflect potential changes to existing and likely future conditions. Conditions in the Sacramento River basin and Delta are complex and subject to change, as described in the following subsections.

Revised Water Operations Modeling Analysis

Formulation efforts for the comprehensive plans are based on the CVP and SWP operational conditions described in the 2004 OCAP BA (Reclamation 2004c) and the Coordinated Operations Agreement between Reclamation and DWR for the CVP and SWP, as ratified by Congress. Operations studies will be updated to reflect water operations resulting from ongoing OCAP reconsultation and other relevant water resources projects and programs, including, potentially, BDCP/DHCCP efforts. The results of these updated studies will be incorporated into future SLWRI documents.

Future studies based on updated water operations will require revising several models and related analyses to reflect potential changes for each of the project resource areas. Figure 6-1 shows the numerical modeling that will need to be performed, and the order in which the modeling will take place. Revised water operations modeling results will be used as input for reservoir and river water temperature sensitivity modeling to determine the potential impacts to fisheries, Delta water quality, CVP/SWP power operations, water supply reliability evaluations, and other potentially affected resource areas.

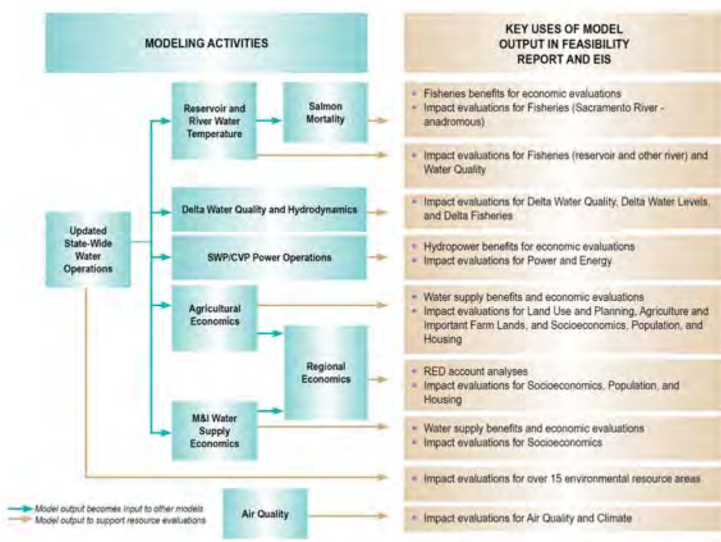

Figure 6-1. Future Modeling Analysis Process

Climate Change

As the SLWRI progresses, a quantitative climate change analysis will be performed to describe the potential effects of future climate change and revised operations on water supply, fisheries, water quality, and other resource areas. Current analysis is a qualitative regarding of the potential range of impacts California might face because of climate change (see Climate Change Projection Appendix).

Off-site Mitigation Development

Several areas around Shasta Reservoir have been identified for potential development to mitigate project-related impacts; however, specific details are not yet available about off-site opportunities to mitigate impacts on biological resources in the primary study area. Additional discussion of mitigation and associated mitigation ratios for lands around Shasta Reservoir will be developed in future SLWRI documents. Preliminary cost allowances have been prepared based on these initial investigations. As the SLWRI progresses, Reclamation anticipates developing more detailed plans and cost estimates for the specific mitigation activities and enhancement features.

Future Economic and Financial Evaluations

Future economic and financial evaluations will focus on reassessing benefits of alternative plans based on updated estimates of plan benefits, identification of a proposed plan (consistent with P&G) and the environmentally preferable alternative (consistent with NEPA), and allocation of costs to project purposes (e.g., cost allocation). As stated above, Reclamation anticipates developing more detailed plans and cost estimates for specific mitigation activities and enhancement features before finalizing project costs. Accordingly, all economic analyses will be updated. Reclamation also plans to assess the financial capability of project beneficiaries. In addition, if the California Water Commission's 2012 Water Bond measure passes, Reclamation will investigate use of bond funding for the public benefits of raising Shasta Dam and Reservoir.

