Final

Economic Valuation Appendix

Shasta Lake Water Resources Investigation

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Abbreviations and Acronyms

2SLS	Two-Stage Least-Squares
AF	acre feet
CALFED	CALFED Bay-Delta Program
CAISO	California Independent System Operator
CalSim-II	California Water Resources Simulation Model II
CEC	California Energy Commission
CP	comprehensive plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento-San Joaquin Delta
DFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
EQ	Environmental Quality
ESA	Federal Endangered Species Act
EWA	Environmental Water Account
FERC	Federal Energy Regulatory Commission
FY	fiscal year
GAO	General Accounting Office
GHG	greenhouse gas
GWh	gigawatt-hour
HU	habitat unit
I-O	input-output
ICE	Intercontinental Exchange
IMPLAN	Impact Analysis for Planning
kWh	kilowatt hour
LCPSIM	Least Cost Planning Simulation Model
LPP	locally preferred plan
LSE	Load Serving Entity
LTGen	LongTermGen
M&I	municipal and industrial
MWDSC	Metropolitan Water District of Southern California
mmbtu	million British thermal units
NED	National Economic Development
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation
NOD	north of the Delta

NP-15	North of Point 15
NWPCC	Northwest Power and Conservation Council
O&M	operations and maintenance
OLS	Ordinary Least Squares
OSE	Other Social Effects
P&G	*Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
P&R	Principles & Requirements
PLEXOS	PLEXOS® Integrated Energy Model
PR&G	Principles, Requirements & Guidelines
PEIS/R	Programmatic Environmental Impact Statement/Report
RA	resource adequacy
RBPP	Red Bluff Pumping Plant
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RED	Regional Economic Development
ROD	Record of Decision
RPS	Renewable Portfolio Standard
SCAQMD	Shasta County Air Quality Management District
SLWRI	Shasta Lake Water Resources Investigation
SOD	south of the Delta
SP15	Power costs for Path 15
SWAP	Statewide Agricultural Production Model
SWP	State Water Project
SWPPower	State Water Project Power
SWRCB	State Water Resources Control Board
TAF	thousand acre feet
U.S.	United States
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WAP	Water Acquisition Program
WECC	Western Electricity Coordinating Council
WSR	Water Supply Reliability
WTP	willingness to pay

Chapter 1 Introduction

This Economic Valuation Appendix was prepared for the Shasta Lake Water Resources Investigation (SLWRI), a feasibility study by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) evaluating the potential enlargement of Shasta Dam and Reservoir in Northern California. Estimating the costs and potential benefits of alternative plans is critical to determining economic feasibility and identifying a corresponding plan recommended for implementation.

Background

Shasta Dam and its 4.55 million acre feet capacity reservoir is operated in conjunction with other Central Valley Project (CVP) facilities to provide for the control of floodwater; storage of surplus winter runoff for irrigation in the Sacramento and San Joaquin valleys and municipal and industrial (M&I) use; maintenance of navigation flows; protection and conservation of fish in the Sacramento River and the Sacramento-San Joaquin Delta (Delta); and generation of hydroelectric energy. Shasta Dam has the largest storage capacity in the CVP/State Water Project (SWP) water management system, and its associated outputs contribute significantly to the California economy.

Purpose and Scope of This Document

The purpose of this document, an appendix to the Final Feasibility Report, is to identify and apply valuation methods to estimate the potential economic effects of SLWRI comprehensive plans/alternatives. Detailed cost estimates for comprehensive plans are documented in the Engineering Summary Appendix to the accompanying Final Environmental Impact Statement (EIS). Together, these appendices support the comparison of benefits, costs, and net benefits of comprehensive plans, which are presented in the Final Feasibility Report.

This appendix identifies valuation methods and valuation estimates for each comprehensive plan for the benefit categories associated with the primary and secondary planning objectives, which are described in the following section.

Planning Objectives

On the basis of the identified water resources problems, needs, and opportunities, study authorities, and other pertinent direction, including information contained in the CALFED Bay-Delta Program (CALFED Programmatic Environmental Impact Statement/Report (PEIS/R) (CALFED 2000a) and Programmatic Record of Decision (ROD)(CALFED 2000b), two primary and five secondary planning objectives were developed. Primary planning objectives are those for which specific alternatives would be formulated to address. 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**
  - **Anadromous Fish Survival –** Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream from the Red Bluff Pumping Plant (RBPP)
  - **Water Supply Reliability –** Increase water supply and water supply reliability for agricultural, M&I, and environmental purposes to help meet future and current water demands, with a focus on enlarging Shasta Dam and Reservoir
- **Secondary Planning Objectives**
  - **Ecosystem Restoration –** Conserve, restore, and enhance ecosystem resources in the Shasta Lake area and along the upper Sacramento River
  - **Flood Damage Reduction –** Reduce flood damage along the Sacramento River
  - **Hydropower –** Develop additional hydropower generation capabilities at Shasta Dam
  - **Recreation –** Maintain and increase recreation opportunities at Shasta Lake
  - **Water Quality –** Maintain or improve water quality conditions in the Sacramento River downstream from Shasta Dam and the Delta.

No-Action Alternative and Comprehensive Plans

The No-Action Alternative and comprehensive plans evaluated in the Final Feasibility Report are summarized briefly below. The No-Action Alternative and comprehensive plans are described in more detail in Final Feasibility Report Chapter 4, “No-Action Alternative and Comprehensive Plans” and in the Plan Formulation Appendix to the accompanying Final EIS.

No-Action Alternative

Under the No-Action Alternative, the Federal Government would continue to implement reasonably foreseeable actions, but would not take additional actions toward implementing a plan to raise Shasta Dam to help address SLWRI primary and secondary planning objectives. For the SLWRI, the No-Action Alternative is based on without-project forecasted 2020-2030 level of development (a 2030 baseline),[1] reasonably foreseeable future projects and facilities, and reflects CVP and SWP operational conditions described in the following:

- The Reclamation 2008 Biological Assessment on the Continued Long-Term Operations of the CVP and SWP
- The USFWS 2008 *Formal ESA Consultation on the Proposed Coordinated Operations of the CVP and SWP* (2008 USFWS Biological Opinion (BO))
- The NMFS 2009 *BO and Conference Opinion on the Long-Term Operations of the CVP and SWP* (2009 NMFS BO)

Consistent with Reclamation planning policy, estimated benefits under comprehensive plans were determined by comparison of the with-project condition to the No-Action Alternative.

Comprehensive Plans

Based on the SLWRI planning objectives, coordination among study team members, and review of comments received during the public scoping and comment processes, the following comprehensive plans were formulated:

- **Comprehensive Plan 1 (CP1) –** Increased water supply reliability and increased anadromous fish survival, with some benefits to other resources through a 6.5-foot raise of Shasta Dam and 256,000-acre-foot enlargement of Shasta Reservoir.
- **Comprehensive Plan 2 (CP2) –** Increased water supply reliability and increased anadromous fish survival, with some benefits to other

[1] The level of development used for future conditions is a composite of multiple land use scenarios developed by DWR and Reclamation. Sacramento Valley hydrology, which includes the Sacramento and Feather River basins, is based on projected 2020 land use assumptions associated with DWR Bulletin 160-98 (1998) and the San Joaquin Valley hydrology is based on the 2030 land use assumptions developed by Reclamation. Under any 2020 to 2030 level of development scenario, the majority of the CVP and SWP unmet demand is located south of the Delta, including the San Joaquin Valley. Please see Table 2-1 in the Modeling Appendix to the accompanying Final EIS for additional information on water operations modeling assumptions.

resources through a 12.5-foot raise of Shasta Dam and 443,000-acre-foot enlargement of Shasta Reservoir.

- **Comprehensive Plan 3 (CP3)** – Increased agricultural water supply reliability and increased anadromous fish survival, with some benefits to other resources through an 18.5-foot raise of Shasta Dam and 634,000-acre-foot enlargement of Shasta Reservoir.

- **Comprehensive Plan 4 (CP4) and Comprehensive Plan 4A (CP4A)–** Focus on increased anadromous fish survival, while increasing water supply reliability and providing some benefits to other resources through an 18.5-foot raise of Shasta Dam and 634,000-acre-foot enlargement of Shasta Reservoir. CP4 would dedicate about 60 percent of the new storage space (378,000 acre-feet) to increasing the cold-water supply for anadromous fish purposes, while CP4A would dedicate about 30 percent of the new storage space (191,000 acre-feet) to increasing the cold-water supply for anadromous fish purposes, and both include features for ecosystem restoration.

- **Comprehensive Plan 5 (CP5) –** Combined plan focused on water supply reliability and anadromous fish survival that includes features for ecosystem restoration, and additional recreation facilities around Shasta Reservoir through an 18.5-foot raise of Shasta Dam and 634,000-acre-foot enlargement of Shasta Reservoir.

Guidelines

The economic valuation approach for Federal water resource projects is to be consistent with the *Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) (WRC 1983). The Federal objective of water and related land 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. Further, numerous Federal laws (e.g., the Endangered Species Act (ESA) (1973), Clean Water Act (1972)) establish policy and Federal interest in the protection, restoration, conservation, and management of protecting environmental quality.

The Federal Objective as updated and specified in the Water Resources Development Act of 2007 is that Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by:

- seeking to maximize sustainable economic development;

- seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and

- protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

In the Water Resources Development Act of 2007, Congress instructed the Secretary of the Army to develop a new P&G for the U.S. Army Corps of Engineers to promote consistency and informed decision making among Federal agencies. In 2009 the Obama Administration began the process of updating the P&G for Federal agencies engaged in water resources planning, including the U.S. Army Corps of Engineers, Environmental Protection Agency, Department of Agriculture, Department of the Interior, National Oceanic and Atmospheric Administration, Tennessee Valley Authority, Federal Emergency Management Agency, and Office of Management and Budget.

In March 2013, the Administration released the Principles & Requirements (P&R) that lay out broad principles to guide Federal investments in water management. In addition, Draft Interagency Guidelines for implementing the Principles & Requirements were also released. The modernized P&R, together with the pending agency specific Guidelines (PR&G), will help accelerate project approvals, reduce costs, and support water infrastructure projects with the greatest economic and community benefits. They will also allow agencies to better consider the full range of long-term economic, social, environmental, cultural, and other benefits.

In consideration of the many complex water management challenges and competing demands for limited Federal resources, it is intended that Federal investments in water resources should strive to maximize public benefits, particularly in comparison to costs. Public benefits encompass environmental, economic, and social goals, include monetary and non-monetary effects and allow for the inclusion of quantified and non-quantified measures. Stakeholders and decision makers expect the formulation and evaluation of a diverse range of alternative solutions. Such solutions may produce varying degrees of effects relative to the three goals specified above and as a result, tradeoffs among potential solutions will need to be assessed and properly communicated during the decision making process.

Thus, in addition to traditional, monetized economic development, projects that contribute to Federal ecosystem and species restoration goals, public health and safety, environmental justice, community benefits, and support recreation opportunities are relevant components of water project planning and development.

Economic evaluation provides a way to understand and evaluate trade-offs that must be made between alternatives with respect to objectives, investments, and other social goals. It also provides a means to identify the plan that is acceptable, effective, efficient, and complete, and contributes the most favorably to national priorities. The Federal P&G established four main accounts for organizing, displaying, and analyzing project alternatives:

- National Economic Development (NED)
- Regional Economic Development (RED)
- Environmental Quality (EQ)
- Other Social Effects (OSE)

The above accounts encompass all significant effects of a plan, consistent with the National Environmental Policy Act (NEPA) of 1970 (42 United States Code 4321 et seq.) and other Federal guidance.

National Economic Development Account

The NED account identifies the alternative providing the greatest net economic benefits to the Nation. The NED account considers and displays the potential changes and effects in the total value of the national output of goods and services from an alternative plan, expressed in monetary units. Contributions to NED are increases in the total value of the national output of goods and services, expressed in monetary units. NED benefits are the direct net benefits that would be expected to accrue in the primary study area and the rest of the Nation should a project or program be implemented. They include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.

The NED account describes the portion of the NEPA human environment, as defined in 40 Code of Federal Regulations 1508.14, that identifies beneficial and adverse effects on the economy which occur as a result of water resources planning and development. The NED account considers the estimated benefits and costs of alternative plans. Beneficial effects could include (1) increases in the economic value of the national output of goods and services from a plan, (2) the value of output resulting from external economies caused by a plan, and (3) the value associated with the use of otherwise unemployed or under-employed labor resources. Adverse effects in the NED account would be the opportunity costs of resources used in implementing a plan. Such opportunity costs could include decreases in output in other sectors, or employment losses. These effects usually include (1) implementation outlays, (2) associated costs, and (3) other direct costs.

After displaying and comparing the estimated benefits and costs for the SLWRI comprehensive plans, the NED analysis considers the monetary and non-monetary trade-offs and culminates in identifying the alternative that would reasonably provide the greatest net economic benefits to the Nation while protecting the environment. As required by the P&G, the plan with the greatest NED benefits is identified as the NED Plan and is usually selected for recommendation to Congress for approval, unless the Secretary of the Interior grants an exception based on overriding considerations and merits of another plan. If another plan is recommended instead of the NED Plan, such as a locally preferred plan (LPP), the NED Plan is still presented as a basis of comparison to define the extent of Federal financial interest in the plan recommended for implementation.

Based on the evaluation of the potential physical accomplishments and the benefits and costs of the alternative plans, CP4A would achieve the highest net NED benefits while protecting the environment and ranks the highest among the comprehensive plans in meeting the P&G criteria. Consistent with the P&Gs, since CP4A generates maximum net NED benefits, CP4A is identified as the NED Plan.

Regional Economic Development Account

The RED account examines and displays potential changes in economic activity at the local or regional level for the alternative plans. RED analysis may reflect only a shift in economic productivity from one region to another, not the change in output at the national level required in Federal analysis. Because local and regional economic activity is of great interest to decision-makers and stakeholders, RED analysis is included to assess changes in personal income and employment.

Environmental Quality Account

The EQ account examines and displays the effects of alternative plans on significant EQ resources and attributes of the NEPA human environment that is essential to a reasoned choice among alternative plans. Beneficial effects in the EQ account are favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Adverse effects in the EQ account are unfavorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources.

