Chapter 3
Plan Formulation

The plan formulation process for Federal water resources studies is identified in the P&G (WRC 1983) and consists of the following deliberate and iterative steps:

- Identifying water resources problems, needs, and opportunities to be addressed, and developing planning objectives, constraints, and criteria.
- Inventorying and forecasting conditions likely to occur in the study area.
- Formulating alternative plans based on potential management measures identified to meet planning objectives within planning constraints, and refining alternative plans.
- Evaluation of potential effects of alternative plans (e.g., economic, environmental, social).

Comparing alternative plans to determine the differences among alternative plans (including no action).

- Selecting a plan for recommendation to decision makers for implementation or no action.

For the SLWRI, consistent with P&G and NEPA, this iterative process was separated into multiple phases, all of which have been completed and are documented in this Final Feasibility Report, related Final EIS, and supporting documents. All phases were completed in coordination and collaboration with stakeholders, cooperating agencies, affected communities, and decision makers. Further, all phases were completed in consideration of study authorizations and guidance, and other pertinent Federal planning procedures, requirements, directives, standards, policy, laws, and executive orders. These planning phases are illustrated in Figure 3-1 and described below:

- **Mission Statement Phase** – This study phase consisted of projecting without-project future conditions; defining resulting resource problems, and needs; defining a specific set of planning objectives; and identifying constraints and criteria for addressing the planning objectives.

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

- **Comprehensive Plans Phase** – The measures and concept plans carried forward were further refined and developed with more specificity to formulate comprehensive plans to address the planning objectives. These plans were then evaluated and compared.

- **Plan Refinement Phase** – This phase focused on further refinement and iterative evaluation of the potential effects of the comprehensive plans. This phase included preparing and circulating a Draft Feasibility Report, which was completed in November 2011 and released to the public in February 2012, and DEIS, which was released to the public in June 2013 for public review and comment.

- **Recommended Plan Phase** – This phase of the SLWRI planning process focuses on identifying a plan for recommendation, and preparing and processing this Final Feasibility Report and the Final EIS to support a Federal decision.

Public and stakeholder outreach was performed concurrently with the above phases, as shown in Figure 3-1. Major reports documenting public and stakeholder outreach include the *Strategic Agency Public Involvement Plan*, published in 2003 (Reclamation), and the *Environmental Scoping Report*, published in 2006 (Reclamation). For additional information on public and stakeholder outreach see Chapter 7 of this Final Feasibility Report.

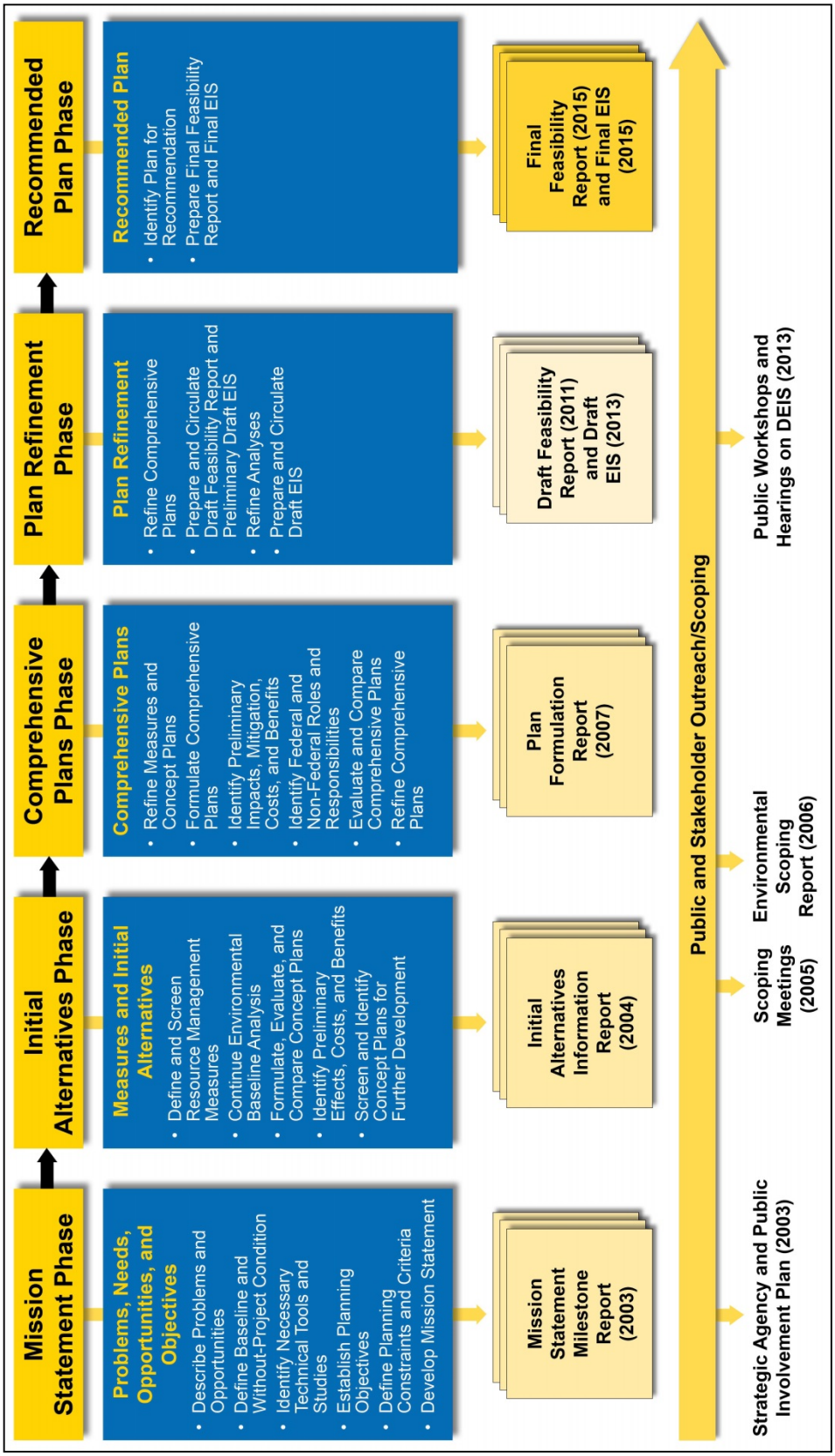

Figure 3-1. Plan Formulation Phases

Planning Objectives

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

National Planning Objectives

The Federal objective is defined in the P&G (WRC 1983):

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

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

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

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

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

SLWRI-Specific Planning Objectives

On the basis of the problems, needs, and opportunities identified and defined in Chapter 2, study authorities, and other pertinent direction, including information contained in the CALFED PEIS/R and Programmatic ROD, primary and secondary planning objectives were developed. Primary planning objectives are those which specific alternatives are formulated to address. The primary objectives are considered to have coequal priority, with each pursued to the maximum practicable extent without adversely affecting the other. Secondary planning objectives are actions, operations, and/or features that should be considered in the plan formulation process, but only to the extent possible through pursuit of the primary planning objectives.

- **Primary Planning Objectives**
  - Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream from the RBPP
  - Increase water supply and water supply reliability for agricultural, M&I, and environmental purposes to help meet current and future water demands, with a focus on enlarging Shasta Dam and Reservoir
- **Secondary Planning Objectives**
  - Conserve, restore, and enhance ecosystem resources in the Shasta Lake area and along the upper Sacramento River
  - Reduce flood damage along the Sacramento River
  - Develop additional hydropower generation capabilities at Shasta Dam
  - Maintain and increase recreation opportunities at Shasta Lake.
  - Maintain or improve water quality conditions in the Sacramento River downstream from Shasta Dam and in the Delta

Planning Constraints and Other Considerations

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

Planning Constraints

Planning constraints help guide the direction and scope of the feasibility study and the formulation and evaluation of alternatives plans. Some planning constraints can also assist in defining existing and likely future resource

conditions. Some planning constraints are more rigid than others. Examples of more rigid constraints include congressional direction in study authorizations; other current applicable laws, regulations, and policies; and physical conditions (e.g., topography, hydrology). Other planning constraints are less restrictive but are still influential in guiding the process. Several key constraints identified for the SLWRI are as follows:

- **Study Authorizations** – On August 30, 1935, in the Rivers and Harbors Bill, an initial amount of Federal funds was authorized for constructing Kennett (now Shasta) Dam. As described in Chapter 1, initial authorization for the SLWRI derives from Public Law 96-375, and additional guidance is contained in Public Law 108-361. These legislative actions authorized an investigation of the potential benefits and costs of enlarging or replacing Shasta Dam and Reservoir.

- **CALFED PEIS/R and Programmatic ROD** – CALFED was established to "develop and implement a long-term comprehensive plan that would restore ecological health and improve water management for beneficial uses of the Bay-Delta system." The 2000 CALFED PEIS/R and Programmatic ROD include program goals, objectives, and projects primarily to benefit the Bay-Delta system. The objectives of the SLWRI are consistent with the CALFED Programmatic ROD (CALFED 2000a) for Shasta Dam enlargement, as follows:

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

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

objectives, and programs and projects of the CALFED PEIS/R and Programmatic ROD (CALFED 2000a, 2000c).

CALFED conducted an initial screening of a list of 52 potential surface water storage sites to reduce the number of sites to a more manageable number for more detailed evaluation during project-specific studies (2000b). CALFED eliminated sites providing less than 200,000 acre-feet storage and those that conflicted with CALFED solution principles, objectives, or policies. Further, based on existing information, CALFED identified some potential surface water storage sites that were more promising in contributing to CALFED goals and objectives and more implementable due to relative costs and stakeholder support. Surface water storage sites recommended by CALFED for subsequent evaluation focused on those with the most potential for helping meet CALFED goals and objectives: Shasta Lake Enlargement, Los Vaqueros Reservoir Enlargement, Sites Reservoir, In-Delta Storage, and development of storage in the upper San Joaquin River Basin (CALFED 2000b) (Figure 3-2).