Non-Federal Sponsor

If authorized for construction, the proposed plan would require a portion of its costs to be reimbursed by a non-Federal sponsor(s). Reimbursable costs include the following: irrigation water supply, M&I water supply, fish and wildlife enhancements outside the Whiskeytown-Shasta-Trinity NRA, and hydropower. To date, interest has been strong in potential SLWRI project implementation to address the identified planning objectives.

Continued Coordination and Evaluations

As the SLWRI progresses, Reclamation will continue to coordinate with stakeholders and other agencies to address and resolve issues related to Native American and cultural resources, water rights, ongoing biological investigations, and relevant projects and programs.

- Reclamation will continue to engage Federally recognized tribal governments and Native American tribal groups in planning and developing the SLWRI. The Draft Feasibility Report and accompanying PDEIS are consistent with the National Historic Preservation Act and Section 106, and describe supporting cultural resources analyses, studies, coordination, impacts, and mitigation, as appropriate.

- Reclamation may need to petition the SWRCB for a new or amended water rights permit. To issue a permit, the SWRCB must find that unappropriated water is available to supply the applicant, and that the applicant's appropriation is in the public interest. Evaluation of water rights will remain a focus of the SLWRI.

- To date, species-specific survey efforts as part of the SLWRI have included focused investigations for a number of special-status species in the inundation and relocation areas. Additional surveys and analysis to refine effects on biological resources within the study area are anticipated before completion of the SLWRI feasibility study.

- Reclamation will continue to coordinate SLWRI activities with other relevant ongoing projects and programs, including BDCP and the RPAs in the OCAP reconsultation process. It is anticipated that the final RPAs will include actions such as fish passage and operational changes at Shasta Dam that would affect or be affected by the SLWRI comprehensive plans.

Selection of Proposed Plan/Preferred Alternative

At this stage of the Federal planning and NEPA processes, the potential effects of alternative plans have been evaluated and compared based on established criteria, and an 18.5-foot raise of Shasta Dam has been identified as the preliminary proposed plan. However, due to uncertainties affecting CVP/SWP operational constraints, operational parameters of the preliminary propose plan have not been specified. At this stage in the planning process, neither a preferred alternative nor an environmentally preferable alternative have been identified in the Preliminary Draft EIS. It is recognized that further refinement and changes may occur to the comprehensive plans after additional operational analyses considering changes in CVP/SWP operational conditions, and input from agencies, stakeholders, and public.

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Chapter 7
Cost Allocation and Ability to Pay

This chapter includes a brief description of cost allocation terminology and methods, and a preliminary cost allocation and apportionment using CP4 as an example. CP4 was selected for this preliminary cost allocation and apportionment because at this stage in the SLWRI, CP4 appears to be the most economically feasible of the Comprehensive Plans.

General Description and Terms

Allocation of Federal water resources project costs is made to derive an equitable distribution of costs among the authorized project purposes, or those purposes proposed for authorization, in accordance with existing law. This preliminary analysis provides an initial indication of the cost implications of constructing the project for each authorized purpose. It does not represent a detailed assessment of the economic effects of costs being borne by different Federal and non-Federal entities, and it does not identify potential non-Federal sponsor(s).

Basic steps associated with cost allocation and apportionment are as follows:

- Identify costs to be allocated
- Allocate costs to project purposes
- Apportion costs to beneficiaries

Costs to Be Allocated

Total Project costs to be allocated include construction costs, IDC, and annual operation, maintenance, and replacement costs.

- **Construction costs –** Construction costs include the cost to implement all elements of the project necessary to achieve the anticipated benefits.
- **Interest during construction –** IDC accounts for the financial cost of project expenditures during the period between when construction begins and benefits are derived. IDC was calculated for the alternatives evaluated in this chapter based on a 4-year construction period.
- **Annual operation, maintenance, and replacement costs –** O&M and replacement costs are the costs required to assure continued benefits over the life of the project.

It should be noted that cost allocation is a financial exercise rather than an economic evaluation. Consequently, project costs may be presented differently in a cost allocation than in an economic analysis.