EQ benefits will be valued relative to their accomplishment levels, and corresponding policy and public laws and regulations. The anadromous fishery restoration objectives are consistent with the species recovery plan, indicating the social preference for these species and a corresponding desire for the ecosystems on which they depend, and which depend on them.

Other potential key secondary and incidental ecosystem accomplishments may include watershed protection, shoreline protection, and lake protection and quality. The need and preference for these benefits are largely based on CALFED programs and objectives, which include ecosystem restoration, watershed management, and water management.

Other Social Effects Account

The OSE examines and displays the potential changes of alternative plans on other social effects not covered under the NED, RED, and EQ accounts. The effects quantified by OSE include urban and community impacts, such as effects on income or population distribution, fiscal conditions of the State and local governments, the quality of community life, and similar impacts. OSE includes impacts to life, health, and safety, including the risk of flood, drought, or disaster; the potential loss of life, property, and essential services; and environmental effects not covered under the NED and EQ accounts. OSE also includes the effects of the displacement of people, businesses, or farms; impacts to the long-term productivity of resources, such as agricultural land, for use by future generations; and effects on energy requirements and conservation.

Chapter 2
Economic Assessment Methods

This chapter describes methods for economic assessments during the SLWRI Feasibility Study and development of the Final Feasibility Report for the SLWRI. The economic analysis addresses the potential incremental economic benefits that may be provided by a range of SLWRI comprehensive plans. Potential agricultural and M&I water supply reliability, hydropower, recreational, and anadromous fish survival benefits from the SLWRI are evaluated. Comprehensive plan costs are documented in the Engineering Summary Appendix to the accompanying Final EIS. Together, these appendices support the comparisons of comprehensive plan benefits, costs, and net benefits, which are presented in the main Final Feasibility Report.

NED Benefit Evaluation Procedures

In general, Federally financed water resource projects are to enhance national economic development, the quality of the environment, the well-being of people in the United States, and regional economic development. NED costs and benefits are the decrease or increase in the value of the national output of goods and services expressed in dollars. NED figures measure the costs and benefits to the Nation, rather than to a particular region.

As described in the P&G, water resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to the NED. The alternative plan with the greatest net economic benefit (the NED plan) determines the greatest potential Federal investment in the project.

The NED account includes the following categories of goods and services: (1) M&I water supply; (2) agricultural floodwater, erosion, and sediment reduction; (3) agricultural drainage; (4) agricultural irrigation; (5) urban flood damage reduction; (6) power (hydropower); (7) transportation (inland navigation); (8) transportation (deep draft navigation); (9) recreation; (10) commercial fishing; and, (11) other categories of benefits for which procedures are documented in the planning report and are consistent with the general measurement standard in the P&Gs. While multipurpose projects may provide additional types of benefits, these categories coincide with project purposes in which an established Federal financial interest exists. Other categories of benefits may be allowed or may be included in Congressional authorization for a specific project.

Environmental benefits, including fisheries and ecosystem resources, are typically included in the EQ account if monetary units cannot be attributed to these benefits. However, for this analysis, fisheries benefits were developed as monetary units, and are included in the NED account. The contribution of the various alternatives to anadromous fish survival is included in the NED account under “other categories of benefits.”

NED costs are the opportunity costs of resource use, and require consideration of the private and public uses that producers and consumers are making of available resources, now and in the future. For goods and services produced in a competitive market, price is often used to reflect opportunity cost. Consequently, market prices should be used to determine NED costs provided the market prices reflect the full economic value of a resource to society. The market price approach should reflect the interaction of supply and demand. If market prices do not reflect total resource values, surrogate values may be used that approximate opportunity costs based on an equivalent use or condition.

For M&I water supplies, the conceptual basis for evaluating benefits is society’s willingness to pay (WTP) for the increase in goods and services attributable to the water supply. According to the P&G, when the market price reflects the marginal cost of water, that price should be used to calculate WTP for additional water supply. In the absence of a direct measure of the WTP, the benefits are instead measured by the cost of the alternative most likely to be implemented in the absence of the project.

Other direct benefits in the NED evaluation are those direct effects of a project that are incidental to the purposes or objectives for which the project is being formulated. Other direct benefits may include improvement in commercial/industrial production possibilities (such as reduced water treatment process costs at industrial facilities) or increases in recreational opportunities. For the SLWRI, other direct benefits include hydropower and recreation.

The two primary decision criteria used in a Federal economic analysis are net benefits and the benefit-cost ratio. The net benefit is the difference between the net present value of benefits and costs, and it measures the extent to which benefits to the Nation exceed project costs. The benefit-cost ratio is calculated by dividing annual project benefits by annual project costs. The net benefits and costs of alternative plans are compared to identify the plan that reasonably maximizes net benefits, or the NED plan. This is not necessarily the plan with the most benefits, but rather the plan that reasonably maximizes net benefits while protecting the environment given the cost to the Nation. Section 1.10.2 of the P&G requires that the NED plan be selected unless the Secretary of the Interior grants an exception.

Economic Valuation Methods

Economic valuation methods generally fall into one of two categories: market valuation or nonmarket valuation. Market values refer to conditions for which a price can be observed, such as crops for human consumptive uses. Nonmarket valuation methods usually apply to resources for which there are no established markets, such as ecosystem restoration or wildlife conservation. As recommended in the P&G, economic benefits may be determined by one of five valuation approaches.

- Willingness to pay
- Actual or simulated market prices
- Change in net income
- Cost of the most likely alternative
- Administratively established values

In general, the P&G recommend that the value of goods and services be measured according to WTP as a measure of demand. Revealed and stated preferences are two approaches for valuing WTP for goods and services. Revealed preferences are based on observed behavior that reflects preferences, while stated preferences are based on directly asking individuals to indicate preferences in a hypothetical setting. Demand functions cannot always be estimated for many goods and services due to a lack of observed market or surveyed data. In lieu of demand function estimation, the P&G recommend the use of actual or simulated market prices, where available, because they represent a close approximation of total WTP value. Other generally acceptable approaches under the P&G include cost based approaches. Each of the valuation approaches recommended by the P&G to estimate NED economic benefits are briefly described below.

Willingness to Pay

The user value or WTP method refers to the value of the resource to the consumer. WTP refers to the value that a "seller" would obtain if able to charge each individual user a price that captures the full value to the user. Implementation of this approach requires estimation of a demand curve. Three methods are commonly used to estimate a demand curve. The methods include revealed preferences, which rely on market-based data; contingent valuation, which uses surveys to directly elicit consumer benefits; and benefits transfer, which uses estimates from previously completed studies. A well-designed contingent valuation survey represents one possible method to measure WTP in a developing market. However, conducting a primary revealed preference or contingent valuation study is often prohibitively time-consuming and expensive. Therefore, values from previous economic studies may be used to estimate WTP provided they are relevant to the study area and output being valued.

Actual or Simulated Market Prices

In cases where a demand curve cannot be directly estimated, market prices may be used to estimate society's WTP for a good or service. The P&G provide some limited guidance on the use of market prices where the output of the plan is expected to have a significant effect on market price. Prices should be expressed in real terms (inflation adjusted). Real prices should be adjusted, where possible, throughout the planning period to account for expected changes in demand and supply conditions.

Change in Net Income

When WTP and market price methods cannot be implemented, the P&G allow estimation of the change in net income to producers associated with a project to obtain an estimate of total value. This method is most frequently applied to circumstances when water supply from the project will be used as an input in a production process. One example is estimation of benefits with the Statewide Agricultural Production Model (SWAP), which measures the change in net income to agricultural producers associated with changes in water supply conditions.

Cost of the Most Likely Alternative

In situations where water supply alternatives to the proposed project exist, the cost of the most likely alternative to obtain the same level of output can be used as a measure of NED benefits. It is important to consider alternatives that would realistically be implemented in the absence of the proposed project. This method is generally considered for benefit categories that cannot be estimated through the market-based methods described above. The cost of the most likely alternative method identifies the cost of obtaining or developing the next unit of a resource to meet a particular objective. The net benefit is estimated by subtracting the cost of developing the project under consideration from the cost of the alternative unit. For example, for water supply reliability, the cost of the most likely alternative represents the next unit of water supply the water user would purchase or develop if the project under consideration were not in place. This method assumes that if the NED Plan is not implemented, the alternative action most likely to take place provides a relevant comparison. If the NED Plan provides the same output as the most likely alternative at a lower cost, the net benefit of the NED Plan is equal to the difference in the project costs.

Administratively Established Values

Administratively established values are representative values for specific goods and services that are cooperatively established by the water resources agencies. This method is the least preferred approach to estimating economic benefits identified in the P&G and is only implemented when other options cannot be completed.

Comprehensive Plan Economic Valuation Approaches

This section briefly describes economic benefit valuation approaches used for comprehensive plans. Valuation approaches are presented for water supply reliability, anadromous fish survival, hydropower, and recreation benefit categories. Flood damage reduction benefits are discussed qualitatively. Additional information describing each benefit category and the valuation approaches is described in Chapters 2 through 6, and Chapter 8 of this appendix.

NED Water Supply Reliability Benefits

Agriculture

Comprehensive plans will improve water supply reliability to agricultural water users particularly during dry years. Agricultural water supply reliability benefits are commonly estimated through the "change in net income" approach described in the P&G. Implementation of the approach can range from simple crop production budget analysis to more complex mathematical programming models such as SWAP, which is a well-accepted and frequently applied economic model of irrigated agricultural production in California. For NED analyses, this study provides an estimate of water supply reliability benefits to agriculture through application of the SWAP model to projected changes in water supply deliveries resulting from the comprehensive plans. While not applied in this study, a statistical comparison of agricultural land prices could also be conducted to estimate agricultural water supply reliability benefits. A comparison of agricultural land prices with varying levels of surface water supply reliability was not pursued due in part to the difficulty in obtaining an adequate number of sales with sufficient reporting of land and water characteristics, and the large geographic area affected by the SLWRI comprehensive plans.

M&I

Water supplies from the comprehensive plans will also improve water supply reliability to M&I water users primarily located south of the Delta. M&I water users have been increasingly participating in the water transfer market to augment supplies. This analysis assumes that the next increment of water supply to M&I users would likely be obtained through water transfers. This analysis relies on values estimated through application of a water transfer pricing model and through consideration of the costs associated with conveying the water to the M&I service areas. This method is consistent with the "cost of the most likely alternative" method recommended by the P&G.

NED Anadromous Fish Survival Benefits

Comprehensive plans provide opportunities for enhancing water temperature and flow conditions in the Sacramento River as a means of improving the riverine ecosystem. The economic benefits of contributions of comprehensive plans to anadromous fish survival are estimated through implementation of a "cost of the most likely alternative" approach. The underlying premise for the valuation approach is that increasing salmon populations is a socially desirable goal, as indicated by the listing of several species as threatened or endangered and the demonstrated expenditures on salmon restoration projects. Because the increased potential to reduce water temperatures and improve flows during critical periods provided by additional surface storage is essential to increasing salmon production, the cost of the most likely alternative is based on the cost of various dam raises operated solely for the purpose of increasing the number of salmon smolt in the Sacramento River.

NED Hydropower Benefits

The proposed modifications of Shasta Dam will alter water flows and reservoir elevations, which will impact hydropower capacity, generation and the ability to provide ancillary services[2] at Shasta Dam and other hydropower facilities throughout the CVP and State Water Project (SWP). Estimates of net changes in hydropower capacity, generation and ancillary services in Western Interconnection electrical power grid were estimated using a number of models and methods. A post-processing of monthly water operations from the California Water Resources Simulation Model II (CalSim-II) resulted in monthly hydropower energy and capacity values for the affected facilities. Power benefits were valued by using PLEXOS® Integrated Energy Model (PLEXOS), a power market simulation model, to forecast energy and ancillary service power market prices for the year 2020 when the 33 percent Renewable Portfolio Standard (RPS), mandated by California law, will have been implemented. The assumption is that power market prices stabilize once the RPS is achieved. Capacity prices were estimated based on the cost of the most likely alternative to provide similar capacity benefits.

NED Recreation Benefits

Raising the height of Shasta dam would affect recreational participation by increasing reservoir elevations, decreasing reservoir drawdown during the peak recreation season (May to September), and increasing average annual reservoir surface area over without-project conditions Recreation benefits are quantified through application of unit values determined by a previous U.S. Forest Service (USFS) economic study (Loomis 2005). . In addition, although not quantified or monetized for the NED analysis, relocating and modernizing related recreation facilities may lead to increased recreational participation.

RED Benefits

Comprehensive plans will introduce short-term construction expenditure within the four-county area (Shasta, Tehama, Trinity, and Siskiyou) containing the dam and reservoir. The regional economic impact analysis estimates the economic effects of the construction expenditure to the region. Regional economic effects, in relation to the RED account described above, are estimated in terms of changes in personal income and employment with Impact Analysis for Planning (IMPLAN) software. The IMPLAN model links construction production to key input suppliers and many other local businesses that provide goods and services to the construction industry.

[2] The California Independent System Operator's (CAISO) ancillary service market is comprised of regulation up, regulation down, spinning reserve and non-spinning reserve providing frequency support, voltage support, and load-following. These services are needed to allow CAISO to precisely match generation and load and operate the grid in a reliable manner.

Risk and Uncertainty

With each aspect of this report, certain assumptions were made based on engineering and scientific judgment regarding best available information, guidance, methods, and tools. Careful consideration was given to the methods, evaluations, and tools for hydrology and system operations, cost estimates, and biological analyses. Analyses were developed with advanced modeling and estimating tools using historical data and trends. While this is a standard method to help evaluate potential outcomes for future operations, biological conditions, and costs, many uncertainties could affect the findings of this appendix, including the magnitude of economic benefits. Various uncertainties and risks associated with the SLWRI economic benefit valuations are discussed in relation to each benefit category below, and in Chapter 6, "National Economic Development Plan and Implementation Requirements," of the Final Feasibility Report. For example, different methods and tools are applied to some benefit categories to illustrate a range of uncertainty in the valuation estimates.

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Chapter 3
NED Water Supply Reliability Benefits

This chapter describes agricultural and M&I water supply reliability benefit estimate methods and results for comprehensive plans. In addition, several water supply reliability benefit sensitivity analyses conducted to address risk and uncertainty of the benefit estimates are presented.