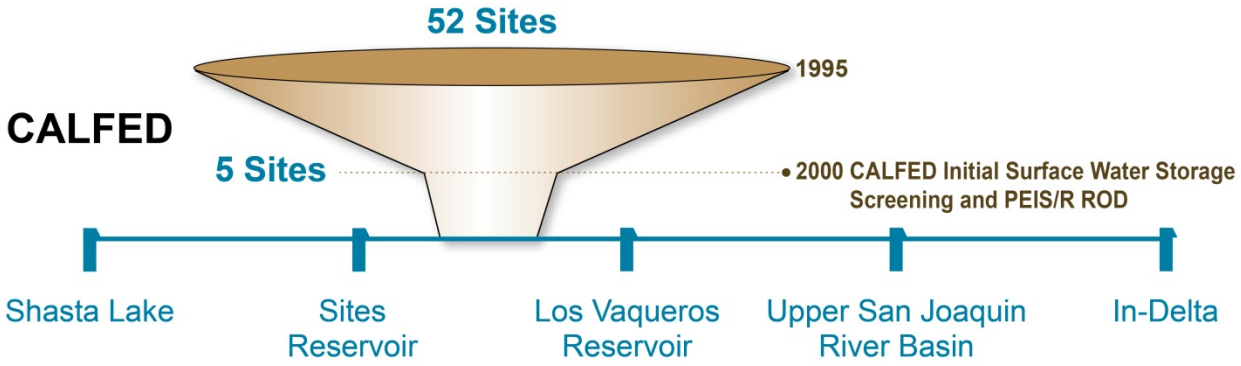

Figure 3-2. CALFED Surface Water Storage Investigations Screening

- **Laws, Regulations, and Policies** – Numerous laws, regulations, executive orders, and policies need to be considered, among them the P&G, NEPA, FWCA, Federal Clean Air Act, Federal CWA, National Historic Preservation Act, California PRC, ESA and CESA, CEQA, and CVPIA. The CVPIA, including the associated AFRP, is pertinent because it identified specific actions for fish and wildlife mitigation, protection, restoration, and enhancement which influence water supply deliveries, river flows, and related environmental conditions in the primary and extended study areas. Other important laws and regulations are discussed in the Plan Formulation Appendix.

Statewide Water Operation Considerations

Reclamation and DWR use CalSim-II, a specific application of the Water Resources Integrated Modeling System (WRIMS) to Central Valley water operations, to study operations, benefits, and effects of new facilities and

operational parameters for the CVP and SWP. Operational assumptions for refinement, modeling, and evaluation of potential effects of the No-Action Alternative and comprehensive plans included in this Final Feasibility Report were derived from the following:

- The Reclamation 2008 *Biological Assessment on the Continued Long-Term Operations of the CVP and SWP* (2008 Long-Term Operation BA) (Reclamation 2008a)

- The USFWS 2008 *Formal ESA Consultation on the Proposed Coordinated Operations of the CVP and SWP* (2008 USFWS BO) (USFWS 2008)

- The NMFS 2009 *BO and Conference Opinion on the Long-Term Operations of the CVP and SWP* (2009a NMFS BO) (NMFS 2009a)

- *Coordinated Operations Agreement* between Reclamation and DWR for the CVP and SWP, as ratified by Congress (Reclamation and DWR 1986)

Despite the uncertainty resulting from ongoing consultation processes, the 2008 Long-Term Operation BA and the 2008 USFWS and 2009 NMFS BOs contain the most recent estimate of potential changes in water operations that could occur in the near future. If the revised USFWS and NMFS BOs contain new or amended RPAs, these legal challenges may result in changes to CVP and SWP operational constraints.

Other Planning Considerations

Other planning considerations were specifically identified to help formulate, evaluate, and compare initial plans and, later, detailed alternatives:

- Alternatives should incorporate results of coordination with other Federal and State agencies such as the USFWS; NMFS; USFS; BIA; BLM; DWR; and CDFW.

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

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

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

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

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

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

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

- Alternatives should strive to balance increased water supply reliability between agricultural and M&I uses.

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

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

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

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

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

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

Criteria

The Federal planning process in the P&G also includes four specific criteria for consideration in formulating and evaluating alternatives: (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability (WRC 1983). Completeness is a determination of whether a plan includes all elements necessary to realize planned effects, and the degree that intended benefits of the plan depend on the actions of others. Effectiveness is the extent to which an alternative alleviates problems and achieves objectives. Efficiency is the measure of how efficiently an alternative alleviates identified problems while realizing specified objectives consistent with protecting the nation's environment. Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals. These criteria, and how they apply in helping to compare comprehensive alternative plans, are described in Chapter 5.

Management Measures

A management measure is a project action or feature that could address a specific planning objective. Concept plans are formulated by combining retained measures that address the primary planning objectives. These concept plans are then refined, as appropriate, considering measures to address the secondary planning objectives.

Measures Considered

More than 60 potential management measures were identified based on information from previous studies, programs, and projects to address the primary and secondary planning objectives and satisfy the other planning constraints, considerations, and criteria. These measures were reviewed and others developed during study team meetings, field inspections, scoping, and public outreach for the SLWRI. Many of these management measures were also considered under CALFED. Since the accompanying EIS tiers to the CALFED PEIS/R, consistent with guidance in the CALFED Programmatic ROD, this Feasibility Report and the accompanying EIS rely on evaluations and alternatives development and screening included in the CALFED PEIS/R. While revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required, many of the management measures, including measures not related to the raising of Shasta Dam, were also evaluated during the SLWRI plan formulation process.

These measures were initially analyzed in the *Mission Statement Milestone Report* (Reclamation 2003b), *Ecosystem Restoration Opportunities in the Upper Sacramento River Region* (Reclamation 2003d), and *Initial Alternatives Information Report* (Reclamation 2004a) to determine whether they would be retained for further consideration. At each step of the plan formulation process, measures were reviewed, and in some cases reconsidered and incorporated into

alternatives, or screened and eliminated from alternatives. The rationale for retaining or deleting each measure is described in greater detail in the Plan Formulation Appendix. Tables 3-1 through 3-4 list the management measures that address the planning objectives and other planning considerations, status of the measures (retained or deleted from further consideration), and rationale for the status determination.

In the discussion of SLWRI management measures and alternative plans, the term "enhancement" specifically refers to restoration actions that would improve environmental conditions above the baseline (without-project condition). Correspondingly, the term "mitigation" refers to restoration actions that improve environmental conditions toward the baseline to compensate for alternative plan impacts. The relationship between restoration, enhancement, and mitigation is illustrated in Figure 3-3.

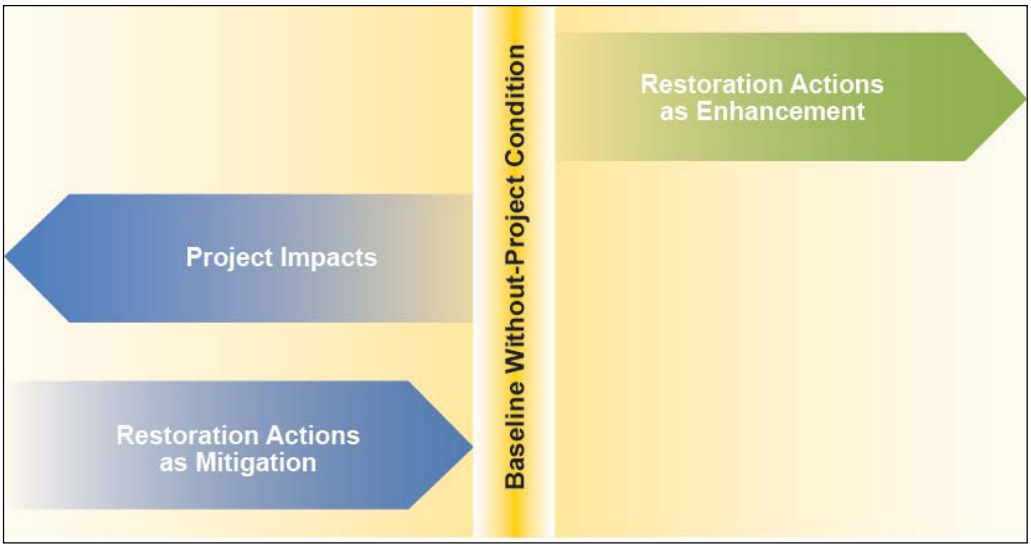

Figure 3-3. Conceptual Schematic of Restoration Actions as Enhancement Versus Restoration Actions as Mitigation

Although management measures were not specifically identified, developed, or retained/deleted based on the potential to address the effects of climate change, many of the measures retained to address the primary and secondary planning objectives would provide additional system flexibility, helping to offset the potential effects of future climate change.

It should be noted that measures that did not directly address the planning objectives, or were otherwise eliminated from consideration and further development as alternative plan components under certain circumstances, were considered for incorporation into alternative plans as mitigation measures. Development and refinement of mitigation measures is described in the Preliminary Environmental Commitments and Mitigation Plan Appendix to the accompanying EIS.