Allocating Costs to Project Purposes

Once all project costs have been identified, they are allocated to the project purposes. Specific costs are costs that serve only one project purpose. Separable costs are the costs of the portion of multi-purpose facilities due to the inclusion of the purpose in question (e.g. higher dam embankment due to flood control purpose). Separable costs include specific costs and may include a portion of joint costs. They are estimated as the reduction in financial costs that would result if a purpose were excluded from an alternative. Remaining joint costs are the costs remaining after specific and separable costs have been removed.

Methods for allocating joint costs generally fall into one of two categories: those that consider benefits, and those that do not. Methods that do not consider benefits may divide joint costs between beneficiaries equally, or based on their share of separable costs. Methods that are based on benefits divide joint costs among beneficiaries proportional to the benefits each receives. The separable costs-remaining benefits (SCRB) method allocates costs among beneficiaries proportional to the benefits remaining after separable costs are removed. Benefits are derived in the economic analysis. Other methods for allocating joint costs based on benefits include the alternative justifiable expenditure method, and the share of total benefits method.

Apportioning Costs to Beneficiaries

The cost allocation process is designed so that costs associated with project purposes can be apportioned to beneficiaries for repayment. Once costs are allocated to the appropriate purposes, they can be apportioned to the Federal Government and non-Federal sponsor(s) based on specific project authorization and/or established Federal cost-sharing laws and regulations.

Federal costs are designated as either reimbursable or nonreimbursable. Reimbursable costs are those that, through some form of up-front cost sharing, repayment, or other financial agreement, are repaid to the Government. Non-reimbursable costs are those borne entirely by the Federal Government. Based on existing legislation, costs allocated to irrigation and M&I water supply, fish and wildlife enhancement, and hydropower purposes are either fully or partly reimbursable by project beneficiaries. Table 7-1 summarizes existing legislation that provides cost-sharing relationships for purposes that may be included in the SLWRI.

Table 7-1. Existing Authorities for Federal Financial Participation in Multipurpose Water Resources Projects

Purpose	Pertinent Legislation	Description
Irrigation Water Supply	Reclamation Act of 1902, as amended	Reimbursable. This act provides for up-front Federal financing of irrigation water supply purposes, with 100% repayment of capital costs and O&M costs by non-Federal project sponsor.
M&I Water Supply	Reclamation Act of 1939, as amended	Reimbursable. This act provides for up-front Federal financing of M&I water supply purposes, with 100% repayment of capital costs (including IDC and interest over the repayment period); 100% of O&M costs are non-Federal.
Hydropower	Reclamation Act of 1906, as amended	Reimbursable. Similar to M&I Water Supply.
Fish and Wildlife Enhancement	Federal Water Project Recreation Act of 1965 (Public Law 89-72), as amended	Nonreimbursable; 100% Federal cost-sharing of all fish and wildlife enhancement areas or facilities within the Whiskeytown-Shasta-Trinity NRA.
	Federal Water Project Recreation Act of 1965 (Public Law 89-72), as amended	Public Law 89-72 provides Federal nonreimbursable share of 75% and non-Federal share of 25% for fish and wildlife enhancements outside of the NRA, including planning, design, and IDC. In addition, 50% of the annual O&M and replacement costs would be a non-Federal responsibility.
Recreation	Whiskeytown-Shasta-Trinity National Recreation Area (Public Law 89-336)	Provides authority for Federal development of recreation facilities in Whiskeytown-Shasta-Trinity NRA.
Flood Control	Flood Control Act of 1939	Authorized the transfer of ownership of the local and state dams to the United States Army Corps of Engineers

Key:
IDC = interest during construction
M&I = municipal and industrial
NRA = National Recreation Area
O&M = operation and maintenance

Potential Cost Allocation Methods

The method of cost allocation used must be consistent with the purposes of the proposed project. For the SLWRI, the proposed project purposes will need to be consistent with those for the existing project features and modified, as appropriate, for potential added purposes. For this cost allocation, project purposes for which costs are to be allocated include: irrigation water supply, M&I water supply, fish and wildlife enhancement, and hydropower. Cost allocation considerations for fish and wildlife enhancement, flood control, and recreation are described below.

The majority of fish and wildlife enhancements for the SLWRI are related to supporting the survival of the anadromous fishery along the upper Sacramento River, with multiple fish species Federally listed as threatened and endangered.