Agriculture Water Supply Reliability

The SLWRI alternative plans increase water supplies to agricultural water users, especially during dry years. The agricultural water supply benefits largely accrue to agricultural water users located south of the Delta. Following is a discussion of the value of agriculture in California, benefit valuation methods, and estimated agriculture water supply reliability benefits.

Value of Agriculture in California

California agricultural production is a multibillion dollar industry that relies on water as a primary input for production. In 2012, California's agriculture sector was comprised of 80,500 farms and ranches which generated more than $44 billion in farm output. Five industries aggregate to 50 percent of this value: dairy, greenhouse and nursery, grapes, almonds, and cattle/calves.

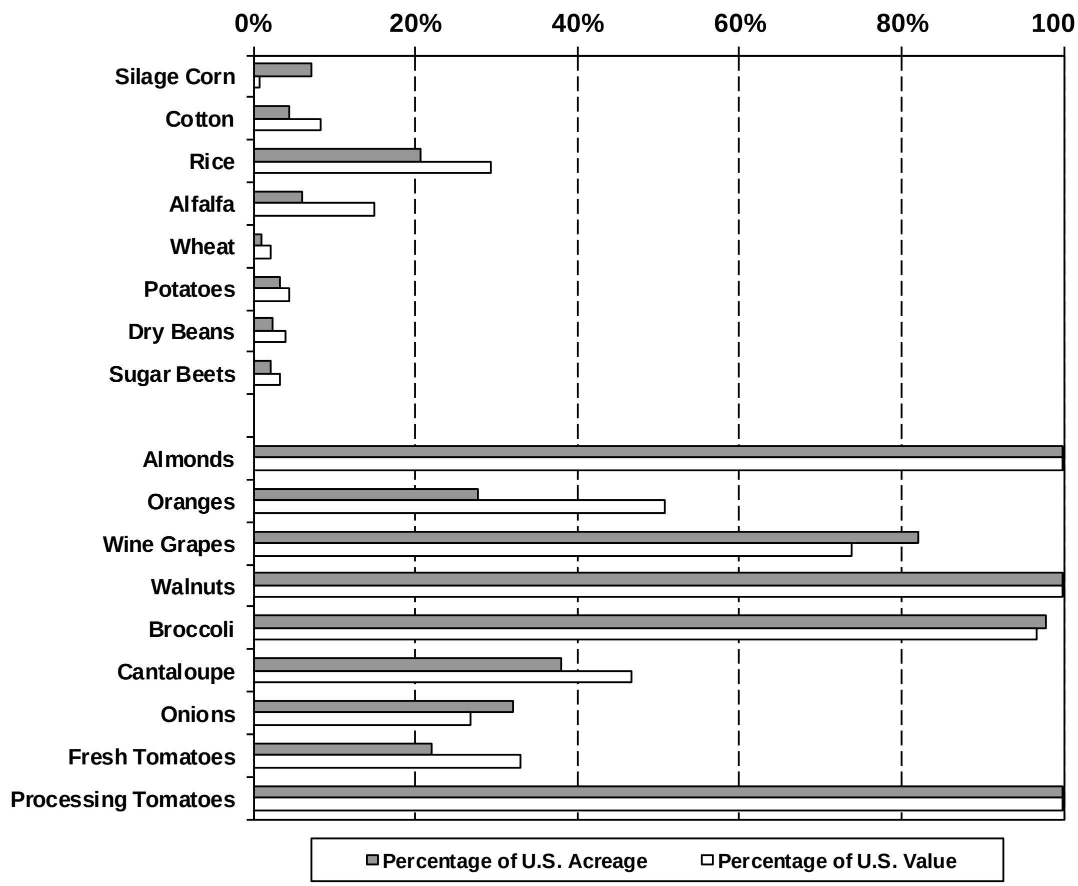
Table 3-1 displays the top five California agricultural commodities in 2012 as well as their proportion of receipts on the national level. California's dairy industry produced 16 percent of the nation's gross receipts in the category. Grapes compromised approximately 10 percent of California's agricultural value, while representing and estimated 91 percent of the nation's gross receipts. California's growing almond production represents the entire national output of the crop.

The value of California's annual farm production exceeds that of any other state. Figure 3-1 shows California's crop production by category relative to the total U.S. production. California has developed a niche as the leading producer for specialty crops. California is the sole producer for walnuts and almonds in the U.S. and accounts for all tomato processing within the U.S. In terms of harvested acreage, California accounts for nearly all broccoli production and nearly 40 percent of cantaloupes. Interruptions to critical water supplies used to grow crops that are primarily produced in California could significantly disrupt U.S. food markets, and other industries dependent on agricultural inputs.

Table 3-1. Top Five California Agricultural Commodities

Commodity	% CA Total Farm Receipts	% U.S. Farm Receipts for Crop
Dairy	15	16
Grapes	10	91
Almonds	10	100
Greenhouse/Nursery	8	23
Cattle/Calves	7	5

Source: U.S. Department of Agriculture National Agricultural Statistics Service. Available at: <http://quickstats.nass.usda.gov>. Accessed June 8, 2014.
Key:
% = percent
CA = California
U.S. = United States



Source: U.S. Department of Agriculture National Agricultural Statistics Service. Available at: <http://quickstats.nass.usda.gov>. Accessed June 8, 2014.

Figure 3-1. Percentage of Total U.S. Harvested Acres and Value of Statewide Agricultural Production Model Crops Produced in California (2012)

Field crops comprise approximately 54 percent of the harvested acres but represent only 20 percent of the total value. Over the last two decades, the harvested area and value of field crops in California has declined. The harvested area for non-field crops in California has increased significantly. The increase in the value of almonds and wine grapes has been especially notable among California crop production.

NED Benefit Valuation Methods

NED benefits from improvements in water supply to agricultural users include the value of increases in agricultural output to the Nation and the cost savings associated with maintaining a given level of output. When water is scarce, farmers may respond by changing cropping patterns, fallowing fields, pumping more groundwater, and/or participating in increased water transfers and exchanges. When water is relatively plentiful, farmers may react by bringing idle fields into production and using increased surface water deliveries instead of pumping groundwater, or engaging in additional groundwater storage and banking. The economic benefits associated with increased water supply reliability to agriculture can be estimated using a variety of approaches described in the P&G. Commonly, WTP is measured by the change in net income that would accrue to agricultural producers as a result of changes in water supply conditions. In addition, the P&G recommends consideration of changes in agricultural land values as a possible valuation approach. Given the history of water market purchases in California, it may also be appropriate to consider water transfer market prices to estimate WTP.

NED agricultural water supply reliability benefits are estimated with the SWAP model. The SWAP model analysis provides benefit estimates produced through the application of the “change in net income” method. In addition, post-processing adjustments are applied to SWAP inputs and output in order for the results to comply with P&G and Reclamation guidelines for NED analysis. In particular, guidelines require that certain prices be used for valuing changes in physical inputs and outputs. In addition, the contract rates for water supplied from the CVP are added to the estimated benefits in order to avoid over estimation (i.e., double-counting) of costs. For a detailed description of the SWAP model and NED benefit adjustment process, please refer to the Modeling Appendix for the accompanying EIS.

It is important to note that potential new water supplies developed for the SLWRI have been formulated for drought period supplies when new increments of reliable water supply would be most needed. In this analysis, the SWAP model is run for the long-term above/below normal, dry, and wet water supply conditions. The estimated annual benefit associated with the SLWRI alternatives is represented by the probability weighted average across the three water year types.

Estimated NED Agriculture Water Supply Reliability Benefits

Table 3-2 provides the change from the without project condition in annual agricultural water supplies for each alternative by geographic region. As shown, a majority of the project water supply is delivered to CVP/SWP south of the Delta (SOD) agricultural contractors during dry years. On average, CP3 provides the largest increase in agricultural water deliveries with 25,900 acre-feet to north of the Delta (NOD) contractors and 36,400 acre-feet to SOD contractors.

Table 3-2. Estimated Changes in CVP/SWP Irrigation Deliveries Relative to Without Project Conditions

Year Type	CP1/CP4 (acre feet)	CP2/CP4A (acre-feet)	CP3 (acre-feet)	CP5 (acre-feet)
Dry/Critical NOD[1]	4,200	9,500	29,400	21,100
Dry/Critical SOD[1]	18,300	28,100	41,300	45,000
Average – All Years NOD	5,900	10,900	25,900	19,600
Average – All Years SOD	14,400	20,500	36,400	31,300

Note:
[1] Year-types as defined in the Sacramento Valley Water Year Hydrologic Classification Index.
Key:
CP = comprehensive plan
CVP = Central Valley Project
M&I = municipal and industrial
NOD = North of Delta
SOD = South of Delta
SWP = State Water Project

Agricultural water supply reliability benefits are measured by the expected changes in net farm income relative to the without-project conditions for each of the proposed alternatives for long-term above/below normal, dry, and wet year conditions (Table 3-3). The values for CP1 and CP4 are identical because operations for both provide for the same quantities of delivered agricultural water supplies. In a similar manner, CP2 and CP4A have the same releases from CVP and SWP facilities and result in identical agricultural water deliveries. In addition to the change in net farm income, NED benefits include changes in consumer surplus associated with changes in crop demand functions due to population and income changes as well as changes in real crop prices. Increases in the average estimated NED benefits range from $3.3 million for CP1 and CP4 to $10.2 million for CP3. The annual benefits are equivalent to unit values that range from $167 per acre feet (AF) for CP2 and CP4A to $176 per AF for CP3. Annual benefits for CP1 and CP4 are equivalent to $173 per AF. Table 3-4 presents the estimated average annual agricultural water supply reliability benefits for comprehensive plans.

Table 3-3. Estimated Agricultural Water Supply Reliability Benefits for Comprehensive Plans, by Year Type

Item	Above/Below Normal Year Type ($1,000)[1]	Dry Year Type ($1,000) [1]	Wet Year Type ($1,000) [1]	Weighted Average ($1,000) [1]
CP1/CP4	2,177	4,309	3,178	3,255
CP2/CP4A	2,431	7,659	5,106	5,143
CP3	8,942	13,161	7,967	10,159
CP5	4,809	13,764	6,382	8,521
Year Type Probabilities (%)	0.32	0.37	0.32	----

Note:
[1] Dollar values are expressed in January 2014 price levels and were adjusted according to the Implicit Price Deflator published by the Bureau of Labor Statistics.
[2] Estimated economic benefits for agricultural water supply reliability were obtained using SWAP.
Key:
CP = Comprehensive Plan
SWAP = Statewide Agricultural Production Model

Table 3-4. Estimated Average Annual NED Agricultural Water Supply Reliability Benefits for Comprehensive Plans

Year Type	CP1/CP4 ($ millions/ year)[1]	CP2/CP4A ($ millions/ year)[1]	CP3 ($ millions/ year)[1]	CP5 ($ millions/ year)[1]
Weighted Average (all years)	3.3	5.1	10.2	8.5

Note:
[1] Dollar values are expressed in January 2014 price levels.
Key:
CP = Comprehensive Plan

M&I Water Supply Reliability

The SLWRI alternatives increase water supplies to M&I water users, especially during dry years. The M&I water supply benefits largely accrue to SWP contract holders located south of the Delta. Estimates for dry year and average deliveries to M&I water users located north and south of the Delta for CP1 through CP5 are shown in Table 3-5.

Table 3-5. Estimated Changes in CVP/SWP M&I Deliveries

Year Type	CP1/CP4 (acre-feet)	CP2/CP4A (acre-feet)	CP3 (acre-feet)	CP5 (acre-feet)
Dry/Critical NOD[1]	300	1,200	5,800	4,100
Dry/Critical SOD[1]	24,400	39,000	(13,300)	43,300
Average – All Years NOD	100	1,400	4,400	3,300
Average – All Years SOD	10,600	18,500	(4,900)	21,700

Note:
[1] Year-types as defined in the Sacramento Valley Water Year Hydrologic Classification Index.
Key:
CP = comprehensive plan
CVP = Central Valley Project
M&I = municipal and industrial
NOD = North of Delta
SOD = South of Delta
SWP = State Water Project

In this analysis, the benefits to M&I water users are measured according to the cost of the most likely alternative water supply that would be pursued in the absence of development of the alternative plans. For water supply reliability benefits, the cost of the most likely alternative represents the next unit of water supply the water user would purchase if the project under consideration were not in place. The cost of the most likely alternative plan assumes that if the NED Plan is not implemented, the alternative action most likely to take place provides a relevant comparison. If the NED Plan provides the same output as the most likely alternative plan at a lower cost, the net benefit of the NED Plan is equal to the difference in the project costs.

To estimate M&I water supply benefits, this study developed and applied a water transfer pricing model. M&I water users have increasingly relied on the water transfer market to augment existing supplies and avoid shortages. This analysis relies in part on market prices paid to purchase water on an annual basis from willing sellers. The market prices are reported according to the payments made directly to the sellers. The buyers incur additional costs to convey the water to their M&I service areas. These costs include both conveyance losses, which diminish the volume of water delivered to end users, as well as wheeling and power charges. The conveyance costs are estimated for M&I water users benefiting from the alternative plans, and added to the estimated market prices to acquire the water to develop an estimate of the full cost associated with additional water supply obtained in the transfer market. Figure 3-2 illustrates the information used to estimate the value of M&I water supplies, and data and estimation methods are described below.