Table 3-1. Management Measures Addressing Primary Planning Objective of Increasing Anadromous Fish Survival

Measure Description	Study Status	Status Rationale
Improve Fish Habitat		
Restore abandoned gravel mines along the Sacramento River	**Deleted**	Moderate potential to effectively address the primary planning objective and for likelihood of success. Although this measure was initially retained during preliminary analyses, it has been deleted from further consideration because of likely marginal benefits to anadromous fish and a general lack of interest from the public and stakeholders. Encompassed within actions evaluated and prioritized under the CALFED ERP.
Construct instream aquatic habitat downstream from Keswick Dam	**Retained**	High potential for combining with other measures. This measure was retained for potential further development because of its potential to successfully address the first primary planning objective, and its potential to combine favorably with other potential measures. In addition, this measure received strong interest from fisheries and resource agencies. Encompassed within actions evaluated and prioritized under CALFED ERP.
Replenish spawning gravel in the Sacramento River	**Retained**	High potential for combining with other measures. Demonstrated benefits that continue as gravel moves downstream. Low initial cost. Concerns over induced downstream impacts to agricultural facilities. Consistent with Federal planning objectives and principles. Encompassed within actions evaluated and prioritized under CALFED ERP.
Construct instream fish habitat on tributaries to the Sacramento River	**Deleted**	Significant benefit to tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Remove instream sediment along Middle Creek	**Deleted**	Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. High uncertainty due to increased need for long-term remediation. Encompassed within actions evaluated and prioritized under CALFED ERP.
Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks	**Deleted**	Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River, and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Improve Water Flows and Quality		
Make additional modifications to Shasta Dam for temperature control	**Retained**	High likelihood of combining with measures involving increasing Shasta Reservoir storage. Although existing TCD at Shasta effectively meets objectives, potential may exist to further modify the device to benefit anadromous fish with increased storage at Shasta Reservoir.
Enlarge Shasta Lake cold-water pool	**Retained**	High potential for combining with other measures. Consistent with other primary planning objective and secondary planning objectives. Consistent with goals of CALFED.
Modify storage and release operations at Shasta Dam	**Retained**	Moderate potential to meet the primary planning objective of increasing anadromous fish survival. This measure was initially deleted from consideration because of analyses indicating a decreased fisheries benefit with increasing Sacramento River flows compared to increasing the cold-water pool. However, this measure has been retained as part of an adaptive management strategy.
Modify ACID diversions to reduce flow fluctuations	**Deleted**	Potential modified operations include not installing diversion dam flash boards in spring, or not removing flash boards in the late summer/fall. Non-installation would conflicts with the other primary planning objective of water supply reliability. Non-removal would potentially conflict with the secondary objective of flood damage reduction. Encompassed within actions evaluated and prioritized under CALFED ERP.
Increase instream flows on Clear, Cow, and Bear creeks	**Deleted**	Independent of hydraulic/hydrologic conditions in upper Sacramento River. Would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. Encompassed within actions evaluated and prioritized under CALFED ERP.

Table 3-1. Management Measures Addressing Primary Planning Objective of Increasing Anadromous Fish Survival (contd.)

Measure Description	Study Status	Status Rationale
Improve Water Flows and Quality (contd.)		
Construct a storage facility on Cottonwood Creek to augment spring instream flows	**Deleted**	Independent of hydraulic/hydrologic conditions in upper Sacramento River. Adverse environmental impacts expected to exceed benefits. Evaluated during the CALFED alternative development process.
Transfer existing Shasta Reservoir storage from water supply to cold-water releases	**Deleted**	Violates basic plan formulation considerations – causes significant reduction in water supply reliability without development of a replacement supply.
Remove Shasta Dam and Reservoir	**Deleted**	Violates basic plan formulation considerations – causes considerable reduction in water supply reliability. No known project or projects could replace the lost benefits provided by Shasta and Keswick dams, reservoirs, and appurtenant facilities, at any price.
Improve Fish Migration		
Improve fish trap below Keswick Dam	**Deleted**	Although helps fish populations, would not contribute to favorable conditions for sustained spawning and rearing of anadromous fish along mainstem Sacramento River.
Screen diversions on Old Cow and South Cow creeks	**Deleted**	Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Remove or screen diversions on Battle Creek	**Deleted**	Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River, and would not contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Construct a migration corridor from the Sacramento River to the Pit River	**Deleted**	Volitional fish passage above Shasta Dam is being studied under a separate Federal program as the result of the 2009 NMFS Biological Opinion.
Cease operating or remove the Red Bluff Diversion Dam	**Deleted**	As the result of another Federal investigation – Red Bluff Diversion Dam Fish Passage Improvement Project – Reclamation subsequently ceased operation of Red Bluff Diversion Dam.
Reoperate the CVP to improve overall fish management	**Deleted**	See above measure regarding the Red Bluff Diversion Dam. Issues regarding reoperating facilities on the Trinity River were addressed in the Trinity River Record of Decision in 2000 (DOI). Any further modification within that system would violate planning criteria for the SLWRI through reducing water supply reliability without development of a replacement supply.
Construct a fish ladder on Shasta Dam	**Deleted**	Volitional fish passage above Shasta Dam is being studied under a separate Federal program as the result of the 2009 NMFS Biological Opinion.
Reintroduce anadromous fish to areas upstream from Shasta Dam	**Deleted**	Non-volitional fish passage above Shasta Dam is being studied under a separate Federal program as the result of the 2009 NMFS Biological Opinion.

Key:
ACID = Anderson-Cottonwood Irrigation District
CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
DOI = U.S. Department of the Interior
ERP = Ecosystem Restoration Program
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
SLWRI = Shasta Lake Water Resources Investigation
TCD = temperature control device

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

Measure Description	Study Status	Status Rationale
Increase Surface Water Storage		
Increase conservation storage space in Shasta Reservoir by raising Shasta Dam	**Retained**	Consistent with primary planning objective and directly contributes to secondary planning objectives.
Construct new conservation storage reservoir(s) upstream from Shasta Reservoir	**Deleted**	Upstream storage sites capable of CVP system-wide benefits would be very costly, result in environmental impacts difficult to mitigate, and would be inconsistent with the 2000 CALFED Programmatic ROD.
Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam	**Deleted**	Although potentially feasible sites/projects exist that could increase water supply reliability, significant overriding environmental and socioeconomic issues restrict implementation at this time. Evaluated during the CALFED alternative development process.
Construct new conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Deleted**	Not as efficient as developing additional storage in Shasta Dam. NODOS being pursued as added increment to system through a separate feasibility-scope study initiated under Public Law 108-361. Evaluated during the CALFED alternative development process.
Construct new conservation surface water storage south of the Sacramento-San Joaquin Delta	**Deleted**	Not an effective alternative to additional storage at Shasta. Does not contribute to other planning objectives. Upper San Joaquin River storage being pursued as added increment to system through a separate feasibility-scope study initiated under Public Law 108-361. Evaluated during the CALFED alternative development process.
Increase total or seasonal conservation storage at other CVP facilities	**Deleted**	Not an efficient alternative to increasing storage in Shasta Reservoir; significantly higher unit cost for increased water supply. Known efforts to increase space in other Northern California CVP (or SWP) reservoirs rejected by CALFED.
Dredge bottom of Shasta Reservoir	**Deleted**	Extremely high cost for a very small potential benefit, and severe environmental impacts associated with disposal of dredged materials.
Reoperate Reservoir		
Increase effective conservation storage space in Shasta Reservoir by increasing efficiency of reservoir operation for water supply reliability	**Retained**	Moderate to high potential for increment of increased water supply reliability at Shasta Reservoir. Although potential for increased water supply reliability is limited, added opportunities exist for increased flood control and other management elements.
Increase the conservation pool in Shasta Reservoir by encroaching on dam freeboard	**Deleted**	Very limited potential to encroach on existing freeboard above full pool, which is only 9.5 feet. Major modifications would be required to the dam and appurtenances to allow operational encroachments on the design freeboard of the dam, only to gain a small potential increase in reservoir storage.
Increase conservation storage space in Shasta Reservoir by reallocating space from flood control	**Deleted**	Very low potential for implementation due to significant adverse impacts on system flood management.

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

Measure Description	Study Status	Status Rationale
Improve Conjunctive Water Management		
Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Deleted**	Implementing additional surface water storage project increment for Shasta would not be as efficient as new storage in Shasta Reservoir. Potential for shared storage in NODOS project is being considered in separate feasibility study initiated under Public Law 108-7. Evaluated during the CALFED alternative development process.
Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam	**Deleted**	Moderate to high potential to enhance water supplies for system deliveries when combined with new storage and reoperation of Shasta Dam and Reservoir. Although this measure was initially retained during preliminary analyses, it has been eliminated because of operations analyses indicating tradeoffs between conjunctive use water supply benefits and critical gains in fisheries accomplishments.
Develop additional conservation groundwater storage south of the Sacramento-San Joaquin Delta	**Deleted**	Not as effective as storage north of the Delta and would not contribute to other study objectives. Evaluated during the CALFED alternative development process.
Coordinate Operation and Precipitation Enhancement		
Improve Delta export and conveyance capability through coordinated CVP and SWP operations	**Deleted**	JPOD is being actively pursued in other programs. A likely without-project condition.
Implement additional precipitation enhancement	**Deleted**	Not an effective alternative to new storage. Very limited potential to benefit drought period water supply reliability. Being actively pursued under without-project conditions.
Reduce Demand		
Implement water use efficiency methods	**Retained**	Although water use efficiency does not increase supplies, conservation is being actively pursued through other programs. Conservation needs to be considered as an element of any plan for addressing California's water future.
Retire agricultural lands	**Deleted**	Limited potential to help meet future water demands in the Central Valley. Agricultural lands of marginal value are often already fallowed drought periods. High degree of uncertainty regarding the ability to acquire and retire sufficient higher productivity lands. Land retirement test programs being performed by Reclamation under other programs. On a large scale, could have significant negative impacts on agricultural industry.
Improve Water Transfers and Purchases		
Transfer water between users	**Deleted**	Not an alternative to new storage at Shasta Dam. Does not address planning objectives or considerations/criteria. Will likely be accomplished with or without additional efforts to develop new sources. Evaluated during the CALFED alternative development process.

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

Measure Description	Study Status	Status Rationale
Expand Delta Export and Conveyance Facilities		
Expand Banks Pumping Plant	**Deleted**	Not an alternative to new storage north of the Delta. Does not address planning objectives or considerations/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Construct DMC/CA intertie	**Deleted**	Not an alternative to new storage north of the Delta. Does not address planning objectives or considerations/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Improve Surface Water Treatment		
Implement treatment/supply of agricultural drainage water	**Deleted**	Not a viable alternative to new water storage. High unit water cost. Evaluated as part of the CALFED Water Quality Program.
Construct desalination facility	**Deleted**	Low potential to address the primary planning objective of agricultural water supply reliability. Most efficient when used as a base water supply; highly inefficient in providing drought period water supplies. Very high unit water cost. Evaluated as part of the CALFED Water Use Efficiency Program.