Improving anadromous fish resources along the Sacramento River is viewed as having a national significance. Authorization for fish and wildlife enhancements is provided by Public Law 89-72, which specifies financial and O&M participation by a non-Federal sponsor unless the "project areas or facilities [are] authorized by law for inclusion within a national recreation area." Therefore, SLWRI fish and wildlife enhancements within the Whiskeytown-Shasta-Trinity National Recreation Area (NRA), which includes Shasta Dam and Reservoir, would not be subject to non-Federal cost-sharing requirements. However, fish and wildlife enhancements outside of the NRA would be subject to cost-sharing requirements as indicated in Table 7-1.

For this cost allocation analysis, no costs are allocated to the flood control project purpose. It is expected that any enlargement of Shasta Reservoir would maintain flood control at a similar or slightly greater level. Due to this fact, benefits for flood control were not quantified, and costs were not allocated to the flood control project purpose.

Normally, for projects within the CVP, recreation would be accomplished under Public Law 89-72 with financial and O&M participation by a non-Federal sponsor. Recreation is not an identified purpose of the SLWRI. However, recreation is included as an important element of the Whiskeytown-Shasta-Trinity National Recreation Act, which was authorized by Public Law 89-336. Under this authorization, the Secretary of the Interior, operating through USFS, has the ability to manage lands and implement facilities to improve recreational use of the lands. Any recreation component of a potential plan will be considered for implementation under Public Law 89-336.

The preferred method to allocate joint costs to project purposes is the SCRB method. This requires calculation of the cost of alternative projects with each of the project purposes removed. Numerous methods exist that potentially could be used to subsequently apportion costs to Federal and non-Federal project beneficiaries. Such methods are discussed below for each of the identified project purposes.

Preliminary Cost Allocation

The following provides an example of how the cost of CP4 might be allocated to project purposes. The SCRB analysis shown below was performed based on information developed to date, and will be further refined in future evaluations. These evaluations will be included in the Final Feasibility Report. The allocation of costs to planning objectives will be more fully developed in further studies.

Alternative Single-Purpose Project Costs

Single-purpose project alternative cost is the cost of the most probable alternative providing the same level of benefit as the multi-purpose project. The single-purpose project cost is used to determine the limiting factor between project purpose benefits and alternative single-purpose project costs. Preliminary estimates of costs for single-purpose alternatives are shown in Table 7-2.

- **Irrigation Water Supply –** This alternative would amount to an increase in the total storage capacity of Shasta Reservoir of about 153,900 acre-feet. This would be sufficient to increase the weighted average annual yield to the CVP/SWP to about 27,900 acre-feet.
- **M&I Water Supply –** This alternative would consist of an increase in the total storage capacity of Shasta Reservoir of about 102,100 acre-feet. This would be sufficient to allow for the CVP/SWP to increase its average annual yield (weighted average) by about 18,500 acre-feet.
- **Fish and Wildlife Enhancement –** This alternative would consist of increasing the total storage space in Shasta Reservoir by about 634,000 acre-feet. This would allow for increasing the cold-water pool in the reservoir consistent to provide an increase in the average annual numbers of salmon in the upper Sacramento River by about 1.2 million juveniles.
- **Hydropower –** This alternative would likely include either further modifications to hydropower generation facilities at Shasta Dam or equivalent generation capacity to achieve an increase of 138 GWh per year.

Separable Costs

Separable costs of each project purpose are the difference between the cost of the multipurpose project and the cost of a project with the purpose omitted. The separable costs shown in Table 7-3 will be subtracted from the specific project purpose benefit to determine the remaining benefit in the SCRB cost allocation process. Following is a summary of each separable cost with the project purpose omitted.

Without Irrigation Water Supply Without irrigation water supply, an alternative would need to be at least large enough to provide for increased fish benefits and for an increase in M&I water supply benefits. This project would likely need some adjustment for increased modifications to provide all of the hydropower benefits of CP4.

