CHAPTER VII
CONCEPT PLANS

A set of concept plans was formulated from the retained resources management measures presented in **Chapter VI**. Because there is a vast array of potential measure combinations and sizes, the strategy was not to develop an exhaustive list of concepts or to optimize concept outputs. Rather, the purpose of this phase of the formulation process was (1) to explore an array of different strategies to address the primary planning objectives, constraints, and criteria, and (2) to identify concepts that may warrant further development into initial alternatives and then detailed alternative plans. These concepts are intended to promote discussion and provide a background for the formulation of initial alternatives and alternative plans in the remainder of the feasibility study, with input from participating agencies, stakeholders, and the public.

The formulation strategy for the concepts was to develop an array of plans representative of the range of potential actions to address objectives of the SLWRI. First, two sets of concepts were developed that focus on a single primary planning objective: either anadromous fish survival (AFS) or water supply reliability (WSR). Although the AFS and WSR concepts focus on single planning objectives, each contributes somewhat to both primary planning objectives. In the three AFS concepts, for example, emphasis was placed on the combinations of measures that could best address the fish survival goals while also considering WSR. Second, a set of concepts was developed that includes a mixture of measures to address both primary and secondary objectives, termed combined objective (CO) concepts.

This chapter is organized into five sections, beginning with a discussion of the Federal No-Action plan followed by a section with overview of the measures contained in the concepts, including a discussion of features that are common to some or all of the concepts. The AFS, WSR, and CO concepts then are discussed individually in the remaining three sections.

NO-ACTION (NO FEDERAL ACTION)

Under the No-Action plan, the Federal Government would take no action toward implementing a specific plan to help increase anadromous fish survival in the upper Sacramento River, nor help address the growing water reliability issues in California. The following discussions highlight the consequences of implementing the No-Action plan, as they relate to the objectives of the SLWRI.

Anadromous Fish Survival

Much has been done, especially over the last decade, 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 gravels to the Sacramento River and work to improve or restore spawning habitat on tributary streams. However, some of these actions have been conflicting. These include implementing requirements of the Trinity River December 2000 ROD, which will reduce 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,

when elements of the Trinity ROD are fully implemented, some of the benefits derived from flow changes and the Shasta TCD will be offset by the reduction in the cooler water from the Trinity River. Over time, especially with increasing needs for additional water supplies, the need will continue for helping to ensure long-term and sustained improvements in anadromous fish populations in the upper Sacramento River.

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. As the population of the Central Valley increases, along with the need to maintain a healthy and vibrant industrial and agricultural economy, the demand for adequate and reliable water supplies will become more acute. Competition for available water supplies will intensify as water demands increase to support M&I, and associated urban growth relative to agricultural uses. It is estimated that the demand for water in the future will significantly exceed available supplies. In drought years in the Sacramento River and San Joaquin River basins, estimated shortages would be about 1.7 MAF by 2020 and 2.6 MAF by 2040. Statewide, during drought years, shortages in reliable supplies could reach about 10 MAF by 2040. Water conservation and reuse efforts are increasing and forced conservation resulting from increasing shortages will continue. Without developing cost-efficient new sources, however, more reliance will be placed on shifting uses from such areas as agricultural production to urban uses. It is likely that with continued and deepening shortages in available water supplies, increasing adverse economic impacts will occur over time in the Central Valley and elsewhere in California.

Environmental Restoration, Flood Control, and Hydropower

Numerous opportunities exist to contribute to restoring ecosystem values in and around Shasta Lake and along the upper Sacramento River that would not be pursued under the No-Action plan. Opportunities exist in Shasta Lake and along the major tributary waterways to benefit resident warm and cold water fisheries. Downstream from Keswick Dam, numerous needs exist to help restore riparian, wetland, and riverine habitats, which support many individual plant and animal species. The quantity, quality, diversity, and connectivity of these habitats along the Sacramento River have been limited by the confinement of the river system by levees, reclamation of adjacent lands for farming, bank protection, channel stabilization, and land development. Conservation efforts, primarily through various State of California and local programs, will continue. However, many of these unmet opportunities and needs will continue in the future.

Shasta Dam and Reservoir have greatly reduced flooding along the Sacramento River. Shasta has paid for itself many times over compared to the amount of flood damages it has prevented. However, residual risks to human life, health, and safety 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 system was designed for can occur and result in extensive flooding along the upper Sacramento River. Any increase of storage space in Shasta Reservoir can help reduce downstream flood flows. Opportunities exist to better manage the flood control system especially with nonstructural actions on tributaries to the Sacramento River between Keswick and Bend Bridge. Under the No-Action plan, these problems would continue. Also, over the next 10 years, California's peak demand for electricity is expected to increase by over 30

percent. Under the No-Action plan, no new hydropower facilities would be constructed to help meet this growing demand.

OVERVIEW OF CONCEPT FEATURES

This section describes various measures or features that are common to all or many of the concepts. Specifically, it summarizes physical features common to the three dam raise scenarios, measures that are common to all of the concepts, and reservoir operation assumptions. The concepts and their unique features are discussed individually in the remaining sections of this chapter. **Table VII-1** summarizes how the retained measures were combined to form concepts that focus on anadromous fish, water supply reliability, or combined objectives.

TABLE VII-1
SUMMARY OF CONCEPT PLAN FEATURES

	Features (Measures Retained)													
		Primary Objective Focus							Secondary Objectives Addressed					
		Water Supply Reliability			Anadromous Fish Survival				Environmental Restoration			Flood Control & Hydropower		
	Raise Shasta Dam (feet)	Increase Conservation Space	Perform Conjunctive Water Management	Reoperate Shasta Dam	Modify TCD	Restore Spawning Habitat	Enlarge Shasta Lake Cold Water Pool	Increase Minimum Flows	Restore Shoreline Aquatic Habitat	Restore Tributary Aquatic Habitat	Restore Riparian Habitat	Modify Flood Control Operations	Modify Hydropower Facilities	
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 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 evaluated in future studies.		
AFS-2	6.5	*					*	X						
AFS-3	6.5	*				X	*	X						
WSR-1	6.5	X					*							
WSR-2	18.5	X					*							
WSR-3	200	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			

Key:
AFS – anadromous fish survival CO – combined objectives TCD – temperature control device WSR – water supply reliability
X – Primary focus of concept * Coincidental benefit, although not a primary focus of the concept[1]

Note:
[1]Raising Shasta Dam provides both water supply and temperature benefits, regardless of the how the additional storage is exercised. While the AFS measures focus 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.