Key:
Banks Pumping Plant = Harvey O. Banks Pumping Plant
CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
DMC/CA = Delta-Mendota Canal/California Aqueduct
JPOD = Joint Point of Diversion
NODOS = North-of-the-Delta Offstream Storage
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
ROD = Record of Decision
SWP = State Water Project

Table 3-3. Management Measures Addressing Secondary Planning Objective of Conserving, Restoring, and Enhancing Ecosystem Resources

Measure Description	Study Status	Status Rationale
Improve Cold-Water and Warm-Water Fishery Habitat		
Construct shoreline fish habitat around Shasta Lake	**Retained**	Would complement measures to increase storage in Shasta Lake.
Construct instream fish habitat on tributaries to Shasta Lake	**Retained**	Would complement measures to increase storage in Shasta Lake. High local interest.
Increase instream flows on the lower McCloud River	**Deleted**	Significant impacts to hydropower.
Reduce acid mine drainage entering Shasta Lake	**Deleted**	Significant implementation, O&M, and liability issues. Encompassed within actions evaluated and prioritized under CALFED ERP.
Reduce motorcraft access to upper reservoir arms	**Deleted**	Motorcraft management is under the purview of USFS.
Increase instream flows on the Pit River	**Deleted**	Significant impacts to hydropower.
Restore and Conserve Riparian and Wetland Habitat		
Restore riparian and floodplain habitat along the Sacramento River	**Retained**	Would be compatible with other primary planning objectives. Consistent with other restoration programs and projects in the primary study area. Encompassed within actions evaluated and prioritized under CALFED ERP.
Restore wetlands along the Fall River and Hat Creek	**Deleted**	Significantly removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Conserve upper Pit River riparian areas	**Deleted**	Significantly removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Restore riparian and floodplain habitat on lower Clear Creek	**Deleted**	Significant benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Promote Great Valley cottonwood regeneration along the Sacramento River	**Deleted**	High uncertainty for Federal participation and potential to conflict with flood control requirements related to levee protection. Encompassed within actions evaluated and prioritized under CALFED ERP.
Conserve riparian corridor along Cow Creek	**Deleted**	Significant benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Remove and control nonnative vegetation in the Cow Creek and Cottonwood Creek watersheds	**Deleted**	Limited ability to provide consistent and reliable benefits, compared with the other measures proposed. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.

Table 3-3. Management Measures Addressing Secondary Planning Objective of Conserving, Restoring, and Enhancing Ecosystem Resources (contd.)

Measure Description	Study Status	Status Rationale
Improve Other Fish and Wildlife Habitat		
Create a parkway along the Sacramento River	**Deleted**	Primarily focuses on land acquisition and conversion to public uses. As a project element, it would be a non-Federal responsibility with little direct Federal interest. Elements are a likely without-project condition.
Enhance forest management practices to conserve bald eagle nesting habitat	**Deleted**	Likely a without-project condition; is an element of USFS forest recovery plans.
Remove and control nonnative plants around Shasta Lake	**Deleted**	Likely a without-project condition; is an element of USFS forest recovery plans.
Control erosion and restore affected habitat in the Shasta Lake area	**Deleted**	Likely a without-project condition; is an element of USFS forest recovery plans.
Develop geographic information system for Shasta to Red Bluff reach	**Deleted**	Would not directly contribute to other primary or secondary planning objectives. GIS mapping likely a without-project condition as part of other ongoing studies and projects.
Implement erosion control in tributary watersheds	**Deleted**	Significant benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions near Shasta Lake or along mainstem Sacramento River.

Key:
CALFED = CALFED Bay-Delta Program
GIS = geographic information system
O&M = operations and maintenance

Table 3-4. Management Measures Addressing Secondary Planning Objectives of Reducing Flood Damage, Developing Additional Hydropower Generation, Maintaining and Increasing Recreation, and Maintaining or Improving Water Quality

Planning Objectives/ Measure Description	Study Status	Status Rationale
Reduce Flood Damage		
Update Shasta Dam and Reservoir flood management operations	**Retained**	Compatible with any potential modification of Shasta Dam and Reservoir. Potential to realize an increase in flood damage reduction with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning considerations/criteria.
Increase flood management storage space in Shasta Reservoir	**Deleted**	Would conflict with the primary planning objectives. Estimated low potential for economic justification (costs are expected to exceed benefits). For increased space via raising Shasta Dam, it is expected that dam raise construction costs would significantly exceed flood damage reduction benefits. For space increase through reoperation, expected costs to replace reduction in water reliability would also significantly exceed flood damage reduction benefits.
Implement nonstructural flood damage reduction measures	**Deleted**	Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Implement traditional flood damage reduction measures	**Deleted**	Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Route probable maximum flood from top of conservation pool	**Deleted**	This measure is already consistent with existing reservoir conditions and operations, making further changes unnecessary.
Develop Additional Hydropower Generation		
Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head	**Retained**	Potential to realize an increase in hydropower output from Shasta with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning considerations/criteria.
Construct new hydropower generation facilities	**Deleted**	This measure would directly contribute to the secondary planning objective but it is an independent action and not directly related to accomplishing the primary planning objectives. Although this measure has potential to realize additional hydropower benefits with increased/replaced hydropower facilities, it could be pursued regardless of primary planning objectives.

Table 3-4. Management Measures Addressing Secondary Planning Objectives of Reducing Flood Damage, Developing Additional Hydropower Generation, Maintaining and Increasing Recreation, and Maintaining or Improving Water Quality (contd.)

Planning Objectives/ Measure Description	Study Status	Status Rationale
Maintain and Increase Recreation Opportunities		
Maintain and enhance recreation capacity, facilities, and opportunities	**Retained**	Compatible with any potential modification of Shasta Dam and Reservoir. Would be consistent with established planning guidelines for Federal water storage projects and with existing recreation uses at Shasta Reservoir.
Develop new National Recreation Area recreation plan	**Deleted**	Developing, coordinating, and implementing a new National Recreation Area as a stand-alone measure is believed to be a separate Federal action outside the scope of this investigation. It is understood, however, that other measures, such as enlarging Shasta Dam and Reservoir would likely require, at minimum, modification of existing recreation plan.
Reoperate reservoir for recreation	**Retained**	Compatible with any potential modification of Shasta Dam and Reservoir. Potential to realize an increase in recreation experiences with increasing size of Shasta Reservoir for primary planning objectives. Limited potential for reservoir reoperation to benefit recreation by allowing more reliable filling of the reservoir during the spring.
Maintain or Improve Water Quality		
Improve operational flexibility for Sacramento-San Joaquin Delta water quality by increasing storage in Shasta Reservoir	**Retained**	Compatible with any potential modification of Shasta Dam and Reservoir. Increased storage would contribute to meeting downstream water quality requirements and would provide for increased operational flexibility and Sacramento-San Joaquin Delta emergency response.

Measures to Address Primary Planning Objectives

As shown in Tables 3-1 and 3-2, numerous measures were identified to address the primary planning objectives of increasing anadromous fish survival and increasing water supply reliability.

Increase Anadromous Fish Survival A number of potential management measures were identified to address increasing anadromous fish survival and other ecosystem restoration opportunities, above and beyond implementation of actions and programs identified in the CVPIA and AFRP. Most are listed in the 2003 *Ecosystem Restoration Office Report* (Reclamation). These measures were separated into three broad categories: (1) improved fish habitat, (2) improved water flows and quality, and (3) improved fish migration. Of more than 20 measures identified specifically to address the primary planning objective of increasing anadromous fish survival in the Sacramento River, 6 measures were initially retained for possible inclusion in concept plans. Through the alternatives formulation and screening process, these measures were further refined and screened. Five measures were incorporated into the comprehensive plans evaluated in this Feasibility Report (see Table 3-1).

As indicated in Table 3-1, many of the management measures considered to address increasing anadromous fish survival are encompassed under the Ecosystem Restoration Program (ERP) included as part of the CALFED Preferred Program Alternative. The CALFED ERP includes multiple actions to address the goal of improving and increasing aquatic and terrestrial habitats and improving ecological functions in the Bay-Delta system to support sustainable populations of diverse and valuable plant and animal species. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities (DFG et al. 2010).

Increase Water Supply Reliability Various potential management measures were identified to address the primary planning objective of increasing water supply reliability for M&I, agricultural, and environmental purposes to help meet current and future water demands. These measures were separated into eight categories: (1) increased surface water storage, (2) reservoir reoperation, (3) improved conjunctive water management, (4) coordinated operation and precipitation enhancement, (5) demand reduction, (6) improved water transfers and purchases, (7) improved Delta export and conveyance, and (8) improved surface water treatment. Of 22 measures considered to help increase water supply reliability, 4 were retained for possible inclusion in concept plans. Through the alternatives formulation and screening process, these measures were further refined and screened. Three measures were incorporated into the comprehensive plans evaluated in this Feasibility Report (see Table 3-2).

Measures to Address Secondary Planning Objectives

The following is a discussion of measures identified to address secondary planning objectives.

Conserving, Restoring, or Enhancing Ecosystem Resources Identifying potential ecosystem restoration opportunities included management measures to address the secondary objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam. The measures were separated into three categories: (1) improving cold-water and warm-water fisheries, (2) restoring and conserving riparian and wetland habitat, and (3) improving other fish and wildlife habitat. Of the 19 management measures identified to address this secondary planning objective, 3 were retained for further development (see Table 3-3). As indicated in Table 3-3, many of the management measures considered to address increasing anadromous fish survival are encompassed under the ERP, which was included as part of the CALFED Preferred Program Alternative.

Reduce Flood Damage Five management measures were identified to help reduce flood damage along the Sacramento River. Of the five, two were initially retained for further development and possible inclusion in concept plans. These included (1) updating Shasta Dam and Reservoir flood management operations and (2) routing the probably maximum flood from the top of the conservation pool. Through additional analyses, the second measure was found to be consistent with existing reservoir operations and was subsequently eliminated from further consideration; the first measure was incorporated into the comprehensive plans evaluated in this Feasibility Report (see Table 3-4).

Develop Additional Hydropower Generation Two management measures were considered to increase hydropower potential in the study area. They included (1) modifying the existing/constructing new generation facilities at Shasta Dam to take advantage of increased hydraulic head and (2) constructing new hydropower generation facilities in the area. As shown in Table 3-4, the first measure was retained for further development in concept and comprehensive plans.