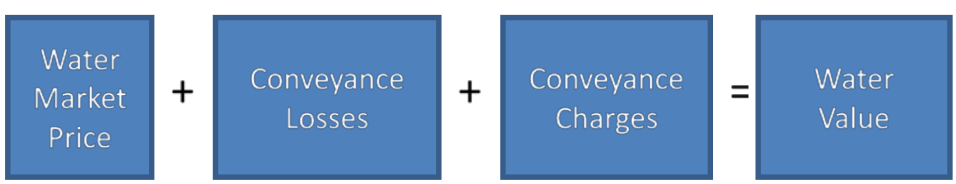


Figure 3-2. General M&I Water Value Estimation Procedures

Water Market Prices

A database of California water market sales was developed and used to develop the water transfer pricing model. Information for each transaction was researched and recorded to allow statistical analysis of a variety of factors influencing water trading activity and prices. During the research, transactions occurring from 1990 through 2013 were documented. The analysis focused on water transactions that are considered to be comparable to water supplied from the SLWRI comprehensive plans. For example, some transactions were excluded from the analysis as they occurred in geographic regions outside of those directly benefitting from the SLWRI comprehensive plans. In addition, transactions involving water sources with significantly different quality and reliability than that provided under comprehensive plans were removed. The transactions were filtered for this analysis according to the following criteria:

- Water sales originating outside the operating region of the CVP/SWP facilities were excluded. These regions include the North Coast, North Lahontan, and South Lahontan regions.
- The model is intended to estimate spot market prices and trading activity. Thus, multi-year transfers and permanent water entitlement sales were excluded.
- “Within-project” transfers were removed from the analysis because they do not reflect transactions whereby buyers and sellers act independently so transaction price is not distorted by a relationship between the two.
- Transactions associated with SWP Turnback Pool supplies were excluded because they are associated with rules that limit market participation.
- Purchases of “flood” supplies were excluded.
- Reclaimed and desalination water sales were removed from the analysis because they deliver water quality different than the project alternatives.
- Water sales with incomplete or inadequate information were excluded.

Following application of the above criteria, 466 spot market transfers remained to support the statistical analysis. All prices are adjusted to January 2014 dollars using the U.S. Consumer Price Index. As previously described, prices and volumes are presented from the seller’s perspective and do not include conveyance charges or losses.

Although Federal and State government agencies have recently been more active in recording some information related to water sales or leases, California has few sources that track water transfers between private individuals. Most of the recorded transfers involve a Federal or State government party either because an agency had to approve the transfer, as is the case when a transfer involves CVP or SWP water, or because the government agency was directly involved in the transfer as a purchaser or a seller. Transfers involving private parties are more difficult to track because the State does not have any reporting requirements. California law states that single-year transfers of water entitlements issued before 1914 are allowed without review as long as they do not adversely impact the water rights of a third party (CALFED 2000). For entitlements issued after 1914, the buyer and seller can petition the State Water Resources Control Board (SWRCB) for a 1-year temporary transfer. Nonetheless, prices for these transfers are not well documented. As a result, the data for this study were obtained from a mixture of public and private sources. Public sources include the following:

- Water Acquisition Program (WAP), Reclamation
- Resources Management Division, Environmental Water Account (EWA)
- State Water Bank, California Department of Water Resources (DWR)
- OnTap database, California DWR
- SWRCB, California Environmental Protection Agency
- Various irrigation districts and municipal water authorities

These sources provided information on the WAP, EWA, State Water Bank, and other public water transfers. State Water Bank observations included transfers to the State Water Bank to capture the price the seller receives.

NED Benefit Estimation Procedures

This study builds on a previous analysis completed by Mann and Hatchett (2006) by applying an expanded data set and considering additional factors that influence water market trading activity and prices. Unlike the Mann and Hatchett analysis which estimated a recursive regression model using Ordinary Least Squares (OLS) techniques, the water transfer pricing model developed in this study is non-recursive, using Two-Stage Least-Squares (2SLS). 2SLS is used to correct for simultaneity bias, where endogenous variables within the model interact. The first stage estimates the unit price for spot market water transfers, and the second stage estimates the level of spot market trading activity using the first stage price predictions as the price variable. The coefficients from the models are used to forecast water prices NOD and SOD over the 100-year planning period.

The water transfer pricing model theorizes that prices and volume of water traded can be estimated through consideration of the following market factors: water supply, geographic location, real water price escalation, buyer type, and state and federal water supply acquisition programs.[3] These factors are described below.

Water Supply

As previously described, hydrologic conditions are a primary driver of water transfer market activity and prices. Therefore, it is important to include variables that appropriately capture water supply conditions to describe water trading activity and prices. In this analysis, water supply conditions are measured using the natural logarithm of the final annual State Water Project allocation to M&I contractors, and the Sacramento River Water Year Index (DWR 2011).

Geographic Location

Water prices and trading activity vary by location according to water year type. Consequently, the origin of the water source for each transaction is used to determine geographic differences in water prices. Water sales applied in the regression analysis were allocated among the Water Transfer Analysis Regions identified by the Common Assumptions Economic Workgroup (CH2M Hill 2006). Binary variables are used to denote the different geographic regions.

Real Water Price Escalation

Due to the growing urban water demand in the State, water transfer prices are anticipated to be increasing over time. To test for hypothesized price appreciation, the model includes an independent variable representing the year in which the transfer occurred (e.g., 1992, 1993, 1994, etc.).

Buyer Type

Previous economic analyses of water market prices have concluded that the type of buyer (e.g., M&I, agricultural, and environmental) influences water prices. The water pricing equation tests the influence of buyer type on water price and trading. In this analysis, binary variables are used to estimate price differences between environmental, urban, and agricultural buyers.

Drought Water Bank

The State has participated in the water market during drought years to facilitate trades. Under this program, DWR sets up a state water bank to facilitate water transfers, typically from NOD sources to SOD agricultural and urban water users facing shortages. To account for the market conditions that existed during operation of the state water bank, a binary variable is included in the model to isolate the transactions from other observations included in the analysis. Because it is a binary variable, it does not affect the slope of the estimated relationship between price and volume traded.

[3] Additional demand and supply factors were tested in the model but did not result in an improvement in overall explanatory power.

CALFED Program's Environmental Water Account

Pursuant to the CALFED Program, the EWA acquired water supplies for environmental purposes annually between 2001 and 2007. The implementation of the EWA impacted spot market trading and prices by introducing a large new demand for water supplies. A dummy variable separating acquisitions by the EWA from other buyers is included to test for the price impacts of the program. A dummy variable in the volume equation indicates the years in which the EWA program was active in the market. This variable tests the program's impact on trading activity.

Federal Water Acquisition Program

Reclamation's WAP has been one of the most active buyers in California's spot market for water. The model includes a variable testing for the program's impact on annual trading activity.

Model Results

Two equations are constructed to estimate the economic benefits of increased M&I water supplies. The first stage of the 2SLS model forecasts water transfer prices based on hydrologic conditions, price appreciation over time, water supplier region, buyer type, buyer location, and premiums associated with DWR Drought Water Bank and EWA transactions. Information on 466 spot market water transfers is included in the data, allowing the model to forecast spot-market prices.

The second stage of the model predicts the total annual volume of water traded in the spot market. Total annual trading volume is calculated using 466 spot market transfers, and is reported in thousands of acre-feet. The trading volume equation projects total annual volume traded based on hydrologic conditions, the market presence of environmental water acquisition programs, and water transfer prices predicted by the first equation. The use of predicted prices in the trading volume equation rather than observed prices recognizes that price and volume are simultaneously determined. Each equation's specification and variables are defined, and the 2SLS regression results are presented in Table 3-6.

Equation 1

$$lnadjprice=scbuyer+ewabuyer+nod+lnfswp+lnyear+ag+env+dwb+e$$

lnadjprice=Natural Logarithm of Price per Acre-Foot, Adjusted to 2011 Dollars
scbuyer=1 if South Coast Region Water Buyer (binary)
ewabuyer=1 if Acquisition by the Environmental Water Account (binary)
nod=1 if North of Delta Water Supplier (binary)
lnfswp=Natural Logarithm of Annual Final State Water Project Allocation to M&I Contractors
lnyear=Natural Logarithm of the Year in which the Transfer Occurred
ag=1 if Agricultural Water End Use (binary)
env=1 if Environmental Water End Use (binary)
dwb=1 if State Water Bank/ Dry Year Water Acquisitions (binary)
e=Error Term

Equation 2

$$lnspottaft=lnsacindex+lnadjpricehat+ewayear+wap+e$$

lnspottaft=Natural Logarithm of Total Acre-Feet Traded Annually (thousands)
lnsacindex=Natural Logarithm of the Sacramento River Water Year Index
lnadjpricehat=Values of the Variable lnadjprice Predicted by Equation 1
ewayear=1 if Year in Which the EWA Operated (binary)
wap=1 if Year in Which the WAP was Active (binary)
e = Error Term

Table 3-6. Two-Stage Least-Squares Regression Results

Equation[1] Dependent Variables	Observations	Parameters	RMSE	R-Squared	F-Statistic	P-Value (P > F)
lnadjprice	466	8	0.510143	0.4638	411.21	0.00
lnspottaft	466	4	0.4203213	0.3696	297.32	0.00
Stage 1: Dependent Variable *lnadjprice*						
Independent Variables	**Coefficient**	**Standard Error**	**t-Statistic**	**P-Value (P > |t|)**	**95% Confidence Interval**	
scbuyer	0.3110	0.0982	3.17	0.00	0.1186	0.5034
ewabuyer	0.4998	0.1000	5.00	0.00	0.3039	0.6957
nod	-0.2636	0.0567	-4.65	0.00	-0.3747	-0.1524
lnfswp	-0.4216	0.0662	-6.37	0.00	-0.5514	-0.2919
lnyear	95.0932	7.5140	12.66	0.00	80.3661	109.8204
ag	-0.2395	0.0832	-2.88	0.00	-0.4025	-0.0765
env	-0.3502	0.0898	-3.90	0.00	-0.5263	-0.1742
dwb	0.2382	0.0880	2.70	0.01	0.0656	0.4107
e	-718.1301	57.1045	-12.58	0.00	-830.0530	-606.2074

Table 3-6. Two-Stage Least-Squares Regression Results (contd.)

Equation[1] Dependent Variables	Observations	Parameters	RMSE	R-Squared	F-Statistic	P-Value (P > F)
Stage 2: Dependent Variable *lnspottaft*						
Independent Variables	**Coefficient**	**Standard Error**	**t-Statistic**	**P-Value (P > |t|)**	**95% Confidence Interval**	
lnsacindex	-1.0888	0.0803	-13.56	0.00	-1.2462	-0.9314
lnadjpricehat	-0.1999	0.0454	-4.40	0.00	-0.2888	-0.1109
ewayear	0.4794	0.0443	10.83	0.00	0.3926	0.5662
wap	0.2054	0.0673	3.05	0.00	0.0736	0.3373
e	8.5307	0.2871	29.72	0.00	7.9681	9.0933

Note:
[1] Equations and variables are defined in Equations 1 and 2 above.
Key:
RMSE = root-mean-square error

All estimated relationships between dependent and independent variables are statistically significant at the 99 percent confidence level. A log-log specification was selected for both equations. Box-Cox transformations show that this specification is preferable to linear or semi-logarithmic equations. The logarithmic relationships between dependent and independent variables can be interpreted as elasticities. For example, the coefficient of approximately -0.42 on the variable *lnfswp* in the price equation indicates that a 1 percent increase in the final SWP allocation is associated with a 0.42 percent decrease in water transfer prices, all else equal.

Equation 1 Discussion

The variable *lnfswp* is a measure of annual water availability. The SWP allocation decreases during drought conditions. Regulatory actions, such as the Wanger decision and related remand processes for the 2008 U.S. Fish and Wildlife Service (USFWS) and 2009 National Marine Fisheries Service (NMFS) biological opinions, can further impact SWP deliveries. The inverse relationship between *lnadjprice* and *lnfswp* is attributable to increased demand for additional water supplies under the hydrologic and regulatory scarcity conditions that drive reduced SWP allocations.

The coefficient value on the variable *lnyear* indicates that water transfer prices rose at a real annual rate of approximately 4.86 percent between 1990 and 2013. This is a relatively high rate of real increase in water transfer prices. Over time, the costs associated with acquiring water on the spot market may converge with M&I willingness-to-pay.

The binary variables in the price equation describe conditions that influence prices but are qualitative in nature. The coefficients for *env* and *ag* represent the influence that buyer type has on price. When these variables are zero, the model estimates prices to urban water users. Agricultural and environmental water users generally paid less for water than urban users, as indicated by the negative coefficients on the two variables. The results show environmental water buyers pay 30 percent less per acre-foot than urban buyers in the market, all else equal. Similarly, water leases for agricultural use were priced 21 percent per acre-foot less than urban water leases, all else equal. The lower prices observed for environmental and agricultural transactions are due to the budget constraints associated with those buyer types.

dwb is an indicator of State water leases through the Drought Water Bank of 1991, 1992, 1994, and 2009. The binary variable is used to account for the price discovery that occurred during operation of the bank. The coefficient value indicates that water leased under the Drought Water Bank was priced 27 percent higher than other transactions, all else equal.

nod is a binary variable measuring the difference in spot market prices between water originating NOD and SOD. Sales from NOD suppliers were estimated to attract 23 percent lower prices. This discount is attributable to water losses that occur for supplies conveyed through the Delta.

According to the coefficient estimated for *scbuyer*, water transactions involving buyers in the South Coast region were priced 36 percent higher than acquisitions by buyers in other regions, all else equal. Premium prices paid by South Coast buyers result from strong competition for water supplies in the region, and the relatively high-value water uses in the area. *ewabuyer* is a binary variable measuring the premium paid by the EWA program above prices paid by other buyers. The coefficient on *ewabuyer* indicates that the EWA paid 65 percent more than other buyers, all else equal.

Equation 2 Discussion

The second equation estimates total annual water market activity in spot market transfers according to hydrologic conditions, demand, and the current range of water transfer prices. The coefficients are used to project the volume of water traded over the analysis period.

The dependent variable in the second equation, *lnspottaft*, is measured as the total annual volume of water (in TAF) traded in regions within the SWP service area through the recorded spot market water transfers beginning in 1990. As shown, the level of market activity holds an inverse relationship with water transfer prices *(lnadjpricehat*), indicating a down-sloping demand curve. Under the same hydrologic and demand conditions, more water trading occurs as prices drop.

Several different proxies for physical water scarcity conditions were tested, including annual CVP allocations, the Sacramento River Water Year Index, and a binary variable separating dry and critically dry years from wetter years. The selected variable *lnsacindex* held the strongest statistical relationship with *lnspottaft*, and has the capacity to show changes in water availability due to annual hydrologic variation.

The binary variables *wap* and *ewayear* estimate the impacts of environmental water acquisition programs on trading activity. The positive coefficients on each variable demonstrate that environmental water acquisition programs shift the water market demand curve out, resulting in a larger volume traded, all else equal.