Common Physical Features

Many of the concepts 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.

Construction Features of Shasta Dam Enlargement

Each of the concepts includes enlarging Shasta Dam and Reservoir by 6.5 feet, 18.5 feet, or 200 feet. **Table VII-2** summarizes the various physical features, construction components, and modifications associated with the three dam raises.

TABLE VII-2
PHYSICAL FEATURES OF DAM RAISE SCENARIOS

Item	*Existing*	6.5-Foot Raise	18.5-Foot Raise	200-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 (ft)	*1,077.5*	1,084.0	1,096.0	1,280.0
Height Above Stream Bed (ft)	*487*	493.5	505.5	689.5
Dam Crest Length (ft)	*3,460*	3,660	3,770	4,930
Dam Crest Width (ft)	*30*	30	30	30
Shasta Lake				
Elevation Change				
Increase in Gross Pool (ft)	-	8.5	20.5	204.5
Elevation of Gross Pool (ft)	*1,067.0*	1,075.5	1,087.5	1,271.5
Elevation Min Operating Pool (ft)	*840*	840	840	840
Capacity (1,000 acre-feet)				
Capacity Increase	-	290	636	9,338
Total at Gross Pool[1]	*4,552*	4,842	5,188	13,890
Min Operating Pool	*590*	590 / 880[2]	590	590
Surface Area Increase (acres)	-	1,060	2,500	31,200
Shoreline Length (miles)	*408*	395	398	540
Reservoir Dikes	*None*	2 Minor Dikes	3 Minor Dikes	4 Major Dikes
Spillway & Outlet Works				
Spillway Crest Elevation (ft)	*1,037*	1,048	1,060	1,244
Top of Gates Elevation (ft)	*1,065*	1,075.5	1,087.5	1,271.5
Number & Type of Gates	*3 Drum Gates*	6 Radial Gates	6 Radial Gates	6 Radial Gates
	28-ft x 110-ft	27.5-ft x 55-ft	27.5-ft x 55-ft	27.5-ft x 55-ft
Total Outlet Capacity (cfs)	*81,800*	88,000	92,100	133,600
Hydropower Features				
Penstocks	*5- to 15-ft diameter*	Strengthen Supports	Strengthen Supports	Replace Gates & Structural Supports
Powerplant	*578 MW*	No Major Modification	No Major Modification	Add Units
Switchyard	-	No Change	No Change	Replace
Keswick Dam and Powerplant	-	No Change	No Change	Modification Required
Temperature Control Device	*Shutter Structure*	Raise/Modify Controls	Raise/Modify Controls	Replace Structure

Key:
cfs – cubic feet per second ft – feet min – minimum MW – megawatt UPRR – Union Pacific Railroad
All elevations in feet above mean sea level

Notes:
[1]Increase in gross 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.
[2]Concept AFS-1 includes increasing the minimum operating pool to 880,000 acre-feet. All other plans assume existing minimum operating pool of 590,000 acre-feet.

Reservoir Area Relocations and Other Impacts

Table VII-3 summarizes relocations and other reservoir area impacts associated with the three dam raises included in the concepts. These impacts would generally be the same for any alternative that included one of the three raises listed.

TABLE VII-3
RESERVOIR AREA IMPACTS ASSOCIATED WITH DAM RAISE OPTIONS

Item	6.5-Foot Raise	18.5-Foot Raise	200-Foot Raise
Pit River Bridge	Minor skirting around Piers 3 and 4	Skirting around Piers 3 and 4	Relocate
Other Bridges[1]	Replace 7 bridges	Replace 7 bridges	Replace 20 bridges
Recreation Facilities	Minor	Moderate	Impact all
Structures	45	130	630
Roads	About 75 small segments (45 paved and 30 unpaved) of existing roads impacted, including portions of Lakeshore Drive, Gilman and Ferder Ferry Roads, Bully Hill Road, and Silverton Road	About 115 segments of existing paved / nonpaved roads impacted; embankments would be constructed for protection of I-5 at Lakeshore and the UPRR at Bridge Bay	About 35 miles of the UPRR, 19 miles of I-5, and numerous associated tunnels, embankments, and other facilities would be relocated; many miles of local roads also would be impacted
Vegetation and Habitat Around Reservoir Rim	Maximum inundation area would increase by about 1,060 acres (3 percent)	Maximum inundation area would increase by about 2,500 acres (8 percent)	Maximum inundation area would increase by about 31,200 acres (roughly double that of existing conditions)
Habitat Along Shasta Lake Tributaries	Infrequent increased inundation along lower tributaries: Sacramento River – 1,100 lf Squaw Creek – 500 lf North Fk Squaw Ck – 500 lf McCloud River – 1,420 lf	Infrequent increased inundation along lower tributaries: Sacramento River – 3,100 lf Squaw Creek – 1,700 lf North Fk Squaw Ck – 1,700 lf McCloud River – 3,480 lf	Periodic increased inundation along lower tributaries: Sacramento River – 6 miles Squaw Creek – 4 miles North Fk Squaw Ck – 2 miles McCloud River – 5 miles
Other	-	-	Removal of Pit 7 Dam

Key: I-5 – Interstate 5 lf – linear feet UPRR – Union Pacific Railroad

Note:

[1]Most bridges impacted would be replaced with higher elevation structures at the same location, but some could be modified or retired. Replacement of the I-5 Antlers Bridge is included in the without-project condition.

Raising the gross pool of the lake would cause direct impacts due to higher water levels, and/or indirect impacts related to facility access, operation, and maintenance. General types of impacts include potential 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 may 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 Lake Shasta, are located within a few feet of the existing gross pool elevation.

Illustration of the extent of inundation for the 6.5-foot and 18.5-foot dam raise is provided in **Plate 13**. The plate shows increased inundation on the Sacramento River arm at the community of Lakeshore, the most populated area around the lake. Due to 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 also would

be impacted. Additional information on the potential extent of inundation and impacted structures can be found in the reference document Shasta Reservoir Area Inventory, Shasta Dam and Reservoir, California (February 2003).

The McCloud River is an area of specific interest. California Public Resources Code 5093.542(c) restricts 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. **Plate 14** illustrates the estimated increase in area of inundation on the McCloud River upstream from the McCloud Bridge for the 6.5- and 18.5-food dam raises. As shown in **Table VII-3** and on the plate, raising Shasta Dam 6.5 feet would result in inundating an additional 1,420 lineal feet (about 9 acres) of the lower McCloud River. This represents about 1 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river. For a dam raise of 18.5 feet, an estimated additional 3,480 feet (27 acres) of the lower McCloud River would be impacted. This represents about 2.7 percent of the designated reach. **Plate 15** shows the maximum area of inundation for dam raises of up to 200 feet.