Maintain and Increase Recreation Opportunities Three management measures were identified to help maintain and increase recreation opportunities at Shasta Lake. Of these three measures, two (see Table 3-4) were retained for further development in concept and comprehensive plans. They include (1) maintaining and enhancing recreation capacity, facilities, and opportunities, and, (2) reoperating the reservoir to stabilize early season filling in Shasta Lake.

Maintain or Improve Water Quality One management measure was identified to improve water quality in the Sacramento River and Delta (see Table 3-4). It was retained for further development in concept and comprehensive plans. This measure involves improving operational flexibility to improve Delta water quality by increasing storage in Shasta Reservoir.

Measures Retained for Further Development

Following is a brief description of the management measures retained for further consideration and incorporated into the comprehensive plans.

Increase Anadromous Fish Survival The following five measures were retained to address the primary objective of increasing the survival of anadromous fish populations in the Sacramento River.

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

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

- **Replenish Spawning Gravel in the Sacramento River –** The restoration of aquatic habitat between Keswick Dam and Red Bluff is of high priority because this reach is one of the few remaining spawning corridors available to anadromous fish along the Sacramento River. This measure would support the primary planning objective of increasing the survival of anadromous fish populations in the Sacramento River by contributing to the replenishment of spawning gravels used by anadromous fish. Gravel recruitment is of particular importance to anadromous fish, which require clean gravels for their spawning beds. Dams, river diversions, gravel mining, and other obstructions have blocked or reduced natural gravel sources. Suitable spawning gravel has been identified as a potential limiting factor in the recovery of anadromous fish populations on the Sacramento River. Several other programs, including CALFED and the AFRP, have

provided gravel replenishment in selected locations. This measure would involve transporting and placing gravel into the Sacramento River downstream from Keswick Dam. Structural treatments may be required below Keswick Dam to prevent the gravel from being washed downstream. Temporary construction easements could be required. Suitable spawning gravel would consist of uncrushed, natural river rock, washed and placed in the river at strategic locations. Hydraulic and geomorphic evaluations are needed to determine the most effective gravel size distribution and the most appropriate locations for gravel placement.

- **Make Additional Modifications to Shasta Dam for Temperature Control** – For relatively small raises of Shasta Dam, the existing TCD structure would be retrofitted to account for additional dam height, and to reduce leakage of warm water into the structure, but no new structure would be needed. However, modifications to, or replacement of, the existing structure are more likely to be necessary for increasingly higher dam raises. This measure would support the primary planning objective of increasing the survival of anadromous fish populations by (1) increasing the ability of operators at Shasta Dam to meet downstream temperature requirements for anadromous fish, (2) providing more flexibility in achieving desirable water temperatures during critical spawning, rearing, and out-migration, and (3) extending the area of suitable spawning habitat farther downstream in the Sacramento River.

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

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

This measure would support the primary planning objective of increasing survival of anadromous fish populations by (1) improving water temperature control, (2) extending suitable spawning habitat, and (3) improving overall physical aquatic habitat conditions in the Sacramento River.

- **Modify Storage and Release Operations at Shasta Dam** – In addition to water temperature, flow conditions in the upper Sacramento River are important in addressing anadromous fish needs. This measure consists of enlarging Shasta Dam and modifying seasonal storage and releases to benefit anadromous fisheries. Although this measure could help provide greater flexibility in meeting water temperature targets, it would be aimed primarily at improving flows and influencing physical channel conditions for anadromous fish. Changes would be made to the timing and magnitude of releases performed to maintain target flows in spawning areas, and improve the quality of aquatic habitat. The quality of aquatic habitat could be further improved by cleaning spawning gravels. This measure could also include release changes during the flood season to permit "pulse flows" and other releases that could improve aquatic habitat conditions. Further, the measure could help provide additional control and dilution of acid mine drainage from Spring Creek. This measure was retained as part of an adaptive management strategy.

Increase Water Supply Reliability The following three measures were retained to address the primary objective of increasing water supply and water supply reliability for agricultural, M&I, and environmental purposes.

- **Increase Conservation Storage Space in Shasta Reservoir by Raising Shasta Dam** – This measure consists of structural raises of Shasta Dam ranging from about 6.5 feet to approximately 200 feet. A range of potential dam raises has been considered in previous studies, including raises of more than 200 feet. A raise of 6.5 feet is included in the Preferred Program Alternative for the CALFED Programmatic ROD (2000a). Raising Shasta Dam would contribute directly to the primary planning objectives, and previous studies have indicated that raising the dam would be technically feasible. Raising Shasta Dam also could contribute to the secondary planning objectives.

- **Increase Effective Conservation Storage Space in Shasta Reservoir by Increasing Efficiency of Reservoir Operation for Water Supply Reliability** – This measure consists of modifying the operation of Shasta Dam to improve water supply reliability. It could also assist in improving efforts to reduce flood damages. Potential methods to improve water supply reliability include modifying rainflood parameters – those which address space for flows from winter rainfall – in the operation rules for Shasta Reservoir and modifying the Shasta

Dam release schedule. The goal of the operation changes would be to minimize required evacuation of the reservoir from about late November through March, and to possibly allow the reservoir to be filled more rapidly in the spring. A primary criterion would be to prevent adversely affecting existing flood protection provided by Shasta Dam.

- **Implement Water Use Efficiency Methods** – Water use efficiency methods can help reduce future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow, and available supplies remain relatively static, more effective use of supplies can reduce potential critical impacts to urban and agricultural resources resulting from water shortages. Many water use efficiency actions will be accomplished with or without implementation of other projects to address water supply reliability. This includes continued implementation of current best management practices for urban and agricultural conservation. It is estimated that additional water conservation measures, although costly to implement, will play a major role in California's water future. Accordingly, water use efficiency was retained for consideration as a potential project element for any plan to be considered for the SLWRI.

Conserve, Restore, and Enhance Ecosystem Resources The following measures were retained to address the secondary objective of conserving, restoring, and enhancing ecosystem resources in the Shasta Lake area and along the upper Sacramento River.

- **Construct Shoreline Fish Habitat Around Shasta Lake** – The mostly barren shoreline of Shasta Lake does not contribute to supporting juvenile fish. In addition, lack of shoreline cover structures, such as vegetation and woody debris, and suitable shallow-water fish habitat around the lake limit preferred habitat for juvenile fish. This measure would improve shallow, warm-water fish habitat at specific locations around the shoreline of Shasta Lake using resilient vegetation and aquatic "cover" structures within the upper drawdown area of the lake. The measure would involve (1) installing artificial fish cover, including complex woody structures, (2) planting water-tolerant and/or erosion-resistant vegetation at prescribed locations within the reservoir drawdown area, and (3) performing selective reservoir rim clearing of specific trees and vegetation. This measure would support the secondary planning objective of preserving and restoring ecosystem resources in the Shasta Lake area by (1) increasing the survival of juvenile fish through improving the quantity of available cover and overall quality of shallow-water habitat, and (2) benefiting land-based species that inhabit the shoreline of Shasta Lake through establishing resilient vegetation.

- **Construct Instream Fish Habitat on Tributaries to Shasta Lake** – This measure would conserve and/or restore instream aquatic habitat on lower reaches of key tributaries to Shasta Lake. Two categories of potential aquatic habitat restoration in tributaries include (1) identifying and correcting barriers to fish passage that are critical to various life stages for native fish species, particularly at culverts and other human-made barriers, and (2) identifying and implementing feasible aquatic habitat improvements intended to conserve or restore degraded aquatic and riparian habitat in tributaries to Shasta Lake. Fish passage improvements include restoring and/or enhancing a minimum of five perennial stream crossings to help enable upstream and downstream passage for all life stages of native fish in Shasta Lake. Aquatic habitat restoration includes efforts to reestablish or enhance aquatic connectivity, and reestablish or conserve riparian vegetation needed to provide shade, cover, and organic material. Additionally, aquatic habitat restoration includes reducing sediment and other pollutants associated with roads and other human-made disturbances from discharging into streams flowing into Shasta Lake. The lower reaches of intermittent and perennial streams tributary to Shasta Lake that support aquatic organisms native to the upper Sacramento River would be targeted for aquatic restoration under this measure, because they provide year-round fish habitat. This measure would support the secondary planning objective of conserving and restoring ecosystem resources in Shasta Lake.

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

Reduce Flood Damage The following measure was retained to address the secondary objective of reducing flood damages along the Sacramento River.

- **Update Shasta Dam and Reservoir Flood Management Operations** – This measure would include reassessing existing seasonal flood

management storage space needs at Shasta using updated information on regional hydrologic and meteorological conditions and rainfall/runoff characteristics in the drainage basin. Potential methods to improve flood management would include improved long-range weather forecasting, implementing additional forecast-based reservoir drawdown to provide additional space for anticipated high flow events, changing the criteria regarding the rate of outflows from Shasta Dam, and modifying target peak flows at Bend Bridge. Several possible reoperation opportunities are described in the document *Assessment of Potential Shasta Dam Reoperation for Flood Control and Water Supply Improvement* (Reclamation 2004c). This measure would not conflict with other secondary planning objectives, planning considerations, or criteria.

Develop Additional Hydropower Generation The following measure was retained to address the secondary objective of developing additional hydropower generation capabilities at Shasta Dam.

- **Modify Existing/Construct New Generation Facilities at Shasta Dam to Take Advantage of Increased Hydraulic Head** – This measure consists of modifying the hydropower generation facilities at Shasta Dam to take advantage of any increases in water surface elevations resulting from enlarging the dam, if applicable. Nearly all releases from Shasta and Keswick dams are made through their generating facilities. On occasion, however, outflows during flood operations are made through the flood control outlets and over the spillway. During these instances, the existing powerplant is bypassed for much of the flood (space evacuation) release. Power generated during these brief and infrequent periods generally has a lower value because of usually abundant supplies during winter periods. Raising Shasta Dam would create the potential to reduce these flood releases in winter and allow water to pass through the generators later in the year when the water and power are usually more valuable. Further, with higher water surface elevation, greater energy levels (head) would be available for operating the turbines.