Future Water Market Prices

In this section, the model is used to project water prices to 2030 by geographic region and hydrologic condition. Table 3-7 provides estimated water prices for municipal spot water acquisitions for selected years. It is assumed that the buyer is located in the South Coast region. NOD and SOD were selected as supplier regions used to estimate the value of the project alternatives. During wet and above normal water years, the analysis applies SOD prices to value increased M&I supplies due to conveyance limitations for NOD supplies. During below normal, dry, and critical-dry years, the analysis applies NOD prices due to increased capacity to move the relatively less expensive NOD water through the Delta.

Table 3-7. Estimated M&I Water Prices for South Coast Buyers

Year Type	Predicted M&I Water Spot Market Price			
	2014 Level of Development ($[1,2]/AF/yr)		2030 Level of Development ($[1,2]/AF/yr)	
	NOD	SOD	NOD	SOD
Wet	217	282	460	599
Above-Normal	237	310	506	658
Below-Normal	268	350	570	743
Dry	303	396	645	838
Critical	337	440	717	933

Notes:
[1] Dollar values are expressed in January 2014 price levels.
[2] Estimated prices are for water transferred among parties located in different hydrologic regions

Key:
Above Normal = Final SWP allocation assumed to be 80%
AF = acre-foot
Below Normal = Final SWP allocation assumed to be 60%
Critical = Final SWP allocation assumed to be 35%
Dry = Final SWP allocation assumed to be 45%
M&I = Municipal and industrial
NOD = Supplier located North of the Delta
SOD = Supplier located South of the Delta
Wet = Final SWP allocation assumed to be 100%

Water Conveyance Costs

The cost to convey water to M&I users is estimated according to the cost to move water through SWP facilities. Conveyance cost varies by location and user type. For example, SWP contractors pay a unit variable cost to move water based on a melded power rate. In comparison, non-SWP contractors pay a wheeling charge for access to SWP facilities in addition to a market rate for the power required to pump the water. As a result, non-SWP contractors incur significantly higher conveyance costs. This section reviews water conveyance costs by buyer type and describes how the information is applied to value the M&I water supply reliability benefits of the alternative plans.

SWP Contractors

DWR charges SWP contractors a Delta water charge and a transportation charge capital cost.

- **Delta water charge –** The Delta water charge is a unit charge applied to each acre-foot of SWP water the contractors are entitled to receive according to their contracts. The charges cover the repayment of all outstanding costs of the project conservation facilities.

- **Transportation charge capital cost component –** The transportation charge capital cost component covers the cost of using the facilities to transport water. The transportation component includes a capital cost for the transportation facilities, a minimum fee for operation of these facilities, and a variable unit cost for water delivery.

The variable unit of the transportation charge capital cost component best represents the conveyance cost that a SWP contractor would incur if it were to purchase water and convey water using SWP facilities. The variable cost reimburses the State for operating costs that depend on the quantities of water delivered to the contractors. The cost is based on the following factors (DWR 2006):

- Power purchase costs
  - Capacity
  - Energy
  - Pine Flat bond service, operations and maintenance (O&M), and transmission costs allocated to aqueduct pumping plants

- Alamo, Devil Canyon, Warne, and Castaic power generation credited at the powerplant reach and charged to aqueduct pumping plants

- Hyatt-Thermalito Diversion Dam powerplant generation charged to aqueduct pumping plants (credits for this generation are reflected in the Delta Water Rate)

- Replacement deposits for equipment at pumping plants and powerplants

- Credits from sale of excess SWP system power

- Program costs (portion) to offset annual fish losses resulting from pumping at Banks Pumping Plant (DWR-California Department of Fish and Wildlife (DFW))

The variable unit cost is paid monthly following actual water delivery. The charges are projected based on a unit charge per acre-foot established on or before July 1 of the preceding year. Those unit charges may be revised during the year to reflect current power costs and revenues. Exhibit B to Bulletin 132-12 (DWR 2012b) provides historic and projected variable unit cost by location (reach) from 1961 to 2035. Table 3-8 provides the 2016 projected conveyance cost.

Table 3-8. SWP Estimated M&I Conveyance Cost by Region for 2016

Buyer Region	Point of Reference (reach in region)	2016 Projected Conveyance Cost ($/AF)
North Bay Aqueduct	Reach 3a Cordelia Pumping Plant	26.90
South Bay Aqueduct	Reach 1 South Bay and Del Valle Pumping Plants	51.36
North San Joaquin Division	Delta Bay through Bethany Reservoir	7.19
San Luis Division	Reach 4 California Aqueduct	18.38
South San Joaquin Division	Reach 15A Teerink Pumping Plant	41.34
Mojave Division	Reach 22b Pearblossom Pumping Plant	199.62
Santa Ana Division	Reach 26a South Portal	154.75
West Branch	Reach 29j Pyramid Lake	146.36
Coastal Branch	Reach 33a Devil's Den Pumping Plant	131.08

Source: California Department of Water Resource, 2012b. Management of the California State Water Project: Bulletin 132-12. Table B-17 Unit Variable OMP&R Component of Transportation Charge.
Key:
AF = acre-foot

Non–SWP Contractors

Non-SWP contractors pay a different rate to wheel water through the SWP facilities. The primary difference is the cost of power. SWP contractors pay a melded rate for power that is below the market rate while non-SWP contractors pay the market rate for power. In addition, non-SWP contractors pay a different wheeling rate for access to SWP facilities. This analysis applies the non-SWP conveyance costs to estimate WTP because they are considered to be more reflective of the opportunity cost for use of the resource.

The following variables are used to estimate conveyance costs:

- **SWP Wheeling Rate –**The non-SWP contractor wheeling rate includes the O&M and capital costs for transportation and conservation facilities, and a cost for direct fish losses (Jones 2012). Wheeling rates were derived for each region by taking the volume-weighted average of annual quantities delivered from each canal (DWR 2012c). The SWP wheeling rate is listed by region in Table 3-9. The rate ranges from $18 per acre-foot for North San Joaquin Division buyers to $632 per acre-foot for buyers in the Coastal Branch of the California Aqueduct. The wheeling rate is provided separately for the Metropolitan Water District of Southern California (MWDSC) because the district receives its water from two different regions where rates vary significantly.

- **Power Costs –** In addition to the SWP wheeling rate, non-SWP contractors pay for power used at the pumping facilities. Power costs for Path 15 (SP15) are available from the Intercontinental Exchange (ICE) Day Ahead Power Price Report and ICE Daily Indices (ICE 2008-2012). SP15 is an 84-mile-long power transmission corridor running north and south through California's Central Valley. SP15 connects Southern California with the northern part of the state. The ICE data provide the volume-weighted averages of wholesale day-ahead firm physical electricity transactions for SP15. This study uses the weighted average off-peak and peak annual price from 2008-2012 to estimate power costs. The power rate is listed in Table 3-9.

- **Cumulative Power Demand –** The amount of power required is based on DWR's estimations of power use per acre-foot for SWP power facilities (DWR 2012a). A pumping plant facility is selected as a reference delivery point for each region. For example, the Cordelia Pumping Plant is chosen as the plant used for buyers wheeling water to the North Bay Aqueduct. Table 3-9 lists the point of reference for each buyer region and the associated cumulative power demand.

Table 3-9. Estimated M&I Conveyance Costs by Region

Contractor Region	Reach	Pumping Plant	Cumulative Power Demand from the Delta (kWh/AF)	Non-SWP Market Power Rate ($/kWh)	Non-SWP Wheeling Rate ($/AF)	Total Conveyance Cost ($/AF)
North Bay Aqueduct	1,3a,3b	Cordelia-Napa	786	0.040	137	169
South Bay Aqueduct	1, 2, 4-9	South Bay and Del Valle	1,165	0.040	63	110
North San Joaquin Division	1	Banks	296	0.040	18	30
San Luis Division	4	Dos Amigos	434	0.040	33	50
South San Joaquin Division	10s,12e,12a,11 b,13b, 16a	Teerink	971	0.040	41	81
Mojave Division	19, 20a, 20b, 21, 22a, 22b, 24	Pearblossom to West Fork Mojave River	4,549	0.040	130	312
Santa Ana Division	22b, 22a	Crafton Hills	6,507	0.040	165	426
West Branch	30	Oso	4,126	0.040	171	336
Coastal Branch	35	Devil’s Den through Tank I	1,416	0.040	632	688
Metropolitan Water District	36a, 28h, 28j, 30	Oso; Cherry Valley	4,126; 6,731	0.040	179	408

Sources: California Department of Water Resources, Management of the California State Water Project: Bulletin 132-12. Table 7. Kilowatt-Hour Per Acre-Foot Factors for Allocating Off-Aqueduct Power Facility Costs, 2012.

Intercontinental Exchange (ICE). 2008-2012. Day Ahead Power Price Report and ICE Daily Indices, SP15 Peak and Off-Peak.

Jones, Jon. Charges for Wheeling Non-State Water Project Water Through State Water Project Facilities, State Water Project Analysis Office Division of Operations and Maintenance, January 17, 2012.

Key:
AF = acre-foot
kWh= kilowatt hour
M&I= municipal and industrial
SWP= State Water Project

Estimated Conveyance Losses

Water delivery results from the CalSim-II model incorporate conveyance losses. Consequently, it is necessary to estimate conveyance losses to adjust estimated water market prices according to the geographic source of the supply. For example, an estimated delivery from CalSim-II of 1,000 acre-feet to an M&I user may require the purchase of 1,111 acre-feet at the source if 10 percent conveyance losses apply. Due to limited information regarding convey losses and specific sources of the transfer water, this analysis applies a 25 percent conveyance loss to water originating NOD. Conveyance losses for water supplies originating SOD are assumed to be 10 percent.

Combined water market prices and conveyance costs are illustrated in Figure 3-3. The values reflect the cost of water to M&I users by location within the SWP system in 2014 assuming a critical year.

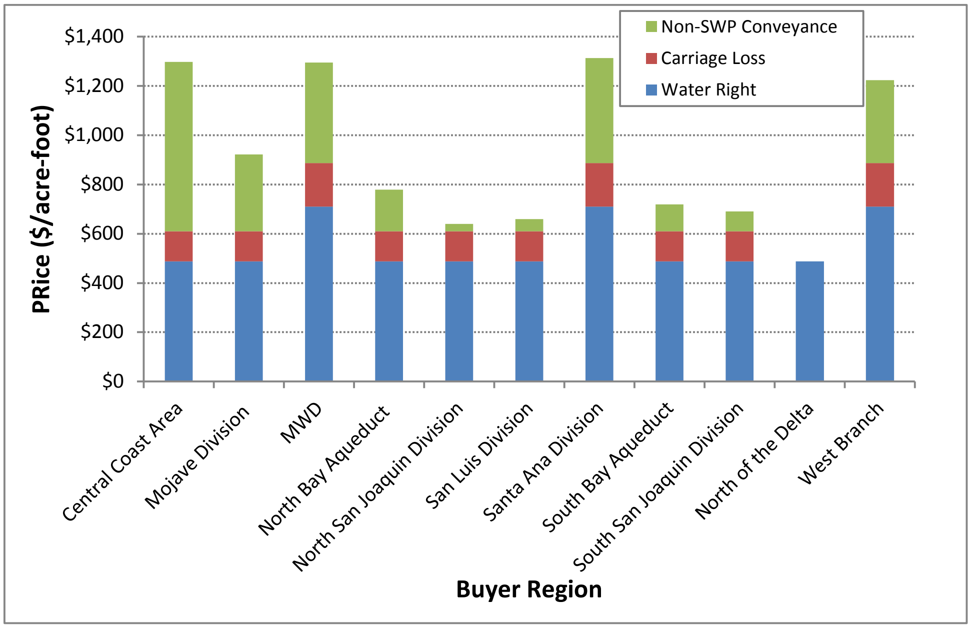


Figure 3-3. Estimated 2014 Water Cost for M&I Water Use During a Critical Water Year

NED M&I Water Supply Reliability Economic Benefits

Table 3-10 presents the estimated annual M&I water supply reliability benefits for each comprehensive plan using the 2030 level of development. The estimated M&I water market prices, by water year type for each water supply region (NOD or SOD) and buyer region, were combined with the estimated conveyance costs (including losses) according to the SWP delivery point for each M&I water contractor experiencing a change in water supply resulting from the comprehensive plans. This provides an estimate of the WTP for each increment of water supply delivered to each M&I water contractor. The WTP estimates were combined with the modeled change in water deliveries for each of the comprehensive plans to estimate the total annual M&I water supply reliability benefits. CP5, which has the highest long-term annual average new supply for SWP M&I contractors, has the highest M&I water supply reliability benefits.

Table 3-10. Estimated Average Annual NED M&I Water Supply Reliability Benefits for Comprehensive Plans

Year Type	CP1/CP4 ($ millions/ year)[1]	CP2/CP4A ($ millions/ year)[1]	CP3 ($ millions/ year)[1]	CP5 ($ millions/ year)[1]
Average (all years)	11.9	21.8	0.0[2]	26.3

Notes:
[1] Dollar values are expressed in January 2014 price levels.
[2] Economic benefit assessment was not competed for reduction in M&I deliveries associated with CP3.
Dollar values are expressed in January 2014 price levels.
Key:
CP= Comprehensive Plan
M&I= municipal and industrial

Total NED Water Supply Reliability Benefits

Total water supply benefits (Table 3-11) are the sum of the agricultural water supply reliability benefits and M&I water supply reliability benefits. Total annual water supply reliability benefits range from $10.2 million for CP3 to $34.8 million for CP5.