Inventories are underway to help define the precise character of the habitat likely impacted by enlarging Shasta Dam and Reservoir. A major emphasis of the next phase of the SLWRI will be to define specific impacts and features to mitigate those impacts. This will influence the type and magnitude of additional features to be included in alternative plans to compensate for potential impacts. The concepts presented herein do not include specific mitigation measures, but it is estimated that these features could include the following:

- More aggressive management of reservoir area lands and/or restoring significantly degraded habitat in the reservoir area
- Physical means of improving aquatic habitat in the reservoir drawdown area and along the lower reaches of tributaries to Shasta Lake (similar to the artificial fish cover and instream habitat improvements proposed in the retained ecosystem restoration measures)
- Initiating land acquisition and management efforts with a focus on improving the quality or quantity of wildlife habitat.

Measures Common to All Concepts

Three of the measures retained in **Chapter VI** are included, to some degree, in all of the concepts: modification of the TCD, reoperation for flood control, and modification of hydropower facilities. These measures would be included, to some extent, with any enlargement of Shasta Dam, as described below.

- **Modification of the TCD -** The minimum modifications to the TCD that would be required if Shasta Dam were raised 6.5 feet, 18.5 feet, or 200 feet are summarized in **Table VII-2**. However, additional modifications to increase the operating range or effectiveness of the TCD might also be included in future alternatives. More understanding about the operation of the existing TCD is needed to identify possible improvements. Future studies will determine what modifications to the TCD are possible and practical, and how they could be

included in alternative plans. For the purpose of this analysis, the existing shutter configuration was used for all simulations.

- **Reoperation of Shasta Dam for flood control -** Physical enlargement of Shasta reservoir would require alterations to the existing flood control operational guidelines or rule curves. The guidelines could be simply adjusted to reflect the physical increase in dam/spillway elevation, or the guidelines could be reformulated to optimize use of the additional storage for flood control and/or increase the flood protection currently provided by the dam. Additional information on potential modifications to the operation rules at Shasta Dam is contained in the reference document Assessment of Potential Shasta Dam Reoperation for Flood Control and Water Supply Improvement.

- **Modification of hydropower facilities at Shasta Dam –** Physical enlargement of Shasta Dam would require various minimum modifications to the existing hydropower facilities at the dam, as summarized in **Table VII-2**, to enable their continued use. However, future alternatives could include additional modifications to increase the power production capabilities of the reservoir (e.g., additional penstocks and generators), commensurate with the magnitude of the enlargement. These opportunities will be evaluated in future studies.

These measures were included in each of the concepts because they would accompany any enlargement, but the extent of modification and/or reoperation was not considered at this time. Future studies will evaluate these measures in greater detail and determine how they could best be combined with the various dam raise and operation scenarios. Hydropower enhancements and increases in flood protection are believed to be separable and independent, and not necessary to identify plans warranting further evaluation in the SLWRI.

Reservoir Operation

The concept plans provide a basis for relative comparison of a range of potential actions to address the SLWRI objectives. To maintain a common baseline among the concepts, it was estimated that the reservoir, and any additional storage created by raising the dam, would be operated as under existing conditions and according to existing institutional agreements. **Plate 16** illustrates simulated reservoir storage fluctuations under existing operating rules for the baseline and three dam raise scenarios. Additional information on potential modifications to the operation of Shasta Dam is contained in the reference document Assessment of Potential Shasta Dam Reoperation for Flood Control and Water supply Improvement. Future studies will explore the potential to reoperate the reservoir and optimize the use of additional storage space for water supply reliability, anadromous fish survival, and other beneficial uses.

Water Rights

The current applications held by Reclamation for the appropriation and use of water in Shasta Lake was issued by the State Water Right Board (now the SWRCB) in 1961 under Decision 990. Any plan to enlarge Shasta Lake would require filing a new application with the SWRCB, or a petition to change an existing state-filed application, for appropriation of new yield created by the enlargement. Such a petition would be published in public venues and interested parties would be given time to file any protests or objections. Protests could be based on numerous issues, such as injury to prior rights, proposed allocation of new yield to the CVP/SWP, or Delta

water quality, and could result in a formal hearing by the SWRCB. Potential water rights issues related to enlarging Shasta Dam will be investigated in greater depth when detailed alternative plans provide a clear picture of the amount of, and potential uses for, any additional yield.

CONCEPTS FOCUSED ON ANADROMOUS FISH SURVIVAL

Three concept plans were formulated from the resource management measures retained to address the primary objective of anadromous fish survival (see **Chapter VI**). The main focus of these concepts 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 concepts, those shown in **Table VII-1** and described below are believed to be reasonably representative of the range of potential actions.

Each of the three AFS concepts includes raising Shasta Dam 6.5 feet, which would raise the gross 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 concepts could be compared. The primary difference between the three AFS concepts 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 on the upper Sacramento River, while AFS-2 and AFS-3 focus the additional storage on regulating flows on the upper Sacramento River. AFS-3 also adds an additional increment, fish habitat restoration on the upper Sacramento River.

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

Concept 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 for the primary purpose of maintaining cooler water temperatures in the upper Sacramento River.

Major Components

Concept AFS-1 includes the following major components:

- 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.
- Increasing the size of the minimum operating pool to 880,000 acre-feet.

Both of these 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 million acre-feet. The existing TCD would be extended and potentially modified to achieve efficient use of the expanded cold water pool. 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.

Accomplishments

The accomplishments of concept AFS-1 are described below in relation to their contribution to the objectives of the SLWRI.

- **Anadromous Fish Survival -** Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. Concept 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 and Red Bluff, 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.

- The relationship between anadromous fish mortality and environmental conditions (including water temperature) is very complex. Consequently, additional studies are required to ascertain specific benefits to the anadromous fishery in the Sacramento River (reduced mortality or increase in population) resulting from increasing the cold water pool in Shasta Lake. However, a preliminary assessment was conducted using analytical approaches similar to those used previously in evaluating the benefits of the TCD. Although the preliminary assessment has notable limitations (see summary in **Chapter IX** or description in **Appendix D**), it provides a means for comparing the relative performance of the concepts. On the basis of this assessment, it is estimated that AFS-1 could contribute to an average annual increase (reduction in mortality) of salmon amounting to about 860 fish (see **Table VII-4**). For higher dam raise scenarios with corresponding increases in the minimum operating pool, the benefit to salmon would be proportionally greater.