Table 7-2. Summary of Costs of Single-Purpose Alternatives[1] ($ millions)

Item	Irrigation Water Supply	M&I Water Supply	Fish and Wildlife Enhancement	Hydropower
Alternative	Enlarge Shasta	Enlarge Shasta	Enlarge Shasta	Substitute Generation
Capacity	153,900 AF	102,100 AF	634,000 AF	138 GWh
Capital Cost				
Construction Cost	$497	$330	$1070	0
IDC	$43	$28	$78	0
Total Investment	$540	$358	$1148	0
Annual Cost[3]				
Interest & Amortization	$22.7	$15.0	$48.2	0.0
O&M[2]	$1.1	$3.8	$1.5	7.7
Total	$23.8	$18.8	$49.7	7.7

Notes:
[1] April 2010 price level and 4-1/8 percent interest rate.
[2] In future analyses, costs will be allocated to gravel augmentation, riparian, floodplain, and side channel habitat restoration, and water use efficiency.
[3] 100-year period of analysis
Key:
AF = acre-feet
GWh = gigawatt-hours
IDC = interest during construction
M&I = municipal and industrial
O&M = operation and maintenance

Table 7-3. Summary of Separable and Joint Costs Using CP4 as an Example[12] ($ millions)

Item	Separable Costs					Joint Cost	Total Cost
	Irrigation Water Supply	M&I Water Supply	Fish and Wildlife Enhancement	Hydro-power	Total		
Capital Cost							
Construction Cost	94.6	62.7	242.7	0.0	400.1	669.9	1070.0
IDC	8.1	5.4	20.8	0.0	34.2	57.3	91.5
Total	102.7	68.1	263.5	0.0	434.3	727.2	1161.5
Annual Cost							
I&A	4.3	2.9	11.1	0.0	18.2	30.5	48.8
O&M[3]	0.5	3.4	0.3	0.0	4.3	1.0	5.2
Total	4.8	6.2	11.4	0.0	22.5	31.5	54.0

Notes:
[1] April 2010 price level and 4-1/8 percent interest rate.
[2] All numbers are rounded for display purposes, and therefore line items may not sum to totals.
[3] In future analyses, costs will be allocated to gravel augmentation, riparian, floodplain, and side channel habitat restoration, and water use efficiency.
Key:
I&A = interest and amortization
IDC = interest during construction
M&I = municipal and industrial
O&M = operation and maintenance

Without M&I Water Supply Similar to above, without M&I water supply, the alternative would need to be at least large enough to provide for increased fish benefits and the increase in irrigation water supply benefits. This project would likely need some adjustment for increased modifications to provide all of the hydropower benefits of CP4.

Without Hydropower Without hydropower, the alternative would need to provide all the benefits of CP4, since the size of the dam raise is not dependent on the power component. Accordingly, the overall size and cost of this alternative would be the same as CP4.

Without Fish and Wildlife Without fish and wildlife, an alternative would need to be at least large enough to provide for increased agricultural water supply and increased M&I water supply benefits. This project would likely need some adjustment for increased modifications to provide all of the hydropower benefits of CP4.

Joint Costs

The joint cost is the cost of facilities that serve two or more project purposes. This cost is the difference between the cost of the multipurpose project and the sum of the separable costs. The joint cost is allocated to each purpose based on remaining benefits, which are the lesser of benefits or single-purpose alternative costs minus the total separable cost. As shown in Table 7-3, the joint construction and annual costs are estimated at $669.9 million and $31.5 million, respectively. Table 7-3 shows the total capital cost, which is then amortized over a 100-year period to develop the annual cost.

Allocated Costs

The SCRB method allocates costs among beneficiaries proportional to the benefits remaining after separable costs are removed. Table 7-4 shows a preliminary estimate of the assignment of costs using CP4 as an example. As shown in Table 7-4, the assignment of construction costs is divided among the four study objectives for which costs are allocated, for a total of about $1,070 million. Determination of the construction cost allocation is an essential part of the multipurpose planning process where cost-sharing will be required. It provides the Federal Government with information needed to determine the magnitude and share of estimated project construction costs that are reimbursable. Cost allocation information is essential to the tests of financial feasibility and plan acceptability. During subsequent planning and construction, it provides the information required for allocating actual expenditures consistent with the plan formulation and allocation principles.