Table 3-11. Estimated Total Average Annual NED Water Supply Reliability Benefits for Comprehensive Plans

Type	CP1/CP4 ($ millions/ year)[1]	CP2/CP4A ($ millions/ year)[1]	CP3 ($ millions/ year)[1]	CP5 $ millions/ year)[1]
Agricultural Water Supply	3.3	5.1	10.2	8.5
M&I Water Supply	11.9	21.8	0.0	26.3
Total	**15.2**	**26.9**	**10.2**	**34.8**

Note:
[1] Dollar values are expressed in January 2014 price levels
Key:
CP= Comprehensive Plan
M&I= municipal and industrial

Risk and Uncertainty

As the population of California grows and the demand for adequate water supplies becomes more acute, the ability of the State to maintain a healthy and vibrant industrial and agricultural economy while protecting aquatic species will be increasingly difficult. Population growth is a driving factor in a trend toward an increase in the value of water in the future. Because of increasing demands on a relatively fixed water supply existing water storage capacity is likely to grow increasingly valuable as water shortages become more frequent and severe. In addition, shifts in cropping patterns from field crops to fruits, nuts, and vegetables may contribute to future increases in the value of water supply reliability as more irrigation water is applied to high-valued commodities. Among the specialized commodities are permanent crops, such as almonds, walnuts, and grapes, which require reliable water supplies and will result in a "hardening" of water demand in the agricultural sector. As this trend continues, it is likely that agriculture will have less flexibility during dry years to transfer water supplies to other users. This demand hardening, in combination with increases in urban water demand will result in increases in the value of reliable water supplies.

Compounding these trends is the uncertainty associated with climate change. As California, the U.S., and others prepare for the contingencies of global warming, the demand for and value of water supply reliability will rise.

Several water supply reliability benefit sensitivity analyses were conducted to address risk and uncertainty of the benefit estimates and are discussed below. These sensitivity analyses are provided for information only and not included in the calculation of the total benefits, NED benefits, or benefit-cost ratios. The following three sensitivity analyses for water supply reliability benefits valuation were performed and are described below:

- Agricultural water supply reliability sensitivity analysis is based on spot market transfers. NED agricultural benefits estimated with the SWAP model are primarily valued according to the increase in net revenues that accrue to agricultural producers from long-term improvements in surface water supply reliability. However, the SWAP model will not allow for planting of some acres and crop types if there are inadequate surface and ground water supplies. This sensitivity analysis considers the opportunity for agricultural producers to secure temporary water through spot market purchases to augment supplies which may improve the long-term financial returns to agricultural producers.

- M&I water supply reliability sensitivity analysis based on Least Cost Planning Simulation Model (LCPSIM). LCPSIM differs from the water transfer pricing approach applied to estimate NED benefits in that it incorporates conservation, groundwater banking, and other water management actions to address urban water shortages. Comparison of the two model results allows for a more complete depiction of the sensitivity of the benefits estimates to inclusion of these different water management actions.

- Total water supply reliability sensitivity analysis based on possible changes in water supply reliability benefits if the value of available and reliable supplies were to increase in real terms over the project planning period.

Agriculture Water Supply Reliability Benefits Sensitivity Analysis

This section provides estimates of the value of additional surface water supplied from the comprehensive plans by applying the results of a statistical model of California spot market water transfer activity, the water transfer pricing model.[4] The water transfer pricing model can be used to estimate agricultural water supply benefits by identifying the buyer type as agricultural. These computations are intended solely for the purpose of sensitivity analysis. Spot market transfer prices paid by agricultural producers may reflect short-term financial decisions to protect investments in high-valued crops. As a result, the prices paid may overstate the long-term benefits associated with improved water supply reliability. The agricultural water supply reliability benefits estimated in this sensitivity analysis are not included in the calculation of the total benefits, NED benefits, or benefit-cost ratios. These values are estimated only as a comparison to the SWAP model results presented above.

Agricultural producers in California have increasingly relied upon water transfers to meet crop water demands, particularly during drier years when supplies from the CVP/SWP are curtailed. However, water transfers occur even during wet conditions in an effort to maintain or improve groundwater availability and pumping lifts. Figure 3-4 provides the annual volume of water purchased in documented spot market transactions by agricultural buyers from 2009 through 2013. As shown, the annual volume has ranged from approximately 40,000 acre-feet to more than 120,000 acre-feet.[5]

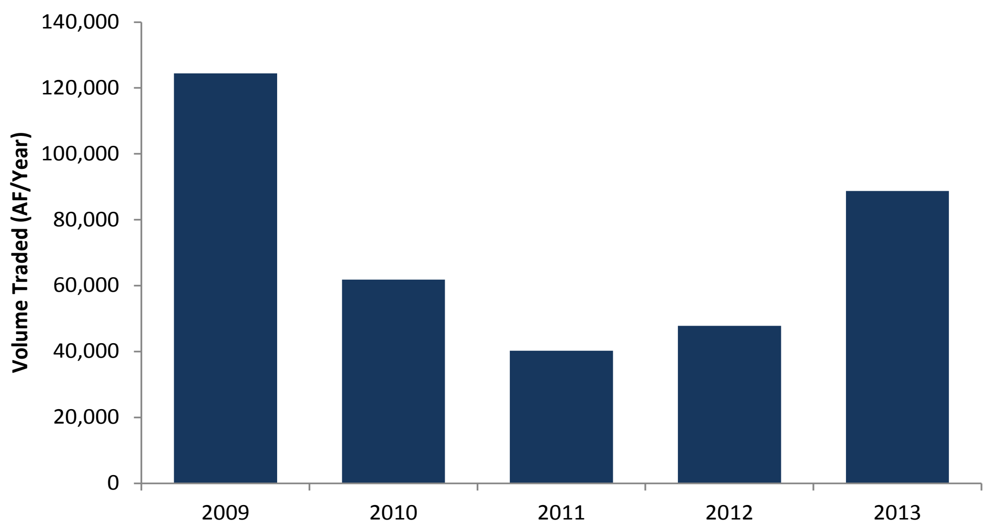


Figure 3-4. Annual Volume of Agricultural Water Purchased on Spot Market (2009-2013)

[4] For a description of the water transfer pricing model, see the "Municipal and Industrial Water Supply Reliability" section of this appendix.

[5] The volumes are associated only with spot market transactions that could be confirmed by the buyer and/or seller. As a result, the volumes represent a subset of the total water volume leased by agricultural buyers.

Table 3-12 provides the estimated water transfer prices under future conditions (i.e., 2030 level of development) for NOD and SOD agricultural buyers. These values are applied according to the location of the agricultural water supply beneficiaries from the SLWRI alternatives. No water conveyance losses or charges are included in this analysis. As a result, the estimates understate the full costs that agricultural buyers incur when purchasing surface water on the spot market.

Table 3-12. Estimated Agricultural Water Spot Market Prices

Year Type	Year Type Probabilities (%)	Predicted Agricultural Water Spot Market Price (2030 Level of Development) ($/AF/yr)[1,2]	
		NOD	SOD
Wet	32	265	345
Above Normal	15	292	380
Below Normal	17	329	428
Dry	22	372	484
Critical	15	413	538

Note:
[1] Dollar values are expressed in January 2014 price levels.
[2] Values derived from the water transfer pricing model.
Key:
Above Normal = Final SWP allocation assumed to be 80%
AF = acre-foot
Below Normal = Final SWP allocation assumed to be 60%
Critical = Final SWP allocation assumed to be 35%
Dry = Final SWP allocation assumed to be 45%
NOD = Supplier located North of the Delta
SOD = Supplier located South of the Delta
Wet = Final SWP allocation assumed to be 100%
yr = year

Table 3-13 provides the estimated agricultural water supply benefits for each of the SLWRI alternatives through application of the water transfer pricing model. As shown, the average annual benefits estimated with the spot market water transfer pricing model range from $6.5 million (CP1) to $20.4 million (CP3). These values significantly exceed the annual agricultural water supply reliability benefits estimated through application of the SWAP model.

Table 3-13. Sensitivity Analysis Comparison for Estimated Agricultural Water Supply Reliability Annual Benefits

Year Type	CP1/CP4 ($ millions/ year)[1]	CP2/CP4A ($ millions/ year)[1]	CP3 ($ millions/ year)[1]	CP5 ($ millions/ year)[1]
Sensitivity Analysis – Water Transfer Pricing Model	6.5	10.0	20.4	16.7
NED Benefit Estimate – SWAP	3.3	5.1	10.2	8.5

Note:
[1] Dollar values are expressed in January 2014 price levels.
Key:
CP = comprehensive plan
NED = National Economic Development
SWAP = Statewide Agricultural Production Model

M&I Water Supply Reliability Benefit Sensitivity Analysis

The LCPSIM was considered to estimate NED benefits associated with M&I water supply reliability. LCPSIM was developed to provide an estimate of the value of water to urban users in the Bay Area and south coast regions through a "least-cost" alternative approach. The regional model uses linear programming to simulate regional water management operations on an annual time step. It uses modeled water supply shortage management measures such as regional carryover storage, water market transfers, conservation, and shortage allocation rules to reduce regionals costs associated with a shortage event. Model output provides a measure of the WTP for increments of new water supplies by urban water providers in the two regions. LCPSIM incorporates a number of assumptions regarding the future development of water supplies and conservation in each model region. Within the two model regions it is assumed that available water supply can be allocated, without costs, to urban water providers within the region. This may overstate the mobility of water and understate the costs (and therefore estimated value) associated with incremental water deliveries. Further, LCPSIM assumes that water managers are risk-neutral when making water management decisions. This assumption may also lead to an underestimate of economic benefits associated with improved water supply reliability as urban water agencies are generally risk-averse operators and may choose to implement a more costly water management action to minimize future risk or reliance upon other water agencies.

For this analysis, LCPSIM parameters associated with water transfer prices were updated according to the values estimated by the water transfer pricing model. The available model parameters reflect a 2025 level of development rather than 2030 as applied using the water transfer pricing model. Due to the increasing urban demand for water over time, the estimated benefits using a 2025 rather than 2030 level of development are somewhat lower. Other storage projects have applied the level of development associated with multiple future years to develop annualized benefit estimates. This has resulted in higher benefit estimates due to increasing urban water demand, lower assumed

Colorado River supplies, and higher energy costs, among other factors. For consistency, this analysis only reports estimates from a single future level of development.

Table 3-14 provides the results from LCPSIM and a comparison to the M&I annual M&I benefits estimated using the water transfer pricing model (presented above). As shown, the estimated benefits using LCPSIM are lower than those estimated using the water transfer pricing model. However, because LCPSIM only includes the South Bay and South Coast regions, some of the M&I water supply provided by the project alternatives is not valued. Further, it is expected that inclusion of analysis years beyond 2025 would result in more comparable benefits across the two approaches.

Table 3-14. Sensitivity Analysis Comparison for Estimated M&I Water Supply Reliability Annual Benefits

Year Type	CP1/CP4 ($ millions/ year)[1]	CP2/CP4A ($ millions/ year)[1]	CP3 ($ millions/ year)[1]	CP5 $ millions/ year)[1]
Sensitivity Analysis – LCPSIM	6.8	10.6	0.0	11.8
NED Benefit Estimate – M&I Water Transfer Pricing Model	11.9	21.8	0.0	26.3

Note:
[1] Dollar values are expressed in January 2014 price levels.
Key:
CP = comprehensive plan
LCPSIM = Least Cost Planning Simulation Model
M&I = municipal and industrial
NED = National Economic Development

Total Water Supply Reliability Benefit Sensitivity Analysis

It is assumed in the above analysis that water supply reliability benefits will remain relatively constant over the 100-year period of analysis. This section includes a preliminary assessment of possible changes in water supply reliability benefits if the value of available and reliable supplies were to increase in real terms over the project planning period. For many reasons, it is expected that net water demands for all purposes will increase in the future. This assessment is an attempt to account for the expected net increase in demand under a without-project future condition of no new projects constructed. Values computed in this sensitivity analysis are displayed but not applied as NED benefits.

Table 3-15 shows the resulting increase in water supply benefits for agricultural and M&I uses for CP1 through CP5, assuming a 1- and 2-percent increase in the real rate of benefit values. The actual rate of this benefit increase above other factors (construction costs for instance) is not known. However, a 1- or 2-percent increase likely represents a conservative estimate. As illustrated by the table, relatively minor annual increases in values over the project planning period have a significant effect on the total estimated benefits.

Table 3-15. Relative Sensitivity of Change in Estimated Water Supply Reliability Benefits Relative to Without-Project Conditions

Assumed Change in Water Supply Reliability Benefits	CP1 ($ millions/ year)[1,2]	CP2 ($ millions/ year)[1,2]	CP3 ($ millions/ year)[1,2]	CP4 ($ millions/ year)[1,2]	CP4A ($ millions/ year)[1,2]	CP5 ($ millions/ year)[1,2]
One Percent Above Inflation						
Agricultural Water Supply	4.3	6.8	13.4	4.3	6.8	11.3
M&I Water Supply	15.8	28.8	0.0	15.8	28.8	34.7
Total[3]	20.1	35.6	13.4	20.1	35.6	46.0
Two Percent Above Inflation						
Agricultural Water Supply	6.0	9.5	18.8	6.0	9.5	15.8
M&I Water Supply[4]	22.1	40.3	0.0	22.1	40.3	48.7
Total[3]	28.1	49.8	18.8	28.1	49.8	64.4

Notes:
[1] Dollar values are expressed in January 2014 price levels.
[2] Water supply benefits are based on weighted average annual increased water deliveries displayed in Tables 3-2 and 3-7 for agriculture and M&I, respectively.
[3] Totals may not add because of rounding.
Key:
CP = comprehensive plan
M&I = municipal and industrial

Chapter 4
NED Anadromous Fish Survival Benefits

Enlarging Shasta Dam and Reservoir would contribute to improved anadromous fish survival and reproduction rates by altering seasonal water flows and temperatures in the Sacramento River downstream from Shasta Dam and other water bodies. This chapter describes anadromous fish survival benefit estimate methods and results for comprehensive plans.

Importance of Anadromous Fish

The number of programs and amount of money dedicated to anadromous fish conservation suggest that society places a high value on salmon restoration. According to the General Accounting Office (GAO), at least 11 Federal agencies and numerous other entities are involved in anadromous fish restoration in the Pacific Northwest. In the Columbia River Basin alone, Federal government agencies spent at least $1.8 billion (unadjusted for inflation) between fiscal year (FY) 1982 and FY 1996, according to GAO estimates. Between FY 1997 and FY 2001, these agencies spent $1.5 billion (or nearly $2.0 billion in current dollars) to rebuild the Columbia River Basin's salmon and steelhead stocks (GAO 2002). The Bonneville Power Administration continues to spend about $60 million annually on Fish and Wildlife programs in the Columbia River Basin (BPA 2014).