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

- **Environmental Restoration, Flood Control, and Hydropower -** Although the focus of this concept 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 of about 51 gigawatt-hours (GWh) per year (see **Chapter IX**). The ability to manage floods would not increase significantly. AFS-1 does not include any specific measures to address the secondary objective of environmental restoration.

- **Other Accomplishments -** 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 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

TABLE VII-4
SUMMARY OF BENEFITS AND COSTS FOR CONCEPTS

Name	Primary Objectives			Secondary Objectives			Cost ($ millions)	
	Increase in Water Supply Reliability (1,000 acre-feet/yr)[1]	Average Annual Salmon Increase[2]	Increase in Spawning Habitat (acres)[3]	Ecosystem Restoration Benefits[4]	Flood Control Benefits[5]	Hydropower Generation (GWh/year)	First Cost[6]	Annual Cost[7]
AFS-1	Incidental	860	-	-	-	51	282	19
AFS-2	20	370	170	-	-	32	282	19
AFS-3	20	370	320	-	-	32	292	20
WSR-1	72	410	-	-	-	15	282	19
WSR-2	125	1,110	-	-	-	44	408	28
WSR-3	703	10,620	-	-	Major	2,254[8]	5,250	383
WSR-4	146	1,020	-	-	-	44	459	32
CO-1	72	410	150	-	Minor	15	292	20
CO-2	125	1,110	150	-	Minor	44	418	29
CO-3	90	980	320	-	Minor	61	418	29
CO-4	89	410	150	500+ acres	Minor	12	356	25
CO-5	146	1,020	150	500+ acres	Minor	44	483	34

Key:
AFS – anadromous fish survival CO – combined objective GWh – gigawatt-hour WSR – water supply reliability

Notes:
[1]Increase in water supply reliability during drought year conditions with Banks Pumping Plant capacity at 6,680 cfs.
[2]Initial estimates for comparison purposes only; to be refined in future investigations.
[3]Includes habitat increase from restoring spawning areas and/or increasing minimum flows, consistent with the objectives of the AFRP. Acres of aquatic habitat associated with increasing minimum flows are preliminary.
[4]Includes restoring riparian and wetland floodplain habitat along the upper Sacramento River and resident fish habitat around Shasta Lake and the lower reaches of its tributaries. Total area and location(s) to be determined.
[5]All concepts provide incidental flood control and hydropower benefits because they all include enlarging Shasta reservoir. The potential range of flood control and hydropower benefits will be evaluated in future studies.
[6]Costs are based on October 2003 price levels.
[7]Costs are annualized using 5-5/8 percent interest over a 100-year period of analysis.
[8]Does not include reduction in generation from the loss of the Pit 7 Dam.

Primary Impacts and Mitigation

Reservoir area relocations and other impacts related to raising Shasta Dam by 6.5 feet are summarized in **Table VII-3**. They 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 due to their proximity to the new water surface at gross pool.

In most years, fluctuation in the lake surface would be similar to without-project conditions because the operation of Shasta Lake would not change significantly for AFS-1. However, water in the reservoir would be drawn down about 8.5 feet below existing conditions during the late fall and winter of some dry years, corresponding to an increase in the drawdown zone of roughly 21 linear feet. It is believed that the potential adverse impacts to recreation of this additional drawdown would be minimal and outweighed by the recreational benefits resulting from the average annual increase in lake surface area.

The expanded drawdown zone would be inundated about once every 3 years, for periods ranging from several days to 10 months. Vegetation in the expanded drawdown zone would eventually be lost over time, but significant amounts would remain on the lower slopes due to the infrequent inundation. As summarized in **Table VII-3**, the lower reaches of tributaries to Shasta Lake also would experience increased inundation.

AFS-1 includes increasing the carryover storage target from 1.9 MAF to about 2.2 MAF, which would have a minor impact on seasonal flows in the upper Sacramento River. There would be an average maximum reduction in winter flows of about 300 cfs (3 percent of without-project flows), and an average maximum increase in summer flows of about 200 cfs (2 percent). It is believed that these relatively small changes in flows would not result in any significant impacts to fish and/or wildlife resources downstream from Shasta Dam.

Economics

Economic analysis provides a framework for quantifying estimated costs and benefits and for assessing the relationships between costs and benefits. For potential Federal projects to be implemented, national economic benefits must exceed project costs. Further, the amount of benefits in excess of costs (net benefits) helps in identifying the potential Federal and non-Federal shares of a project. National Economic Development (NED) and National Environmental Restoration (NER) benefits will be developed in the next phase of the investigation.

A summary of estimated first and annual costs and summary of anticipated benefits is provided for each concept. A breakdown of costs by major plan feature, and the estimated first and annual costs for each of the concepts is contained in **Chapter IX**. The estimated first costs are based largely on information contained in the Reclamation 1999 Appraisal Report and recent information on relocations. The annual cost is based on a project life of 100 years and a Federal discount rate of 5-⅝ percent. A comparison of the concepts based on these and other factors is contained in **Chapter VIII**.

- **Costs -** The estimated first cost for this plan is $282 million (see **Table VII-4**). The estimated annual costs amount to about $19 million.
- **Benefits -** The most significant benefit of AFS-1 is the increase in anadromous fish population, estimated as 860 fish per year on average. 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. The primary benefits of the concepts are summarized in **Table VII-4**.

Concept 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.

Major Components

The primary component of concept AFS-2 includes the following major component:

- 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 is focused on increasing the minimum flow target for winter-run salmon on the upper Sacramento River, consistent with the goals of the January 2001 Final Restoration Plan for the AFRP. Similar to AFS-1, this concept would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 million acre-feet, 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, the 290,000 acre-feet of 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. Future alternatives could consider higher flow targets if negative water supply and hydropower impacts could be offset by larger storage increases in Shasta Dam (e.g., dam raises higher than 6.5 feet).

Accomplishments

The accomplishments of concept AFS-2 are described below in relation to the objectives of the SLWRI.

- **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 spring-run, late-fall-run, and endangered winter-run 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 dryer 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).