Maintain and Increase Recreation Opportunities The following measures were retained to address the secondary objective of maintaining and increasing recreation opportunities at Shasta Lake.

- **Maintain and Enhance Recreation Capacity, Facilities, and Opportunities** – Recreation is not a specific purpose of the Shasta Division of the CVP, and no formal recreation facilities were developed as part of the original project. However, in 1965, Congress established the Whiskeytown-Shasta-Trinity NRA. As a result of that act and subsequent direction, USFS manages recreation within the NRA, which includes managing numerous water resources and related recreation

activities at Shasta Lake. Increasing the storage in Shasta Lake would provide a larger water surface for recreation and reduce drawdown during the recreation season. This measure focuses on maintaining existing recreation capacity at Shasta Dam and Lake through relocating and modernizing recreation facilities adversely affected by a higher lake level. It also includes enhancing opportunities related to the larger lake surface and modernized recreation facilities.

- **Reoperate Reservoir for Recreation** – This measure consists of changing the established rules for operating Shasta Dam and Reservoir for flood management to benefit recreation resources at Shasta Lake. A claim by many of the recreation interests around Shasta Lake is that often the lake has to be drawn down in early spring for flood management purposes and then, because of limited inflows in the remainder of the season, the lake cannot recover, which adversely impacts recreation (as well as water supply). Local residents identify 2004 as an example and also claim that the existing reservoir operation rules for flood management are outdated (based on a USACE report dated 1977, over 35 years ago) and that by using more recent data and current technologies, the drawdown would not be required in some years, or would not be as significant. There is limited potential for changes in flood management rules to allow for more operational flexibility in reservoir drawdown requirements in response to storms with improved advanced forecasting. Additionally, with an increase in reservoir depth due to raising Shasta Dam, reservoir reoperation would likely include raising the bottom of flood control pool elevation, allowing for higher winter and spring water levels.

Maintain or Improve Water Quality The following measure was retained to address the secondary objective of maintaining or improving water quality conditions downstream from Shasta Dam and in the Delta.

- **Improve Operational Flexibility for Sacramento-San Joaquin Delta Water Quality by Increasing Storage in Shasta Reservoir** – This measure consists of enlarging Shasta Dam to improve operational flexibility, which could contribute to Delta water quality conditions and Delta emergency response. Shasta Dam has the ability to provide increased releases and high flow releases to reestablish Delta water quality. Improved Delta water quality conditions could provide benefits for both water supply reliability and ecosystem restoration by potentially increasing Delta outflow during drought years, and reducing salinity during critical periods.

Measures Summary

Table 3-5 summarizes the final management measures carried forward to address the primary and secondary planning objectives. Of the management measures considered, eight measures addressing primary planning objectives

were identified for further consideration and potential inclusion in alternative plans. Additionally, eight measures addressing the secondary planning objectives were identified for further consideration and inclusion, to the extent possible, in alternative plans. Measures that have been carried forward are believed to best address the objectives of the SLWRI, with consideration of planning constraints and criteria.

Concept Plans

Concept plans are plans that are conceptual in scope, formulated from retained management measures to investigate strategies to address project objectives. For the SLWRI, concept plans were first formulated from the retained management measures, as shown in Table 3-6. As noted in Table 3-6, some management measures initially carried forward and included in concept plans were later eliminated from further consideration during the planning process and are not included in the final management measures in Table 3-5. Each concept plan was reviewed for impacts, costs, and benefits and compared to planning objectives to determine whether the plan should be eliminated or carried forward into the comprehensive plans phase. The purpose of this phase of the formulation process was to (1) explore an array of different strategies to address the primary planning objectives, constraints, considerations, and criteria, and (2) identify concepts that warranted further development in the comprehensive plans phase.

Table 3-5. Final Measures to Address Planning Objectives

Planning Objective	Management Measure	
Primary Planning Objectives		
Increase Anadromous Fish Survival	Construct Instream Aquatic Habitat	Construct instream aquatic habitat downstream from Keswick Dam through side channel restoration
	Replenish Spawning Gravel	Replenish spawning gravel in the Sacramento River
	Modify Temperature Control Device	Make additional modifications to Shasta Dam for temperature control
	Enlarge Shasta Lake Cold-Water Pool	Raise Shasta Dam to increase the cold-water pool in the lake to increase anadromous fish survival
	Modify Storage and Release Operations at Shasta Dam	Modify storage and release operations at Shasta Dam to benefit anadromous fish (included as part of adaptive management strategy)
Increase Water Supply and Supply Reliability	Increase Conservation Storage	Increase conservation storage space in Shasta Reservoir by raising Shasta Dam
	Reoperate Shasta Dam	Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability
	Reduce Demand	Identify and implement, to the extent possible, water use efficiency methods
Secondary Planning Objectives		
Conserve, Restore, and Enhance Ecosystem Resources	Restore Shoreline Aquatic Habitat	Construct shoreline fish habitat around Shasta Lake
	Restore Tributary Aquatic Habitat	Construct instream fish habitat on tributaries to Shasta Lake
	Restore Riparian Habitat	Restore riparian and floodplain habitat along the upper Sacramento River
Reduce Flood Damage	Modify Flood Operations Guidelines	Update Shasta Dam and Reservoir flood management operations to improve system-wide reliability and public health and safety
Develop Additional Hydropower Generation	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head
Maintain and Increase Recreation	Maintain and Enhance Recreation Facilities	Maintain and enhance recreation capacity, facilities, and opportunities
	Reoperate Reservoir	Increase recreation use by stabilizing early season filling in Shasta Lake
Maintain or Improve Water Quality	Increase Operational Flexibility	Improve operational flexibility for Delta water quality by increasing storage in Shasta Reservoir

Key:
Delta = Sacramento-San Joaquin Delta

Table 3-6. Summary of Concept Plan Features

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

Notes:

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

[2] All concept plans include water demand reduction.

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

[4] Water quality and recreation were added as secondary objectives after development of concept plans, and are not considered in this table.

Key:

* Coincidental benefit, although not a primary focus of the concept plan.

AFS = anadromous fish survival

CO = combined objectives

TCD = temperature control device

WSR = water supply reliability

X = Primary focus of concept plan

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

Each of the concept plans (and later comprehensive plans) included various common features: (1) modifications to the TCD, (2) reoperation of Shasta Dam for flood management, and (3) facilities to take advantage of the increased head for hydropower. Concept plans are described in detail in the Plan Formulation Appendix and summarized briefly below.

Plans Focused on Anadromous Fish Survival

Three concept plans were formulated from the management measures retained to address the primary planning objective of AFS. Each plan includes raising Shasta Dam 6.5 feet and enlarging the reservoir by 256,000 acre-feet, but the plans differ in how the additional storage would be used to benefit anadromous fish. Progressively higher raises produce proportionally greater benefits to anadromous fish. 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 plans could be compared.

AFS-1 – Increase Cold-Water Assets with Shasta Operating Pool Raise

The primary focus of AFS-1 is to maintain cooler water temperatures in the upper Sacramento River by increasing the minimum end-of-October carryover storage target. This would allow additional cold water to be stored for use in 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. It was found that this plan had a significant potential to benefit anadromous fish in the upper Sacramento River, but there would be no additional increase in water supply reliability. This plan was not retained for further development as a stand-alone plan because it did not meet the primary planning objective of increasing water supply reliability. However, major features of this plan were retained for further development into comprehensive plans.

AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement

AFS-2 focuses on the primary planning objective of anadromous fish survival by using the additional reservoir storage to increase minimum seasonal flows in the upper Sacramento River. No changes would be made to the carryover target

volume or minimum operating pool. Subsequent evaluation indicated that although at various stages of development the concept of increasing minimum flows would be beneficial for fish, at other life stages increasing minimum flows would be detrimental. Accordingly, this plan was deleted from further development.

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

AFS-3 is similar to AFS-2, except that it also includes acquiring, restoring, and reclaiming one or more inactive gravel mine along the upper Sacramento River to restore about 150 acres of aquatic and floodplain habitat. However, increasing minimum flows was not found to significantly benefit to anadromous fish, and concerns were expressed regarding significant uncertainties about offstream areas being able to successfully support viable fish spawning and rearing. Further, during public scoping activities in late 2005, little to no interest was demonstrated for restoring inactive gravel mines along the Sacramento River above the RBPP. Accordingly, this plan element was deleted from further consideration.

Plans Focused on Water Supply Reliability

Four concept plans were formulated from the management measures retained to address the primary planning objective of increasing WSR. The magnitude of enlarging Shasta Dam was important when developing the WSR plans because storage capacity is the most influential factor in determining benefits to water supply reliability for this study. Hence, three dam raises were considered in the WSR plans: 6.5 feet, 18.5 feet, and 200 feet. Water supply reliability estimates presented in this section are from the 2004 *SLWRI Initial Alternatives Information Report* (Reclamation 2004a). Increases in south-of-Delta agricultural water deliveries comprise the majority of water supply reliability benefits for all WSR plans. The remaining benefits are seen in increased water deliveries for south-of-Delta M&I and north-of-Delta agricultural and M&I uses.

WSR-1 – Increase Water Supply Reliability with 6.5-foot Dam Raise

WSR-1 would increase water supply reliability by increasing critical and dry year water supplies for CVP and SWP deliveries by at least 72,000 acre-feet per year. In addition to water supply reliability, there would be benefits to anadromous fish in the upper Sacramento River, increases in power generation, and the potential for increases in reservoir area recreation. This plan was retained for further development.

WSR-2 – Increase Water Supply Reliability with 18.5-foot Dam Raise

The 18.5-foot raise is the largest practical dam raise that does not require relocating the Pit River Bridge, and would increase the capacity of the reservoir by 634,000 acre-feet to a total of 5.19 MAF. WSR-2 would increase water supply reliability by increasing critical and dry year water supplies for CVP and SWP deliveries by at least 125,000 acre-feet per year. Additionally, there would

be benefits to anadromous fish in the upper Sacramento River, increases in power generation, and the potential for increases in reservoir area recreation. This plan was retained for further development.