Table 7-4. Preliminary Cost Allocation Using CP4 as an Example ($ millions)[1 2 3]

	Item/ Calculation	Irrigation Water Supply	M&I Water Supply	Fish and Wildlife Enhancement	Hydro-power	Total
		A	B	C	D	E
Allocated Total Annual Costs						
1	Average Annual Benefits	8.3	18.7	49.2	7.7	83.9
2	Single-Purpose Projects	23.8	18.8	49.7	7.7	-
3	Justifiable Expenditure (Lessor of Benefits/Single Purpose Alt Costs)	8.3	18.7	49.2	7.7	83.9
4	Separable Annual Costs	4.8	6.2	11.4	0.0	22.5
5	Remaining Benefits/Justifiable Expenditure (3) - (4)	3.5	12.5	37.8	7.7	61.4
6	% Remaining Benefits (A5 to D5) ÷ (E5)	5.7%	20.3%	61.5%	12.5%	100.0%
7	Allocated Joint Cost (A6 to D6) x (E7)	1.8	6.4	19.4	3.9	31.5
8	Total Allocated Costs (4) + (7)	6.6	12.6	30.8	3.9	54.0
Allocated O&M Annual Costs[4]						
9	Separable O&M Cost	0.5	3.4	0.3	0.0	4.3
10	Allocated Remaining Joint Cost (A6 to D6) x (E10)	0.1	0.2	0.6	0.1	1.0
11	Total O&M Allocated (9) + (10)	0.6	3.6	0.9	0.1	5.2
Allocation of Capital Cost						
12	Annual Capital Cost (8) – (11)	6.0	9.1	29.8	3.8	48.8
13	% Annual Capital Cost (A12 to D12) ÷ (E12)	12.4%	18.6%	61.2%	7.9%	100.0%
14	Allocated Capital Cost (A13 to D13) x (E14)	143.8	215.6	710.9	91.2	1,161.5
Allocated Construction Costs						
15	Allocated IDC [(A15 to D15) ÷ (E15)] x (E14)	11.3	17.0	56.0	7.2	91.5
16	Construction Cost (14) – (15)	132.5	198.6	654.9	84.0	1,069.9
17	% of Total Construction Cost (A16 to D16) ÷ (E16)	12.4%	18.6%	61.2%	7.9%	100.0%

Note:
[1] April 2010 price level, 4 1/8 percent interest rate, and 100-year period of analysis.
[2] All numbers are rounded for display purposes, and therefore line items may not sum to totals.
[3] Subject to refinement/change during remainder of feasibility study.
[4] In future analyses, costs will be allocated to gravel augmentation, riparian, floodplain, and side channel habitat restoration, and water use efficiency.
Key:
IDC = interest during construction
M&I = municipal and industrial
O&M = operation and maintenance

Table 7-4 displays a step-by-step process for determining the construction cost to be allocated to each project purpose. The construction cost allocated to each project purpose is the total annual cost with O&M costs and interest during construction (IDC) removed.

Annual Cost – O&M Cost – IDC Cost = Construction Cost

The total annual cost calculation subtracts the separable costs (calculated in Table 7-3) from the annual benefits of each project purpose. The resulting allocated joint cost is based on the percentage of the remaining benefits each project purpose comprises. The total allocated costs are the sum of the separable annual costs and the allocated joint remaining costs.

O&M costs are then subtracted from the total cost to determine the capital cost allocated to each project purpose. A similar approach for developing the O&M costs was used to subtract the separable costs and allocate the remaining O&M joint costs based on the percentage of the remaining O&M costs. Subtracting the O&M costs from the annual costs leaves the capital costs to be allocated to each project purpose.

Finally, IDC is subtracted to determine the construction cost allocated to each project purpose. The IDC is calculated as the percentage of the total capital cost multiplied by the total IDC. Subtracting IDC from the capital cost leaves the construction cost allocated to each project purpose.