  The relationship between anadromous fish mortality and environmental conditions (including river flow) is very complex. Consequently, additional studies are required to determine the benefits of increasing minimum flows to the anadromous fishery in the Sacramento River in terms of decreased mortality or increased population. However, 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 were increased from 3,250 cfs to 4,200 cfs. Although the preliminary assessment has limitations (see summary in **Chapter IX** and description in **Appendix D**), it provides a means for comparing the relative performance of the concepts. 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 (see **Table VII-4**).

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 about 370 salmon.

- **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.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface in the reservoir would result in a net increase in power generation of about 32 GWh per year. 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 objective of environmental restoration. However, increasing minimum flows would provide incidental benefits to riparian habitat along the upper Sacramento River.
- **Other Accomplishments -** 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 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

Primary Impacts and Mitigation

Primary impacts associated with AFS-2 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Increasing minimum flow on the upper Sacramento River to about 4,200 cfs would not significantly impact other project operations at Shasta Dam.

Economics

- **Costs -** The estimated first cost for this plan is $282 million (see **Table VII-4**). Estimated annual costs amount to about $19 million.
- **Benefits -** Primary benefits of AFS-2 include (1) increased spawning habitat for anadromous fish resulting from increasing minimum flows, (2) increases in anadromous fish populations through increasing the cold water pool in Shasta Lake, and (3) a small increase in water supply reliability. AFS-2 also would provide incidental increases in flood control and

hydropower. Benefits of AFS-2 include about 170 acres of additional potential spawning habitat along the upper Sacramento River attributed to increased minimum flows, and an average annual increase of about 370 salmon attributed to the enlarged cold water pool. The water supply reliability benefits are somewhat small: about 20,000 acre-feet increased yield during critical years. Consequently, the majority of the costs for AFS-2 would likely be allocated to anadromous fish survival. This concept would contribute to both NED and NER objectives.

Concept 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.

Major Components

Concept AFS-3 includes the following major components:

- 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.
- 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 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 million acre-feet; 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 VII-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.

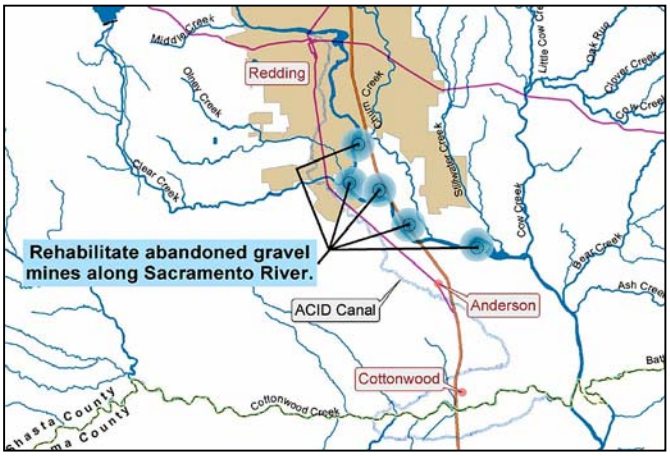

Figure VII-1 – Potential locations along Sacramento River where abandoned gravel mines could be considered for restoration.

Accomplishments

The accomplishments of concept AFS-3 are described below in relation to the objectives of the SLWRI.

- **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 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 of potential spawning habitat to the upper Sacramento River between Keswick and Battle Creek. As described for AFS-2, raising Shasta Dam also would increase the cold water pool, and preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 370 salmon.
- **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.
- **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 32 GWh per year. Flood control operations at Shasta Dam and Reservoir would continue as under existing conditions.
- **Other Accomplishments -** 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 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

Primary Impacts and Mitigation

Primary impacts associated with AFS-3 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Increasing minimum flow on the upper Sacramento River to about 4,200 cfs would not significantly impact other project operations at Shasta Dam. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this plan is $292 million (see **Table VII-4**). Estimated annual costs amount to about $20 million. Of the total annual cost of this plan, the cost attributed to restoring 150 acres of abandoned gravel mines is about $1 million. In contrast, the cost for the relatively small increment of restored habitat attributed to increasing flows is very high.

- **Benefits -** Primary benefits of AFS-3 include (1) increases in spawning habitat resulting from increasing minimum flows and restoring abandoned gravel mines, (2) increases in anadromous fish populations through increasing the cold water pool in Shasta Lake, and (3) a small increase in water supply reliability. AFS-3 also would provide incidental increases in flood control and hydropower. Benefits include 320 acres of additional spawning habitat along the upper Sacramento River attributed to increased minimum flows and restoration, and an average annual increase of about 370 salmon attributed to the enlarged cold water pool. Water supply reliability benefits are somewhat small, about 20,000 acre-feet increased yield during drought years. Consequently, the majority of the costs for AFS-3 would be allocated to anadromous fish survival. This concept would contribute to both NED and NER objectives.

CONCEPTS FOCUSED ON WATER SUPPLY RELIABILITY

Four concepts were formulated from the management measures retained to address the primary objective of increasing water supply reliability. Although each WSR concept 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 the enlargement of Shasta Dam was important when developing the WSR concepts because storage size is the most influential factor in determining benefits to water supply reliability. Hence, three dam raises were considered in the WSR concepts: 6.5 feet, 18.5 feet, and 200 feet. The concepts summarized in **Table VII-1** and described below are believed to be reasonably representative of the range of potential actions to address the primary study objective of water supply reliability.

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

Concept 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

Concept WSR-1 includes the following major components:

- Raising Shasta Dam by 6.5 feet for the primary purpose of creating 290,000 acre-feet of additional storage available for water supply.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

Each of these components is focused 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 would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 million acre-feet 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. A description of the conceptual modifications of the operation rules is included in the reference document Assessment of Potential of Shasta Dam Reoperation for Flood Control and Water Supply Improvement.

Accomplishments

The accomplishments of concept WSR-1 are described below in relation to their contributions to the objectives of the SLWRI.

- **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 410 fish per year.
- **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 also help reduce CVPIA redirected supplies during drought years by about 13 percent.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 15 GWh per year. A potential also exists to slightly increase the ability to control large flood events. WSR-1 does not include any specific measures to address the secondary objective of environmental restoration.
- **Other Accomplishments –** 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 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

Primary Impacts and Mitigation

Primary impacts associated with WSR-1 are related to raising Shasta Dam by 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Although the reservoir would be operated somewhat differently than for AFS-1, water surface elevation fluctuations in the lake would have similar impacts on recreation.