WSR-3 – Increase Water Supply Reliability with 200-foot Dam Raise

The 200-foot raise is the maximum amount considered to be technically feasible and would increase the capacity of the reservoir by 9.3 MAF to a total of 13.9 MAF. The magnitude of this raise would require significant modifications or replacement of most facilities associated with the dam, including hydropower facilities, and would require modifying Keswick Dam and its powerplant. This plan would provide a major increase in water supply reliability, anadromous fish, hydropower, flood damage reduction, and recreation resources. However, the plan is not financially feasible at this time because the construction cost is estimated at over $6 billion (at October 2008 price levels). Accordingly, this plan was deleted from further consideration in this Feasibility Report.

WSR-4 – Increase Water Supply Reliability with 18.5-foot Dam Raise and Conjunctive Water Management

This plan is similar to WSR-2, but includes implementing a conjunctive water management component consisting largely of contracts between Reclamation and certain Sacramento River basin water users. The conjunctive water management component includes downstream facilities, such as additional river diversions and transmission and groundwater pumping facilities, to facilitate exchanges. Reclamation would provide additional surface supplies in wet and normal water years to participating CVP users, in exchange for reducing deliveries in dry and critical years, when users would rely more on groundwater supplies. Preliminary estimates of the conjunctive water management component associated this alternative indicated that water supplies for CVP and SWP deliveries could be increased between 10 to 20 percent. This plan was initially retained for further development. However, subsequent analysis of WSR-4 indicated tradeoffs between conjunctive use water supply benefits and critical gains in fisheries benefits. The resulting reduction in benefits to fisheries operations in dry and critical years[1] was deemed unacceptable in terms of meeting primary project objectives. Thus, WSR-4 was eliminated from further consideration.

Plans Focused on Combined Objectives

Five combination plans are summarized below that were developed to represent a reasonable balance between the two primary planning objectives. The CO concept plans also include measures to actively address the secondary planning objectives, as appropriate. The CO plans identified below are believed to be reasonably representative, although not exhaustively, of the range of potential and applicable actions.

[1] Throughout this document, water year types are defined according to the Sacramento Valley Index Water Year Hydrologic Classification unless specified otherwise.

CO-1 and CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with 6.5-foot and 18.5-foot Dam Raises, Respectively

Both CO-1 and CO-2 would dedicate some of the added reservoir space from the dam raise to increasing the minimum carryover storage in Shasta Reservoir to make more cold-water releases for regulating water temperature in the upper Sacramento River. Similar to AFS-3, both CO plans include restoring one or more inactive gravel mine along the upper Sacramento River, providing additional aquatic and floodplain resources to the Sacramento River between Keswick and Battle Creek, a critical spawning reach. Both plans could increase water supply reliability by increasing water supplies for CVP and SWP critical and dry year deliveries by 72,000 acre-feet and 125,000 acre-feet, for CO-1 and CO-2, respectively. A higher water surface elevation in the reservoir would result in a net increase in power generation, and increase the maximum surface area, which would benefit recreation. For reasons similar to those described for AFS-3, both CO-1 and CO-2 were eliminated as stand-alone plans and the gravel mine restoration components of both plans were deleted from further consideration.

CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with 18.5-foot Dam Raise

CO-3 includes features similar to those of 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 Chinook salmon on the upper Sacramento River. Under this preliminary plan, approximately 320,000 acre-feet would be dedicated to increasing minimum flows from approximately 3,250 cfs to about 4,200 cfs between October 1 and April 30. However, as described for ASF-2, while it was concluded that although at various stages of development the concept of increasing minimum flows would be beneficial for fish, at other life stages, increasing minimum flows would be detrimental. Accordingly, this plan was deleted from further development.

CO-4 and CO-5 – Multipurpose with 6.5-foot and 18.5-foot Dam Raise, Respectively

CO-4 and CO-5 address both the primary and secondary planning objectives of the SLWRI through a combination of measures, including raising Shasta Dam, restoring habitat, and adding recreation facilities in the Shasta Lake area. Enlargement of the reservoir and limited reservoir reoperation would also help improve operations for flood management and recreation. The secondary planning objective of environmental restoration also would be addressed through shoreline and tributary habitat improvements, including restoring (1) resident fish habitat in Shasta Lake and (2) riparian habitat at locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek. This plan, at the 18.5-foot dam raise (CO-5), was retained for further development.

Comprehensive Plan Development and Influencing Factors

Consistent with the P&G, the iterative plan formulation process includes assessing and refining concept plans and management measures carried forward to formulate comprehensive plans. Following is a summary of the rationale used to formulate SLWRI comprehensive plans in the Draft Feasibility Report and DEIS and the final comprehensive plans in the Final Feasibility Report and Final EIS.

Formulation of Comprehensive Plans

As described above, numerous management measures were identified, evaluated, and screened. Through continued refinement of management measures and concept plans carried forward, the following plan types were identified for further development into comprehensive plans:

- Plan(s) to raise Shasta Dam between 6.5 feet and 18.5 feet, focusing on both water supply reliability and anadromous fish survival but with benefits to various secondary planning objectives

- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on anadromous fish survival, but also including water supply reliability and other various secondary planning objectives

- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on all planning objectives

Considering results of initial plan formulation efforts, the approach was to first formulate plans focusing on different dam raise heights within the range of 6.5 to 18.5 feet to address the first plan type listed above. A dam raise of 12.5 feet in CP2 was chosen because it represented a midpoint between the smallest and largest practical dam raises. Next, the approach was to identify the most efficient and effective dam raise height and formulate comprehensive plans to focus on anadromous fish survival and other objectives at this height.

Comprehensive Plans in the Draft Feasibility Report and Supporting Documents

Using the general rationale described above, and incorporating input from the public scoping process and continued coordination with resource agencies and other interested parties, five comprehensive plans were developed for the Draft Feasibility Report and Preliminary DEIS:

- **Preliminary Comprehensive Plan 1 (PCP1)** – 6.5-foot-dam raise, enlarging the reservoir by 256,000 acre-feet, focusing on both anadromous fish survival and water supply reliability

- **Preliminary Comprehensive Plan 2 (PCP2)** – 12.5-foot-dam raise, enlarging the reservoir by 443,000 acre-feet, focusing on both anadromous fish survival and water supply reliability

- **Preliminary Comprehensive Plan 3 (PCP3)** – 18.5-foot-dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on both anadromous fish survival and water supply reliability

- **Preliminary Comprehensive Plan 4 (PCP4)** – 18.5-foot-dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on anadromous fish survival while increasing water supply reliability

- **Preliminary Comprehensive Plan 5 (PCP5)** – 18.5-foot-dam raise, enlarging the reservoir by 634,000 acre-feet; a combination plan focusing on all planning objectives

As described further in Section "Related Studies, Projects, and Programs," of Chapter 1, due to uncertainty related to CVP and SWP operational constraints, water operations modeling and related evaluations in the 2011 Draft Feasibility Report and Preliminary DEIS were based on available modeling analyses at the time. This modeling reflected CVP and SWP operations and constraints described in the 2004 Long-Term Operation BA, 2004 NMFS BO, and 2005 USFWS BO.

- The Reclamation 2004 *Long-Term CVP and SWP Operations Criteria and Plan Biological Assessment* (2004 Long-Term Operations BA) (Reclamation 2004)

- The NMFS 2004 *Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan* (2004 NMFS BO) (NMFS 2004)

- The USFWS 2005 *Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues* (2005 USFWS BO) (USFWS 2005)

These analyses were suitable for comparison purposes, and reflected expected variation among the alternatives, including the type and relative magnitude of anticipated impacts and benefits.

Because of the large number of possibilities for increasing anadromous fish survival, additional analyses were conducted to determine the combination of actions that would provide the greatest overall benefits within PCP4. These analyses are described below.

Refinement of Plan for Anadromous Fish Survival Focus with Water Supply Reliability Primarily using the SALMOD model, and based on output from the water operations (CalSim-II), reservoir temperature, and river temperature models, a suite of flow- and temperature-focused actions (scenarios) were investigated to assess which combination of actions would likely result in the maximum increase in fish populations.

To formulate PCP4, three dam height raises were considered (6.5 feet, 12.5 feet, and 18.5 feet), resulting in 256,000 acre-feet, 443,000 acre-feet, and 634,000 acre-feet of increased storage, respectively. For each of these proposed dam raises, several combinations for allocating the increased storage were analyzed. For instance, assuming a dam raise of 12.5 feet, three options were considered: (1) no increase in the minimum pool, (2) an increase in the minimum pool similar to a 6.5-foot dam raise, and (3) all of the increased space dedicated to increased fisheries. The combinations considered represent scenarios developed to focus on increasing the cold-water pool, and are listed in Table 3-7.

Additional scenarios focusing on increasing Sacramento River flows with an 18.5-foot raise were also analyzed. The flow combinations were based primarily on flows identified as part of the Anadromous Fish Restoration Program (USFWS 2001). These scenarios are listed in Table 3-8.

Quantitative analysis indicated that increasing the minimum pool in Shasta Reservoir would have the greatest net fishery benefit. By increasing the minimum pool, the allowable carryover pool storage would increase in the reservoir. This carryover would act to conserve cold water that could be managed to better benefit anadromous fish. Scenarios 1, 2, 3, and 4 (flow augmentation scenarios) showed limited benefits to anadromous fish compared with other scenarios, and were eliminated from further analysis. Scenarios B, E, and I would not contribute to increased water supply reliability. Although PCP4 focuses on anadromous fish survival, because these three scenarios would not contribute to a primary planning objective, they were deleted from further consideration. Of the remaining scenarios, Scenarios D and H were deemed to be the most cost-effective. Based on further analysis, Scenario H was chosen to represent reservoir operations in PCP4 because this scenario would provide the greatest benefit to anadromous fish and still meet the primary planning objective of water supply reliability. Scenario comparison and selection are further discussed in the Plan Formulation Appendix.