Cost Assignment

Table 7-5 shows an estimate of the assignment of costs using CP4 as an example. The assignment percentages are based on those included in Table 7-4. As can be seen, the assignment of costs includes costs to accomplish the four planning objectives. These costs amount to $1,070.0 million. Also shown in Table 7-5, of the costs allocated to achieving CP4, approximately 61 percent are estimated to be a Federal responsibility and about 39 percent a non-Federal responsibility.

Table 7-5. Preliminary Cost Assignment Using CP4 as an Example[1 2] ($ millions)

Purpose/Action	Total		Cost Apportionment			
			Federal		Non-Federal	
	Percent	Cost	Percent	Cost	Percent	Cost
Study Objectives						
Irrigation Water Supply	12.4%	$132.5	0%	$0.0	100%	$132.5
M&I Water Supply	18.6%	$198.6	0%	$0.0	100%	$198.6
Fish & Wildlife Enhancement	61.2%	$654.9	100%	$654.9	0%	$0.0
Hydropower	7.9%	$84.0	0%	$0.0	100%	$84.0
Total	100.0%	$1069.9	61.2%	$100.0	38.8%	$100.0

Notes:
[1] All numbers are rounded for display purposes, and therefore line items may not sum to totals.
[2] Subject to refinement/change during remainder of feasibility study. Updated information on a Recommended Plan will be provided in Final Feasibility Report.
Key:
M&I = municipal and industrial

Future Financial Analyses

Financial feasibility analyses for any proposed modification of the Shasta Project facilities is required to evaluate the ability of project beneficiaries to repay their portion of the allocated project costs in accordance with Reclamation standards, policy, and pertinent Federal law. Section 9(a) of the Reclamation Project Act of 1939 states that (1) the ability to repay the part of the estimated cost that can be properly allocated to irrigation water supply, municipal and industrial (M&I) water supply, power, or other miscellaneous project purposes must be evaluated, (2) that it must be evaluated before a project can be approved, and (3) that if the beneficiaries cannot repay the project costs, an act of Congress is required to move forward with the project. In accordance with this requirement, an initial approach to estimate financial feasibility for irrigation water supply, M&I water supply, and hydropower has been developed and is provided below. Based on costs allocated to various project purposes, assessments of the financial capability of project beneficiaries will be refined and presented in the Final Feasibility Report.

Initial Repayment studies have been conducted to determine if (1) beneficiaries are able to pay reimbursable costs for project outputs over the project's repayment period, (2) sufficient capital is authorized and available to finance construction to completion, and (3) estimated revenues are sufficient to cover allocated costs over the repayment period. Table 7-4 shows the allocation of construction costs, including interest during construction (IDC), and annual allocated operation and maintenance (O&M) costs to the authorized project purposes of the CVP. The cost allocated to each project purpose was used to calculate the ability of the beneficiaries to pay.

Irrigation Water Supply Financial Feasibility

Costs allocated to the irrigation water supply purpose using CP4 as an example are estimated to be $143.8 million, as shown in Table 7-4. Two scenarios of financial feasibility for irrigation water supplies were evaluated. The first scenario is based on the assumption that the increment of agricultural water supply from CP4 is fully integrated into the CVP to meet existing contracts, with a 40-year repayment for construction costs. The second scenario assumes the increment of water associated with CP4 would require new contracts. The new contractors would pay the incremental cost of the dam enlargement over a 40-year period. The second scenario would require legislative action. The CVP Irrigation Ratesetting Policy established in 1988 is used to recover O&M costs and provide repayment of construction costs through water service contracts.

Financial feasibility is determined by comparing the CVP contractors' ability to pay with the annualized repayment of construction costs and recovery of O&M costs. Of the 250 CVP contractors, 4 representative CVP agricultural water contractors were selected to represent all contractors' ability to repay the allocated costs. Contractor payment capacities were computed using existing enterprise farm budgets from previous economic projects, indexed to 2010 dollars. Contractor financial statements were averaged over the previous 5 years to compute each district's O&M costs. Water costs (O&M, repayment of construction, and current CVPIA restoration charges) were multiplied by 5-year average deliveries to compute the cost of water. The contractors' ability to pay per acre-foot is computed and presented in Table 7-6 below.