Economics

- **Costs -** The estimated first cost for this plan is $282 million and estimated annual costs amount to about $19 million, similar to those described previously for AFS-1.
- **Benefits -** The most significant benefits of WSR- 1 are (1) increased dry year water supply reliability, and (2) increased anadromous fish populations resulting from the enlarged cold

water pool. Although the physical components and costs of this concept are similar to AFS-1, this concept operates the reservoir in a manner that creates greater water supply reliability improvements. Benefits include an increase in drought year water supply of 72,000 acre-feet and an average increase of about 410 salmon per year. The plan also would provide incidental increases in hydropower and flood control. This concept would contribute to both NED and NER objectives.

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

WSR-2 focuses on the primary objective of water supply reliability by raising Shasta Dam 18.5 feet.

Major Components

Concept WSR-2 includes the following major components:

- Raising Shasta Dam by 18.5 feet for the primary purpose of creating 636,000 acre-feet of additional storage available for water supply.
- 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 636,000 acre-feet to a total of 5.19 million acre-feet (see **Table VII-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 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.

Accomplishments

Accomplishments of concept WSR-2 are described below in relation to their contributions to the objectives of the SLWRI.

- **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 1,110 fish per year.
- **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.

- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 44 GWh per year. A potential also exists to slightly increase the ability to control large flood events. WSR-2 does not include any specific measures to address the secondary objective of environmental restoration.

- **Other Accomplishments –** 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.

Primary Impacts and Mitigation

Primary impacts associated with WSR-2 are related to raising Shasta Dam by 18.5 feet, as summarized in **Table VII-3**. Impacts include modifying the Pit River Bridge, replacing 7 other bridges, relocating 130 structures, and inundating numerous small segments of existing paved and nonpaved roads. Two power transmission lines, several water storage tanks, and three USFS fire stations also would be impacted. Of the structures impacted, 40 are private dwellings and about 60 are resort/marina or other commercial buildings. Portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road would be relocated. Embankments would be constructed to protect I-5 at Lakeshore and the UPRR at Bridge Bay.

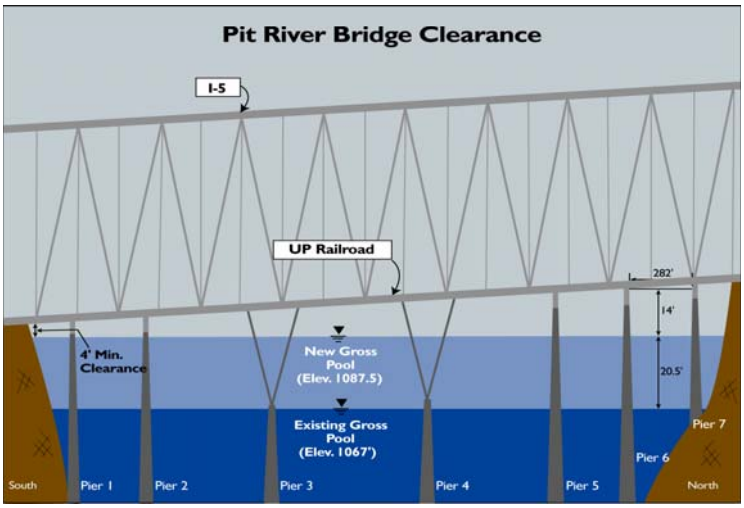

Figure VII-2 – Minimum clearances for boat traffic at Pit River Bridge, gross pool with 18.5-foot dam.

Although recreation would generally improve under WSR-2, 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 those 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 gross 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**.** **Figure VII-2** illustrates that the minimum clearance at the new gross pool would be about 14 feet between Piers 6 and 7. This could impact boating on the lake, as some houseboats are up to16 feet high. 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. Accordingly, WSR-2 would likely need to include features to help offset these impacts. Possible actions for further consideration could include reservoir operation modifications, boat scheduling assistance, or financial compensation.

As described previously, reservoir area habitat inventories are underway to quantify potential habitats impacted by raising Shasta Dam. The maximum inundation area would increase by about 2,500 acres over existing conditions. The expanded drawdown zone would be inundated about once every 3 to 4 years, for periods ranging from several days to several months. Vegetation in the expanded drawdown zone would eventually be lost over time, but significant amounts would remain on the lower slopes due to the infrequent inundation. As shown in **Table VII-3**, the lower reaches of the tributaries to Shasta Lake also would experience increased inundation.

Economics

- **Costs -** The estimated first cost for this plan is $408 million and the estimated annual costs are about $28 million.
- **Benefits -** The most significant benefits of WSR- 2 are (1) increased dry year water supply reliability, and (2) increased anadromous fish populations resulting from the enlarged cold water pool. Specifically, the drought year water supply would increase 125,000 acre-feet and an average increase of about 1,110 salmon per year. The plan also would provide an additional 44 GWh in hydropower capacity. This concept would contribute to NED and NER objectives.

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

WSR-3 focuses on the primary objective of water supply reliability by raising Shasta Dam by 200 feet.

Major Components

Concept WSR-3 includes the following major components:

- Raising Shasta Dam by about 200 feet for the primary purpose of creating 9.3 million acre-feet of additional storage available for water supply.
- Making major modifications to or replacing dam appurtenances, including hydropower facilities and the TCD.

Raising Shasta Dam by about 200 feet is considered to be the largest technically feasible raise without completely reconstructing the existing dam. The 200-foot raise would increase the capacity of the reservoir by 9.3 million acre-feet to a total of 13.9 million acre-feet. The magnitude of this raise would require significant modifications or replacement of most facilities associated with the dam (see **Table VII-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 for dam operators to meet both temperature and minimum flow requirements on the upper Sacramento River.

Accomplishments

The accomplishments of concept WSR-3 are described below in relation to their contributions to the objectives of the SLWRI.

- **Anadromous Fish Survival –** Raising Shasta Dam by 200 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 an average increase in the salmon population of over 10,000 fish per year over the life of the project. 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.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a significant net increase in power generation, amounting to about 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 also exists to significantly increase the ability to control large flood events. WSR-3 does not include any specific measures to address the secondary objective of environmental restoration.
- **Other Accomplishments –** 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 31,200 acres (roughly twice that of existing conditions), from 29,600 to about 60,700 acres.

Primary Impacts and Mitigation

The primary impacts associated with WSR-3 are related to raising Shasta Dam by 200 feet, as summarized in **Table VII-3**. They 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. Significant impacts would occur to all recreational facilities surrounding the lake. About 35 miles of the UPRR, 19 miles of I-5, and numerous associated tunnels, embankments, and other facilities would be relocated.