The Pacific Coastal Salmon Recovery Fund (NMFS 2011), a fishery restoration program established by Congress, contributed $884.8 million to states and tribes from FY 2000 to FY 2010 for restoring salmon stocks in California, Oregon, Washington, Idaho, and Alaska. State matching funds for this program totaled more than $451 million during this period (through FY 2009).

Because Chinook salmon are migratory, open-access biotic resources, their full value is not reflected in typical market transactions. Economic practitioners, recognizing that society does value such ecological resources, have developed a variety of nonmarket valuation techniques that may be used in estimating the value of these resources. Assigning a benefit value to anadromous fish based on sports fishing significantly underestimates the value society assigns to a viable anadromous fish stock. This is because only use values are represented and not nonuse values, which are the values people place on the resource independent of their desires or intentions to use it.

An extensive literature exists defining efforts at valuing fisheries, including salmon. Much of the literature has focused on valuing recreational harvests, and attributing value to increased salmon levels or harvest success (Olson et al. 1991, Berrens et al. 1993, and Layman et al. 1996). Recent efforts have also attempted to address the total economic value of ecosystems, freshwater salmon habitat, and restored riverine systems. Holmlund and Hammer (1999) identified the ecosystem services generated by fish populations. Knowler et al. (2003) estimated the value of Coho salmon habitat (in Canada) to be worth $1,322 to $7,010 (1994 dollars) per kilometer. Loomis et al. (2000) developed a framework and survey for determining the willingness to pay of residents for the restoration of a river in Colorado.

In addition, there have been some efforts to estimate the WTP of individuals (or households) for the preservation or recovery of ESA-listed species, including "Pacific salmon and steelhead." Loomis and White (1996) estimated the annual willingness to pay by households for preserving Pacific salmon and steelhead as $63 (1996 dollars), as the average of multiple studies. Hanneman, Loomis, and Kanninen (1991) attempted to estimate the WTP of California residents to restore flows to the Upper San Joaquin River for use in Chinook salmon restoration. They estimated a value of $181 (1989 dollars) per household. Layton, Brown, and Plummer (2001) attempted to value an increase (doubling) in the population of migratory salmon in Washington, including ESA-listed species. Richardson and Loomis (2009) conducted a meta-analysis of economic value of ESA-listed species, updating the earlier Loomis and White (1996) compendium; they determined that overall WTP values have actually increased on a per-capita basis with the passage of time.

NED Benefit Estimation Methodology

The process used in this evaluation to estimate economic benefits for increasing the populations of anadromous fish along the upper Sacramento River is based on a"least-cost" most likely alternative approach. Under this process, it is estimated that increasing the Chinook salmon populations is a socially desirable goal, as indicated by the listing of several species as threatened or endangered, and the demonstrated expenditures on salmon restoration projects. Given that increasing salmon populations is a socially desirable goal, the least costly method of attaining increases in salmon populations is sought. Because the increased potential of additional surface water storage to reduce water temperatures during critical periods is essential to increasing salmon production, the least-cost and most likely alternative would be based on the cost of various dam raises operated solely for the purpose of increasing the number of Chinook salmon smolts in the Sacramento River.

Designs and cost estimates have been developed for three most likely alternative dam raise scenarios operated solely for increased fish production, where all of the increased volume would be dedicated to increasing the cold-water pool – 6.5 feet, 12.5 feet, and 18.5 feet. These scenarios represent most likely alternatives to achieve improved anadromous fish survival, which include single purpose operations focused only on improving anadromous fish survival and do not include comprehensive plan water supply and other objectives. In addition, estimates of increases in Chinook salmon populations (expressed in habitat units of 1,000 additional smolt per year passing the RBPP) have been developed for the three dam raise scenarios.

This analysis using the CalSim-II, reservoir and river temperature, and SALMOD (a salmon population model) models is described in the Modeling Appendix to the accompanying Final EIS. The Modeling Appendix includes background (e.g., description, calibration), assumptions, model limitations and uncertainties, and related considerations for each model. In addition, rationale for key assumptions are described, such as the same spawning population being used at the start of each year in the SALMOD model simulations. Included in Table 4-1 is the estimated increase in Chinook salmon production (referred to here as habitat units (HU), where 1,000 salmon = 1 HU) for each scenario representing dam raise alternatives operated solely for increased fish production, where all of the increased volume would be dedicated to increasing the cold-water pool. Also included in the table is the estimated average annual cost for each of the three scenario dam raises. Figure 4-1 shows plots of dam raises versus HUs. The figure includes an equation of the "best fit" line/curve.

Table 4-1. Estimated Salmon Production and Annual Cost for Single Purpose Operations for Dam Raise Scenarios

Dam Raise (feet)	Habitat Units[1]	Annual Cost[2] ($ millions/ year)
0	0	0.0
6.5	673	41.3
12.5	1,000	45.3
18.5	971	52.3

Notes:
[1] Each habitat unit equals 1,000 additional Chinook salmon produced.
[2] Based on January 2014 price levels, 100-year period of analysis, 3-1/2 percent interest rate for entire dam raise.

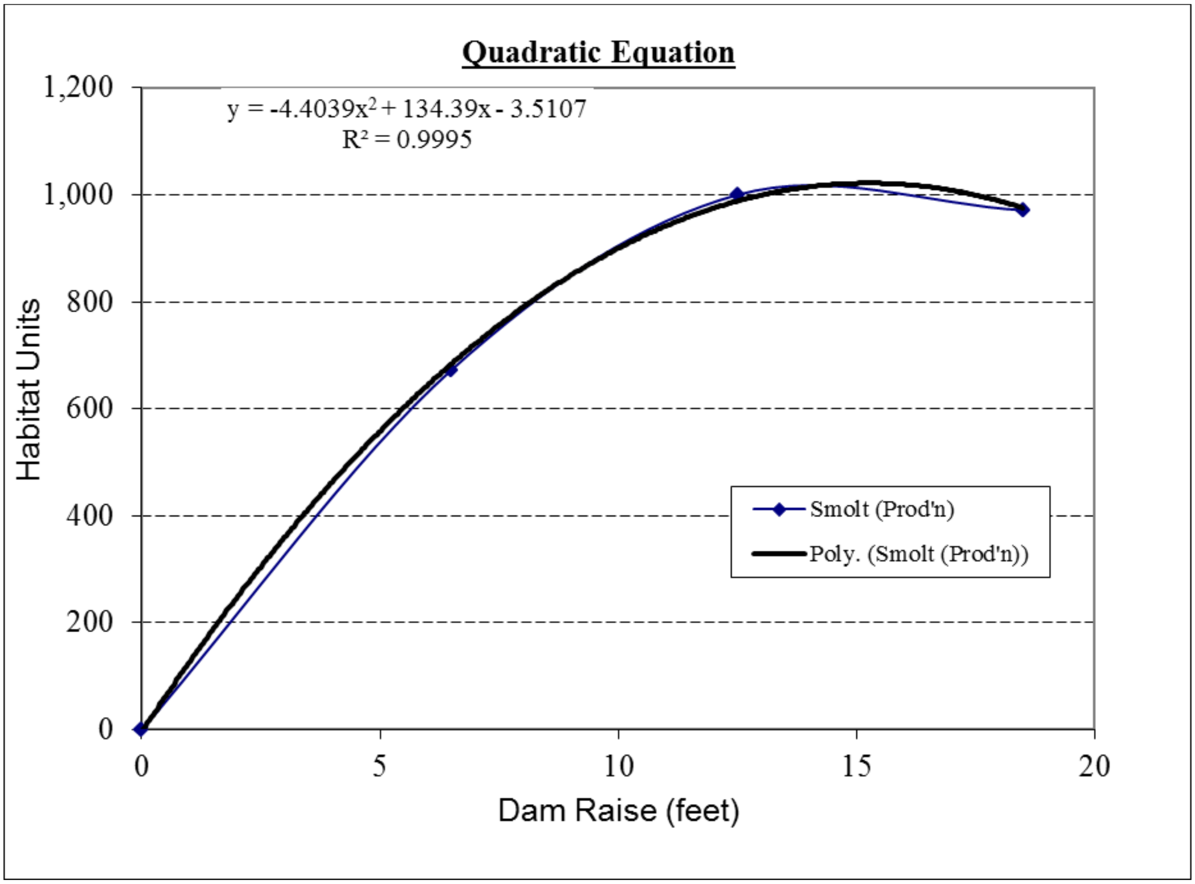


Figure 4-1. Relationship Between Estimated Habitat Unit Increase Relative to Dam Raise

Table 4-2 displays the estimated minimum average annual equivalent cost per HU of $46,857 for the 12.5-foot dam raise and this relationship is also displayed in Figure 4-2. This cost was identified as the least-cost alternative method of producing a Chinook salmon HU, and was applied as a "per HU benefit estimate" to each of the project alternatives. Using this HU value, estimates of relative monetary benefits for each of the comprehensive plans were derived. These benefit values are shown in Table 4-3. Estimated least-cost average annual equivalent anadromous fish survival benefits are $2.9 million for CP1; $17.8 million for CP2; $9.7 million for CP3; $38.1 million for CP4; $33.3 million for CP4A; and, $17.7 million for CP5.

Table 4-2. Development of Estimated Least Cost Per Habitat Unit

Sole Purpose Dam Raise (feet)	Habitat Units[1,2]	Annual Cost ($ millions/ year)[3]	Cost per Habitat Unit ($1,000)[3]
0.5[4]	63	35.3	564,840
1.7[5]	212	36.4	171,729
3.2[6]	381	37.8	99,137
6.5	684	40.8	59,694
12.5	988	46.3	46,857
18.5	975	51.8	53,088

Notes:

[1] Each habitat unit equals 1,000 additional salmon produced.

[2] Habitat units are based on relationship between habitat units and dam raise heights displayed in Figure4-1.

[3] Dollar values are expressed in millions, January 2014 price levels.

[4] Dam raise height is equivalent to habitat units provided by CP1.

[5] Dam raise height is equivalent to habitat units provided by CP3.

[6] Dam raise height is equivalent to habitat units provided by CP2.

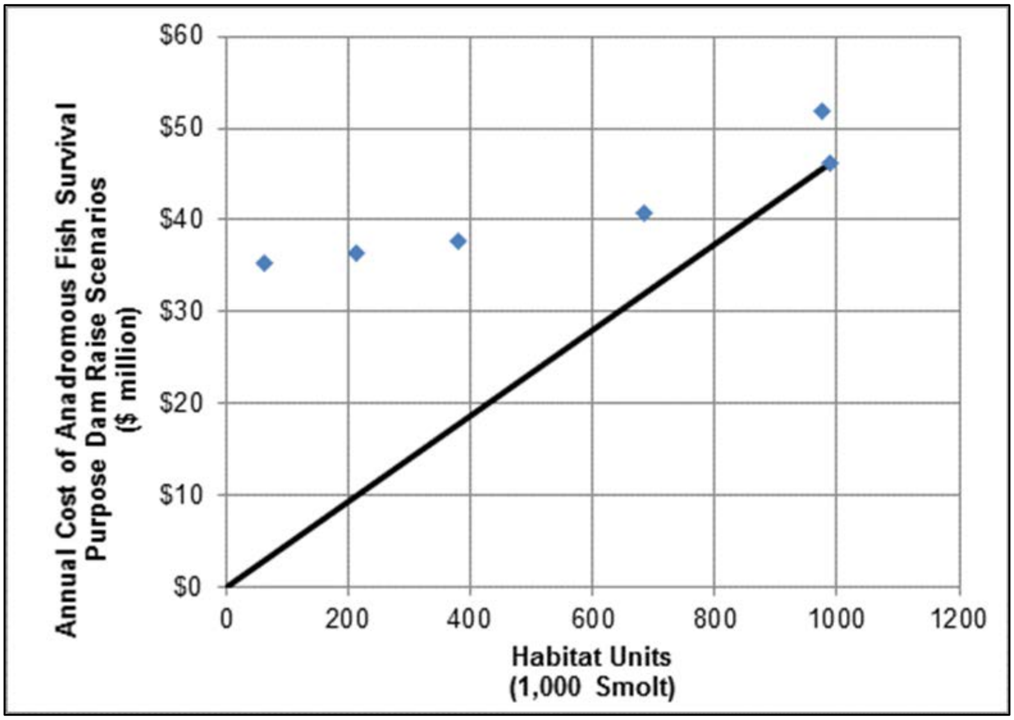


Figure 4-2. Least Cost per Habitat Unit Assessment of Anadromous Fish Survival Purpose Dam Raise Scenarios

Table 4-3. Estimated Average Annual NED Anadromous Fish Survival Benefits for Comprehensive Plans

Description	CP1	CP2	CP3	CP4	CP4A	CP5
Change in Average Annual Salmon Habitat Units Relative to No-Action Alternative[1]	61.3	379.2	207.4	812.6	710.0	377.8
Total Annual Benefits ($ millions/ year)[2,3]	2.9	17.8	9.7	38.1	33.3	17.7

Notes:
[1] Each habitat unit equals 1,000 additional Chinook salmon smolt produced.
[2] Dollar values are expressed in January 2014 price levels.
[3] Estimated anadromous fish survival benefits were based on least-cost alternative estimates and average annual smolt production for each comprehensive plan.
Key:
CP = comprehensive plan

Risk and Uncertainty

In general terms, total economic value is measured as the combination of market and non-market components. For many common resource uses, such as agriculture or hydroelectric power generation, well established markets with considerable and publicly available price information provides a ready measure of “value.” For other resource uses, such as recreation, there is both market (e.g., admittance or user fee) and non-market components, but a fairly large body of literature exists that can support development of total value. However, for the largely non-market basis for value associated with ecosystem services, ecosystem improvements, or enhancement and/or protection of ESA-listed species, the information base is far more limited. There is normally a high reliance on site-specific biological, physical, and hydrologic information that is often not available. Although there is consensus among economists that non-market values exist and are positive, there is also recognition that methods for measuring these values are difficult. The lack of consensus about appropriate methods and varying levels of resource data and information contributes to uncertainty in ecosystem benefits.