Table 3-7. Scenarios Considered for Cold-Water Storage – Anadromous Fish Survival Focus Plan

Cold-Water Pool Scenarios	Dam Raise (feet)	Enlarged Reservoir	Description
A (PCP1)	6.5	256,000 acre-feet	No increase in minimum pool.
B	6.5	256,000 acre-feet	Dedicating 256,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.
C (PCP2)	12.5	443,000 acre-feet	No increase in minimum pool.
D	12.5	443,000 acre-feet	Dedicating 187,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
E	12.5	443,000 acre-feet	Dedicating 443,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.
F (PCP3/PCP5)	18.5	634,000 acre-feet	No increase in minimum pool.
G	18.5	634,000 acre-feet	Dedicating 191,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
H (PCP4)	18.5	634,000 acre-feet	Dedicating 378,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
I	18.5	634,000 acre-feet	Dedicating 634,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.

Key:
PCP = preliminary comprehensive plan

Table 3-8. Scenarios Considered to Augment Flows – Anadromous Fish Survival Focus Plan

Flow Augmentation Scenario	Dam Raise (feet)	Enlarged Reservoir	Description
1	18.5	634,000 acre-feet	October – March AFRP flows or 500 cfs increase, whichever is less
2	18.5	634,000 acre-feet	October – March AFRP flows or 750 cfs increase, whichever is less
3	18.5	634,000 acre-feet	October – March AFRP flows or 1,000 cfs increase, whichever is less
4	18.5	634,000 acre-feet	Increase August flows to 10,000 cfs and September flows to 6,000 cfs for temperature control

Key:
AFRP = Anadromous Fish Restoration Program (USFWS 2001)
cfs = cubic foot per second

Refinement of Comprehensive Plans for the Final Feasibility Report, DEIS, and Final EIS

Following the release of the Draft Feasibility Report and Preliminary DEIS, Comprehensive Plans were further refined for the DEIS based on several factors, including updates to CVP and SWP water operations and stakeholder input. Water operations modeling in CalSim-II and related analyses were updated to include the following:

- 2008 USFWS BO (USFWS 2008)
- 2009 NMFS BO (NMFS 2009a)
- Additional changes in CVP and SWP facilities and operations, such as the enlarged Los Vaqueros Reservoir and implementation of the San Joaquin River Restoration Program
- Additional changes in non-CVP/SWP facilities and operations, such as the addition of the Freeport Regional Water Project

Preliminary analyses based on these updated operations indicated shifts in the distribution of water supply benefits from M&I to agricultural uses, resulting in decreased M&I water supply benefits for the Draft Feasibility Report comprehensive plans.

To improve the balance between agricultural and M&I water supply benefits, a portion of the increased storage capacity in Shasta Reservoir was reserved to specifically focus on increasing M&I deliveries during dry and critical years under Comprehensive Plan 1 (CP1), Comprehensive Plan 2 (CP2), Comprehensive Plan 4 (CP4), and Comprehensive Plan 5 (CP5). Operations targeting increased M&I deliveries were based on existing and anticipated future demands, operational priorities, and facilities of the SWP, which provides M&I water to a majority of the State's population.

In addition, to provide a greater range of focus and operations within the set of comprehensive plans, water supply operations for Comprehensive Plan 3 (CP3) were focused on agricultural water supply reliability and anadromous fish survival. Accordingly, for CP3, none of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries.

Refinement of Operational Scenario for Plan Focused on Anadromous Fish Survival with Water Supply Reliability Based on public comments on the Draft Feasibility Report and DEIS, a refined operational scenario (Comprehensive Plan 4A (CP4A)) was developed for the anadromous fish focused plan. This new operational scenario is a refinement of the operations for CP4, based on several factors, including the updated CVP and SWP operations, described above, which are based on the 2008 USFWS BO and 2009 NMFS BO. A suite of temperature and flow-focused actions (scenarios) were

investigated to assess which combination of actions would likely maximize increases in anadromous fish populations. These investigations primarily used the SALMOD model, and were based on output from the water operations (CalSim-II), reservoir temperature, and river temperature models. Similar scenario refinements were considered for the Draft Feasibility Report, as summarized in Table 3-7 and Table 3-8. However, Draft Feasibility Report scenarios were based on CVP and SWP operational scenarios including the 2004 NMFS BO and 2005 USFWS BO, which have been since updated.

A range of scenarios were considered during the development of CP4A. For these scenarios, several combinations for allocating the increased storage were analyzed, focusing on either increasing the volume of the cold-water pool in Shasta Reservoir or augmenting flows downstream from Shasta Dam. Flow augmentation scenarios were based primarily on flows identified as part of the Anadromous Fish Restoration Plan (USFWS 2001). Table 3-9 highlights the range of scenarios considered and estimated benefits to water supply reliability and anadromous fisheries under each scenario.

CP4A was selected as the refined operational scenario for CP4, as it allows for improved balance between water supply benefits and fisheries benefits compared to other scenarios.

Based on the refinements described above, this Final Feasibility Report and the accompanying Final EIS includes the following final array of comprehensive plans:

- **CP1** – 6.5-foot dam raise, enlarging the reservoir by 256,000 acre-feet, focusing on both anadromous fish survival and water supply reliability

- **CP2** – 12.5-foot dam raise, enlarging the reservoir by 443,000 acre-feet, focusing on both anadromous fish survival and water supply reliability

- **CP3** – 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on both agricultural water supply reliability and anadromous fish survival

- **CP4 and CP4A** – 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on anadromous fish survival while increasing water supply reliability

- **CP5** – 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, a combination plan focusing on all objectives

The No-Action Alternative and comprehensive plans for this Feasibility Report are described in detail in Chapter 4.

Table 3-9. Scenarios Considered for Refinement of Final EIS Comprehensive Plans

Scenario	Dam Raise (feet)	Enlarged Reservoir (acre-feet)	Description	Production Increase (number of fish)[1]	Total Increase in Water Supply Reliability[2] Average (acre-feet/year)	Total Increase in Water Supply Reliability[2] Dry/Critical (acre-feet/year)
Scenarios Considered for Cold-Water Storage as Part of Fish Focus Plan						
A (CP1)	6.5	256,000	No increase in minimum cold-water pool for fishery benefit. 70,000 acre-feet and 35,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	61,300	31,000	47,300
B	6.5	256,000	Dedicate 256,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit. No increased storage capacity in Shasta Reservoir reserved for water supply.	673,000	0	0
C (CP2)	12.5	443,000	No increase in minimum cold-water pool for fishery benefit. 100,000 acre-feet and 50,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	379,200	51,300	77,800
D	12.5	443,000	Dedicate 187,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit. 70,000 acre-feet and 35,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	428,700	31,000	47,300
E	12.5	443,000	Dedicate 443,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit. No increased storage capacity in Shasta Reservoir reserved for water supply.	999,900	0	0
F (CP3)	18.5	634,000	No increase in minimum cold-water pool for fishery benefit. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	207,400	61,700	63,100
F (CP5)	18.5	634,000	No increase in minimum cold-water pool for fishery benefit. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	377,800	75,900	113,500
G (CP4A)	18.5	634,000	Dedicate 191,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit. 100,000 acre-feet and 50,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	710,000	51,300	77,800

Table 3-9. Scenarios Considered for Refinement of Final EIS Comprehensive Plans (contd.)

Scenario	Dam Raise (feet)	Enlarged Reservoir (acre-feet)	Description	Production Increase (number of fish)[1]	Total Increase in Water Supply Reliability[2] Average (acre-feet/year)	Total Increase in Water Supply Reliability[2] Dry/Critical (acre-feet/year)
Scenarios Considered for Cold-Water Storage as Part of Fish Focus Plan (contd.)						
H (CP4)	18.5	634,000	Dedicate 378,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit. 70,000 acre-feet and 35,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	812,600	31,000	47,300
I	18.5	634,000	Dedicate 634,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit. No increased storage capacity in Shasta Reservoir reserved for water supply.	971,400	0	0
Scenarios Considered to Augment Flows as Part of Fish Focus Plan						
1[3]	18.5	634,000	October – March AFRP flows or 500 cfs increase, whichever is lower. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	348,700	54,600	57,200
1[4]	18.5	634,000	October – March AFRP flows or 500 cfs increase, whichever is lower. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	319,300	65,000	91,300
3[3]	18.5	634,000	October – March AFRP flows or 1,000 cfs increase, whichever is lower. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	222,800	42,200	35,700
3[4]	18.5	634,000	October – March AFRP flows or 1,000 cfs increase, whichever is lower. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	309,500	54,600	69,300
4[3]	18.5	634,000	Increase August flows to 10,000 cfs and September flows to 6,000 cfs for temperature control. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	88,400	62,600	76,400
4[4]	18.5	634,000	Increase August flows to 10,000 cfs and September flows to 6,000 cfs for temperature control. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	63,900	73,000	122,800

Table 3-9. Scenarios Considered for Refinement of Final EIS Comprehensive Plans (contd.)

Notes:

[1] Estimates of increased anadromous fish survival were based on simulations using the SALMOD model. These estimates represent an index of production increase, based on the simulated average annual increase in juvenile Chinook salmon surviving to migrate downstream from the RBPP.

[2] Increased water supply reliability was simulated with CalSim-II based on October to September water years. Water Year Types Based on the Sacramento Valley Water Year Hydrologic Classification. Water operations based on the USFWS 2008 *USFWS 2008 Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the CVP and SWP (*USFWS 2008) and NMFS 2009 *Biological Opinion and Conference Opinion on the Long-Term Operations of the CVP and SWP* (NMFS 2009a).

[3] Refined operational scenario based on CP3 and corresponding distribution of water supply benefits.

[4] Refined operational scenario based on CP5 and corresponding distribution of water supply benefits.

Key:

AFRP = Anadromous Fish Restoration Program

cfs = cubic feet per second

CP = Comprehensive Plan

CVP = Central Valley Project

M&I = municipal and industrial

NMFS = National Marine Fisheries Service

RBPP = Red Bluff Diversion Dam

SWP = State Water Project

USFWS = U.S. Department of the Interior, Fish and Wildlife Service

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