Although recreation would generally improve under WSR-3, the maximum drawdown zone would increase significantly. While drawdown to minimum pool would occur infrequently, this area would be largely devoid of vegetation, impacting the natural aesthetic value of the shoreline for recreational users. Further, recreational access to natural features (such as the Shasta Caves) and various historic sites would be limited.

The Pit 7 Dam is located at the existing headwater of Shasta Lake (see **Figure VII-3**). The dam is 200 feet high and was constructed for hydropower purposes in the mid-1960s by PG&E. The gross 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 VII-3 - The Pit 7 Dam, located on the Pit River upstream from Shasta Lake, is 200 feet high.

As described previously, reservoir area habitat inventories are underway to quantify potential habitats impacted by raising Shasta Dam. The maximum inundation area would increase by about 31,000 acres over existing conditions, and environmental impacts could be significant. The expanded drawdown zone would be inundated about once every 3 years, for periods ranging from several days to several months. Vegetation over most of the expanded drawdown zone would be lost over time. As shown in **Table VII-3**, increased inundation would be experienced along several miles of the lower reaches of the tributaries to Shasta Lake. There is also a potential to impact historic sites and cultural resources around the reservoir.

Economics

- **Costs -** The estimated first cost for this plan is $5.3 billion and estimated annual costs are about $383 million.
- **Benefits -** Primary benefits of WSR-3 are (1) increased water supply reliability, (2) increased anadromous fish populations resulting from the enlarged cold water pool, and (3) increased hydropower production. Increased water supply reliability, which would amount to about 703,000 acre-feet per year (drought year), would be accompanied by significant increases in the anadromous fish population (possibly as high as 10,000 fish per year). The concept also would provide substantial increases in net hydropower generation to the CVP, about 2.3 million GWh per year (not including generation reduction from loss of the Pit 7 Dam), which could increase revenues by over $100 million per year. This concept would contribute to NED and NER objectives.

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

WSR-4 focuses on the primary objective of water supply reliability by raising Shasta Dam 18.5 feet in combination with a conjunctive water management program.

Major Components

Concept WSR-4 includes the following major components:

- Raising Shasta Dam by 18.5 feet for the primary purpose of creating 636,000 acre-feet of additional storage available for water supply.
- 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 million acre-feet (see **Table VII-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 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. Contract agreements would focus on exchanging additional surface supplies in normal water years with participating CVP users for reducing deliveries (reliance on groundwater supplies) in dry and critically dry years (see **Figure VII-4**). Surface water supplies for dry and critically dry years would be used to increase the reliability of CVP and SWP supplies south of the Delta in dryer years.

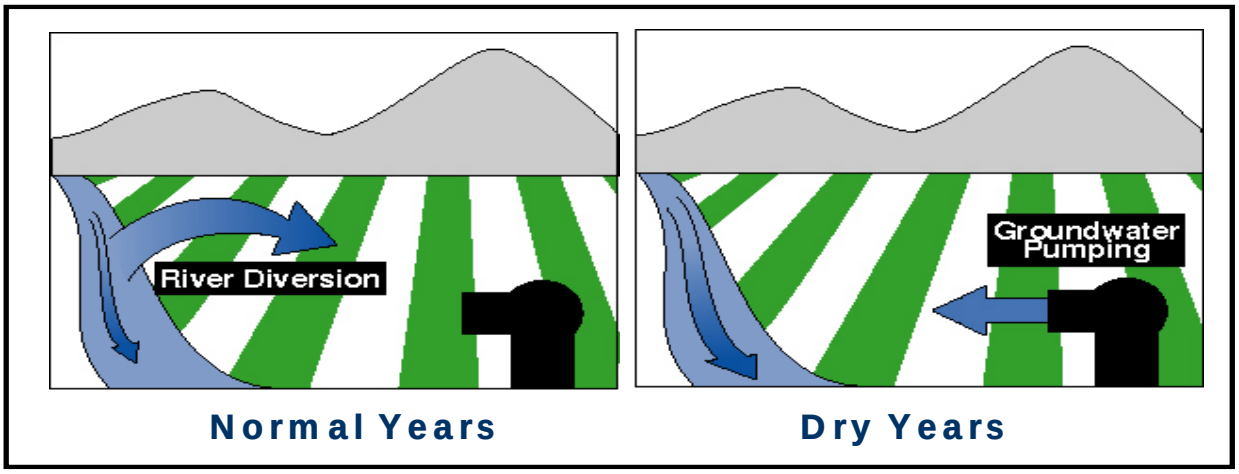

Figure VII-4 – Conjunctive water management concept– participating Sacramento River CVP water users would take more water during normal years and defer deliveries during dry years.

Accomplishments

Accomplishments of concept WSR-4 are described below in relation to their contribution to the primary and secondary planning objectives.

- **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 of about 1,020 fish per year.
- **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.
- **Environmental Restoration, Flood Control, and Hydropower -** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 44 GWh per year. A potential also exists to slightly increase the ability to control large flood events. WSR-4 does not include any specific measures to address the secondary objective of environmental restoration.
- **Other Accomplishments –** 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.

Primary Impacts and Mitigation

Primary impacts associated with WSR-4 are related to raising Shasta Dam by 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2.

Economics

- **Costs -** The estimated first cost for this plan is $459 million and estimated annual costs are about $32 million.
- **Benefits -** The most significant benefits of WSR- 4 are (1) increased dry year water supply reliability, and (2) increased anadromous fish populations resulting from the enlarged cold water pool. Specifically, benefits include an increase in drought year water supply of 146,000 acre-feet and an average increase of about 1,020 salmon per year. The plan also would provide incidental increases in hydropower. This concept would contribute to NED and NER objectives.

CONCEPTS FOCUSED ON COMBINED OBJECTIVES

Five concepts were formulated from the retained management measures to represent a reasonable balance between the two primary objectives, as shown in **Table VII-1**. The combined objective concepts also include measures to actively address the secondary objectives, as appropriate. As with previous concepts, numerous potential sizes and combinations of components are possible. The combined objective concepts identified below are believed to be reasonably representative, although not exhaustively, of the range of potential and applicable actions.

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

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

Major Components

Concept 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 temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 290,000 acre-feet to a total of 4.84 million acre-feet 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).

Accomplishments

Accomplishments of concept CO-1 are described below in relation to the objectives of the SLWRI.

- **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 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 Accomplishments –** 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.