Table 7-6. Ability to Pay Results for Four Representative Contractors

	San Joaquin	Sacramento River	South of Delta	Northern Sacramento
Ability to Pay ($/acre-foot)	7.50	324.55	150.59	97.40

Key: Delta = Sacramento-San Joaquin Delta

An increase in the annual cost of irrigation water of $3.9 million was allocated to CVP irrigation contractors. To derive the increase in the cost of water using Scenario 1, the $3.9 million in additional annual costs is divided by the 5-year average of annual water deliveries, 2.2 million acre-feet. This results in a marginal increase of $1.77 per acre-foot. The marginal increase would fall within the ability to pay for each of the four representative contractors.

For Scenario 2, financial feasibility was also determined by comparing the new partner/contractor's ability to pay the annualized construction costs and O&M. At present, specific non-Federal project sponsors/contractors have not been identified. If new contracts were identified, the costs would be spread over an average annual increase of 27,900 acre-feet. Assuming the same 40-year repayment period, the cost per acre-foot is estimated at $140. Specific analysis for any project sponsor/contractor would be required before a determination of financial feasibility could be considered complete.

Of the 250 CVP contractors, about 40 irrigation contractors have their water rates reduced by the Restoration charge and the amount charged for construction costs because it has been determined that the district is unable to pay these charges. Of these contractors, some are able to pay a portion of the costs while a majority do not have the ability to pay their allocated O&M costs, and are considered operating on a willing-to-pay basis. These few contractors would not have the ability to pay the additional costs resulting from the potential implementation of the example plan used (CP4). Aid to irrigation for these contractors is reviewed every 5 years, and recent studies indicate that CVP contractors' ability to pay current costs has significantly improved. However, it is likely that a number of contractors will operate on a willing-to-pay basis.

Municipal and Industrial Water Supply Financial Feasibility

The costs allocated to the M&I water service purpose from the example preliminary proposed plan are estimated to be $215.6 million, as shown in Table 7-4. The same two scenarios used for irrigation financial feasibility were used for M&I.

Current water rates were used as an estimate of the M&I contractor's ability to pay for additional water. It is assumed that a small change in the water rate will have little effect on a district's ability-to-pay. The M&I water rates for CVP contractors range from $15 – $61 per acre-foot (Reclamation 2011d); the M&I water rates for SWP contractors range from about $37 – $1,102 per acre-foot (DWR 2008). In evaluating Scenario 1, annual allocated costs to M&I are approximately $18.1 million, including interest on any unpaid balances. If these costs are spread over the average 5-year M&I deliveries of 335,217 acre-feet (Reclamation 2011d), plus the additional water supply reliability, 18,500 acre-feet, the marginal impact would be $51 per acre-foot.

Under Scenario 2, it is assumed that the costs of the project would be repaid separately from existing CVP costs. To determine the cost of water supply reliability, the total annual costs allocated to M&I water contractors are divided by the estimated average annual yield increase ($18.1 million/18,500 acre-feet), which equals $978 per acre-foot. This is well above the current water rates for CVP contractors and all but two SWP contractors. At this stage of analysis, applying the second repayment scenario is problematic because it results in a large increase in the rate for M&I water supply reliability relative to the existing rate. This large increase results in an inability to determine the M&I contractors' ability to pay.

During future analyses, other models and repayment scenarios may be used to refine the estimate of the value of water to the M&I contractor, to refine the estimate the M&I contractors' willingness-to-pay, or to identify the least-cost alternative water supply for the proposed plan, once selected.

Hydropower Financial Feasibility

Hydropower generated through CVP facilities is marketed by Western Area Power Administration (Western). Western's annual revenue requirements from generation are approximately $105 million annually. Rates are set to generate sufficient revenues to meet this requirement. Allocated annual costs for the example preliminary proposed plan are approximately $4.8 million, which is less than a 5 percent increase in revenue requirement. During the last several years, the rate that Western charges for electricity has exceeded market rates for short periods of time. Increases in rates during these periods would not be beneficial to contractors purchasing electricity. In general, it is expected that a 5 percent increase in rates would be supportable by those that purchase power from Western.

Chapter 8
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