Primary Impacts and Mitigation

Primary impacts associated with CO-1 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $292 million, and the estimated annual costs are about $20 million.
- **Benefits -** Primary benefits of CO-1 are improved anadromous fish survival from increasing the cold water pool in Shasta Reservoir and restoring aquatic and floodplain habitat, and increased water supply reliability. CO-1 also would provide incidental increases in flood control and hydropower. Specifically, benefits include 150 acres of additional spawning habitat along the upper Sacramento River, and an average annual increase of about 410 salmon attributed to the enlarged cold water pool. Water supply reliability benefits include a 72,000 acre-feet increase in yield during drought years. This concept would contribute to NED and NER objectives.

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

Concept CO-2 addresses both primary planning objectives by raising Shasta Dam by 18.5 feet in combination with anadromous fish habitat restoration.

Major Components

Concept 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 temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 636,000 acre-feet to a total of 5.19 million acre-feet, 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).

Accomplishments

Accomplishments of concept CO-2 are described below in relation to the objectives of the SLWRI.

- **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 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 to a small degree.
- **Other Accomplishments –** 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.

Primary Impacts and Mitigation

Primary impacts associated with CO-2 are related to raising Shasta Dam 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $418 million, and estimated annual costs are about $29 million.
- **Benefits -** Primary benefits of CO-2 are improved anadromous fish survival from increasing the cold water pool in Shasta Reservoir and restoring aquatic and floodplain habitat, and increased water supply reliability. CO-2 also would provide a small increase in hydropower. Specifically, benefits include 150 acres of additional spawning habitat along the upper Sacramento River, and an average annual increase of about 1,110 salmon attributed to the enlarged cold water pool. Water supply reliability benefits include a 125,000 acre-feet increase in yield during drought years. This concept would contribute to NED and NER objectives.

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

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

Major Components

Concept 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 approximately 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 AFRP. 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).

Accomplishments

Accomplishments of concept CO-3 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival –** CO-3 would benefit anadromous fish by increasing seasonal minimum flows and improving 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 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 Accomplishments –** 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.

Primary Impacts and Mitigation

Primary impacts associated with CO-3 are related to raising Shasta Dam 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2. Some potential exists for impacting existing habitat at gravel mine restoration sites, but these impacts would likely result from a conversion of present land use back to a more typical riverine environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs** - The estimated first cost for this concept is $418 million, and estimated annual costs are about $29 million.
- **Benefits** - Primary benefits of CO-3 are improved anadromous fish survival from improving flow conditions, restoring aquatic and floodplain habitat, and increasing the cold water pool in Shasta Reservoir, and increased water supply reliability. Specifically, benefits include 320 acres of additional spawning habitat along the upper Sacramento River, and an average annual increase of about 980 salmon attributed to flow increases and the enlarged cold water pool. Water supply reliability benefits include a 90,000 acre-feet increase in yield during drought years. CO-3 also would provide an increase of 61 GWh per year in hydropower generation. This concept would contribute to NED and NER objectives.

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

Concept 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.

Major Components

Concept 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 reoperating 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 VII-5**). 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, and 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.

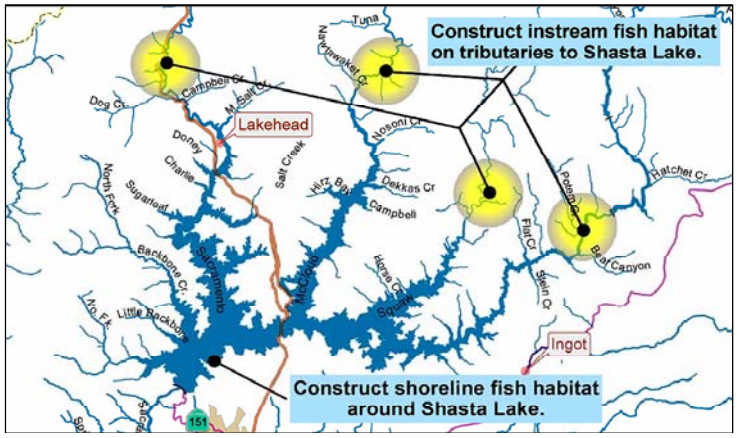

Figure VII-5 – Potential ecosystem restoration features in the Shasta Lake area.

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 Concept CO-4 is acquisition and restoration of wetland and riparian areas along the upper Sacramento River. The location and 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.

Accomplishments

The accomplishments of concept CO-4 are described below in relation to the objectives of the SLWRI.

- **Anadromous Fish Survival –** CO-4 would benefit anadromous fish by improving 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 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 500 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 Accomplishments –** 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.

Primary Impacts and Mitigation

The primary impacts associated with CO-4 are related to raising Shasta Dam 6.5 feet, as summarized in **Table VII-3** and described previously for AFS-1. 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 native environment; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $356 million, and estimated annual costs are about $25 million.
- **Benefits -** Primary benefits of CO-4 are (1) improved anadromous fish survival from restoring aquatic and floodplain habitat, and an increase in the cold water pool in Shasta Reservoir; and (2) increased water supply reliability. These benefits include 150 acres of additional spawning habitat along the upper Sacramento River; an average annual increase of about 410 salmon attributed to the enlarged cold water pool; and over 500 acres of additional habitat restoration in the Shasta Lake area and along the upper Sacramento River. Water supply reliability benefits include an increase in yield of 89,000 acre-feet during drought years. This concept would contribute to NED and NER objectives.

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

Concept 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 Components

Concept CO-5 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 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 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 million acre-feet 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.

Accomplishments

The accomplishments of concept CO-5 are described below in relation to the objectives of the SLWRI.

- **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 to 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 Accomplishments –** 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.

Primary Impacts and Mitigation

Primary impacts associated with CO-5 are related to raising Shasta Dam 18.5 feet, as summarized in **Table VII-3** and described previously for WSR-2. 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; consequently, these impacts are not likely to require mitigation.

Economics

- **Costs -** The estimated first cost for this concept is $483 million, and estimated annual costs are about $34 million.
- **Benefits -** Primary benefits of CO-5 are (1) improved anadromous fish survival from the restoration of aquatic and floodplain habitat, and an increase in the cold water pool in Shasta Reservoir, and (2) increased water supply reliability. These benefits include 150 acres of additional spawning habitat along the upper Sacramento River; an average annual increase of about 1,110 salmon attributed to the enlarged cold water pool; and over 500 acres of additional habitat restoration in the Shasta Lake area and along the upper Sacramento River. Water supply reliability benefits include an increase in yield of 146,000 acre-feet during drought years. This concept would contribute to NED and NER objectives.