The NED ecosystem benefit estimates related to increased anadromous fish survival presented in this section are based on a secondary, indirect method that relies on costs as a proxy for consumer “willingness to pay,” and is consistent with NED valuation requirements. As noted in the P&G, this method is acceptable, but only when other more precise methods are ruled out from lack of site-specific information.

A sensitivity analysis was also conducted for anadromous fish survival focused alternatives to address risk and uncertainty of the benefit estimates and is discussed below. This sensitivity analysis is not included in the calculation of the total benefits, NED benefits, or benefit-cost ratios, but is provided for informational purposes to demonstrate a range of potential values.

Endangered Species Environmental Restoration Benefit Sensitivity Analysis – Anadromous Fish Survival Focused Alternatives –CP4 and CP4A

Providing supplemental and strategically released cold water to the Sacramento River can increase the survival of anadromous fish in the system. To the extent that the biological improvement can be measured, various methods are available to quantify the economic benefits. The Comprehensive Plans that are most focused on anadromous fish survival are CP4 and CP4A. The level of improvement to Chinook salmon in these alternatives is determined through the use of the SALMOD model, described in the Modeling Appendix. For this sensitivity analysis, the economic benefits of improving habitat for ESA-listed Chinook salmon are estimated based on the application of benefit transfer methods with values from a recent study in the Klamath River basin that addressed habitat improvements for fish (Reclamation 2011).

Klamath Restoration Nonuse Survey A recent study of particular comparability to the situation on the Sacramento River was conducted by Reclamation in the Klamath River Basin Restoration investigation (Reclamation 2011). The study, by RTI International (2012), attempted to estimate the nonuse value (also referred to as existence, passive use, and bequest value) of alternatives for restoration. In that effort, the WTP of households was isolated for increasing the population of Chinook salmon, and reducing the risk of extinction for coho salmon from high to moderate.

Their analysis included a separation of the surveyed population by geographic location for sampling and tabulation. Under this premise, persons (households) closest to the site would most likely be affected or place some value on the resource. Those residing farther away would have many other options to recreate or otherwise value, and may be less willing to pay for a site improvement. ESA-listed species by virtue of their Federal listing, have characteristics that suggest a national, or at least broader, geographic range is appropriate in terms of the defined affected region.

Some of the findings of the RTI International study are shown in Table 4-4, presented for three geographic regions: the twelve-county Klamath area (in Southern Oregon and Northern California), the rest of Oregon and California, and the remainder of the United States.

Table 4-4. Estimated Annual Household WTP for Reduced Extinction Risk for Coho Salmon from High to Moderate

Region	WTP[1]
12-County Klamath Area	$38.46
Rest of Oregon and California	$50.02
Rest of United States	$39.11

Source: RTI International 2012, Table 8-2, p. 8-4.
Note:
[1] Average annual per household willingness-to-pay for reducing the risk of extinction for Coho salmon from high to moderate and for suckers from very high to high. The "Action Plan" from which this is derived includes a 30 percent increase in the number of returning Chinook salmon and steelhead adults.
Key:
WTP = willingness to pay

The estimates provided in Table 4-4 are within a reasonable range, and perhaps even on the low end, when compared to other studies of the value of preserving ESA-listed salmon. For example, the Richardson and Loomis (2009) meta-analysis found estimates ranging from $28.29 to $141.27 per household for protection of Pacific salmon and steelhead species, with a mean estimate of $89.99 per household.[6] Although the Klamath estimates are lower than the mean of Richardson and Loomis, they may be a better reflection of the situation on the Sacramento River since most of the Richardson and Loomis (2009) studies used local or statewide populations, rather than nationwide, in their surveys. A more localized survey could yield an upward bias on value when applied nationally.

Applying Economic Estimates to SALMOD Model Results SALMOD modeling is documented in the Modeling Appendix and was performed for four separate runs of Chinook salmon in the Sacramento River, including: fall, late-fall, winter, and spring. For this sensitivity analysis, SALMOD results for winter-run and spring-run Chinook salmon are used since they are both listed under the State and Federal ESA as endangered and threatened, respectively.

The SALMOD results for each run were ranked from lowest to highest, based on the No-Action Alternative conditions. The production in the lowest 16 years (lowest 20 percent) were identified as the "low production" years.

Table 4-5 displays the SALMOD change in productive capability results by overall average (all years) and "low production" years for CP4 and CP4A. The "average" percent change in productive capability across all modeled water years can be interpreted as the long-term improvement in productive capability of each run. The "low production" percent change in productive capability is the average percent change in the lowest production years under the No-Action Alternative. The "low production" percent change in productive capability can

[6] Richardson and Loomis included two studies, one at $10 per household, in their range that applied to Atlantic salmon in Massachusetts. These are not considered relevant to this Feasibility Study, and therefore the original range of estimates by Richardson and Loomis was recalculated with the Atlantic salmon studies removed.

be interpreted as the anticipated change in productive capability for winter-run and spring-run Chinook salmon for the years in which production under the No-Action conditions is lowest, or when the run is most vulnerable.

Table 4-5. Estimated Change in Productive Capability for Average Years and Low Production Years[1]

Alternative	Winter-Run Chinook Salmon		Spring-Run Chinook Salmon	
	Average	Low Production[2]	Average	Low Production[2]
CP4	1.7%	15.3%	3.6%	48.8%
CP4A	0.7%	9.4%	2.4%	33.2%

Notes:
[1] Values are based on SALMOD output
[2] Low Production Years are the productions in the lowest 20 percent of the years
Key:
CP = comprehensive plan

As shown in Table 4-5, the estimated average percentage increase in productive capability in the alternatives is much smaller than a "30 percent increase … each year," a primary feature in the Klamath Restoration study survey (RTI 2012). The modeled change is small enough for each alternative to be within the margin of error of prediction. For the economic analysis, it is unlikely that the biological results for the alternatives will provide any meaningful indication of a beneficial outcome relative to the component associated with a "30 percent increase…each year" in adults. So, for analytical purposes, the average change results in nearly zero change in economic benefits.

The change in relative risk of extinction is more difficult to assess, as SALMOD does not measure survival through the entire life cycle of Chinook salmon (e.g., it does not calculate survival in the Delta or Pacific Ocean). However, extinction risk reduction is encapsulated by improving conditions when the fish is at its most vulnerable state, or when productive capability is at its lowest under the No-Action conditions. The increases in Chinook salmon productive capability in the "low production" years resulting from CP4 and CP4A significantly reduce the risk of extinction, and therefore increase the chances for success of winter-run and spring-run Chinook salmon in moving towards the goals established by NMFS and U.S. Fish and Wildlife Service (USFWS) through the Recovery Plan and the Anadromous Fish Restoration Program doubling goals (NMFS 2009, USFWS 2001).

As shown in Table 4-5, CP4 and CP4A both provide increases in the productive capabilities of both winter-run and spring-run Chinook salmon above the No-Action Alternative in the lowest production years, almost all of which are dry and critical years. While compounding impacts of consecutive dry years were not explicitly modeled in SALMOD, the alternatives would have a considerable effect on improving the chance of success for species survival by virtue of their consecutive low-production year water storage, and the benefits of the increased cold water pool.

Economic Estimates of the Alternatives The calculation of ecosystem benefits is made for each of the three geographic zones. The total benefits for each anadromous fish survival focused alternative is the sum of the individual zones, but results are presented showing each zone individually. Benefits are calculated according to the following formula:

*Benefits = [(Wtd Avg / 30%) * 50%] +
[(Low Prod / 100%) * Risk Factor * 50%] *
(Households * WTP per HH)*

where:

Benefits are the total benefits for a zone (1, 2, or 3)

Wtd Avg is the weighted average increase above the baseline in the productive capability of the species run;

Low Prod is the percent change in productive capability within the 20 percent of years with the lowest baseline production;

Risk Factor is a weighting that is applied relative to the starting baseline;

Households is the number of households in the geographic zone; and

WTP per HH is the willingness to pay per household within the zone.

Table 4-6 presents combined sensitivity analysis results for the alternatives (CP4 and CP4A) that are most focused on anadromous fish survival. The results, presented by geographic zone, indicate that each anadromous fish survival focused alternative provides positive Chinook salmon benefits. Benefits in Zone 1 (the four-county area surrounding and adjacent to the Shasta Lake project) range from $0.58 million to $0.89 million per year. Benefits in Zone 2, which encompasses the remainder of California outside of Zone 1, are estimated to be $92.5 million to $141.8 million per year. Benefits in Zone 3, which includes the rest of the United States outside of California, range from $183.2 million to $280.9 million per year. Total benefits, the sum of all three zones, range from $276.3 million to $423.5 million per year. As noted above, CP4 and CP4A do not show large increases in overall productive capability when all years are combined (Table 4-5). However, when separated by the lowest production years, which are primarily critical and dry years, productive capability significantly increases for both winter-run and spring-run Chinook salmon. This also shows in a significant extinction risk reduction for both winter-run and spring-run Chinook salmon under CP4 and CP4A. These sensitivity analysis results indicate that the NED ecosystem benefit estimates for anadromous fish survival focused alternatives may be understated.

Table 4-6. Sensitivity Analysis for Estimated Ecosystem Benefits for Anadromous Fish Survival Focused Alternatives and by Geographic Zone

Alternative	Zone 1: Four-County[1] Region ($ millions/ year)	Zone 2: Rest of California ($ millions/ year)	Zone 3: Rest of United States ($ millions/ year)	TOTAL: Sum of Zones ($ millions/ year)
CP4	0.89	141.8	280.9	423.5
CP4A	0.58	92.5	183.2	276.3

Notes:
[1] Four-county region includes Shasta, Tehama, Trinity, and Siskiyou Counties.
[2] Dollar values are expressed in January 2014 price levels.
Key:
CP = comprehensive plan

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Chapter 5
NED Hydropower Benefits

The proposed enlargement of Shasta Dam, would affect reservoir elevations, volume of flow through generation facilities, and water deliveries, which will impact hydropower capacity, generation and the ability to provide ancillary services[7] at Shasta Dam and other hydropower facilities throughout the CVP and SWP. Estimates of net changes in CVP hydropower capacity, generation and ancillary services and SWP power generation in the Western Interconnection electrical power grid were estimated using a number of models. Monthly CVP/SWP power generation and capacities were derived through post processing CalSim-II outputs using the power tools LongTermGen (LTGen) and State Water Project Power (SWPPower). PLEXOS was used to disaggregate monthly power production to hourly power accomplishments based on recent historical operations. Power benefits were valued by using PLEXOS to forecast energy and ancillary service power market prices for the year 2020 when the 33 percent RPS, mandated by California law, will have been implemented. The assumption is that power market prices stabilize once the RPS is achieved. Planning capacity prices were forecast based on the cost of a new aero-derivative combustion turbine, the current capacity market price, and the year when the Western Electricity Coordinating Council (WECC) becomes capacity deficit. Please refer to the Modeling Appendix to the accompanying Final EIS for descriptions of water supply operations and hydropower modeling (LTGEN and SWPPower) procedures.

Hydropower Valuation Methods

Available hydropower valuation methods include the user-value and least-cost alternative. The user-value method would estimate the magnitude of the economic benefit from increased net hydropower accomplishments. The user-value method would use projected prices a variety of power products, such as those obtained from CAISO, to determine the value of additional hydropower output. The least-cost alternative method would be based on the cost of developing an equal quantity of net power generation capacity at an alternative facility. SLWRI hydropower benefits were estimated by the user-value method for generation and ancillary services because these electricity prices could be readily evaluated using the PLEXOS model. The value of hydropower capacity was evaluated using a combination of user-value and the least-cost alternative.

[7] CAISO ancillary service market is comprised of regulation up, regulation down, spinning reserve and non-spinning reserve providing frequency support, voltage support, and load-following. These services are needed to allow CAISO to precisely match generation and load and operate the grid in a reliable manner.

Results of NED Hydropower Benefits Estimation

The value of energy and ancillary services is estimated by applying the forecasted market value in the year 2020 to generation and ancillary service accomplishments and then indexing the benefits to a 2014 price level. Energy market value is determined by the forecasted shadow price from PLEXOS (i.e., marginal value) on an hourly basis for NP-15 (North of Path 15), which is the Northern California area of the CAISO balancing authority. Since the shadow prices are initially based on the incremental cost of the marginal generating units, the "market price" represents a conservative estimate of the energy value, as no bid mark-ups or market power is assumed. Ancillary service benefits are based on forecasted market prices for the year 2020 from PLEXOS and also do not include any assumption of market power.

There are two types of resource adequacy (RA) capacity currently required in California to ensure sufficient generation is available to meet load at all times considering both variations in weather and various types of outages: (1) a statewide requirement that all Load Serving Entities (primarily utilities--LSEs) provide for a planning reserve margin of 15 percent to 17 percent capacity above forecasted peak loads in the five summer months (May-September) and (2) a local RA requirement similar to the statewide one that is geographically specific to a number of areas in California where transmission constraints restrict the amount of generation available to meet load.[8] Currently, capacity prices are relatively low because the CAISO power system has sufficient resources to be considered adequate. However, CAISO filed a tariff amendment on August 1, 2014 with the Federal Energy Regulatory Commission (FERC) to initiate a Flexible Resource Adequacy Capacity Market to procure upward and downward ramping capacity required to accommodate sudden output changes inherent in variable resources, such as wind and solar.[9] Since hydropower is very flexible, the advent of this market could place a premium on the value on hydropower capacity. The incremental capacity available from the potential enlargement of Shasta Dam could be used to satisfy either the standard or the flexible resource adequacy capacity requirement. Based on the North American Electric Reliability Corporation (NERC) Long-Term Reliability Assessment (December 2013), the WECC-wide "anticipated" planning reserve margin is 19.9 percent in 2023 (the last year of the evaluation).[10] Given California's mandated 15 percent reserve margin, it is anticipated that new resource adequacy capacity will not be needed in California until 2025 or later. At that point, capacity is valued at the least cost to build new thermal capacity with comparable attributes to hydropower capacity.

Consumer Price Indices were used to index the market price to a January 2014 price level. Table 5-1 shows the estimated average annual benefits for increased

[8] http://www.cpuc.ca.gov/PUC/energy/Procurement/RA/ra_history.htm
[9] http://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleCapacityProcurement.aspx
[10] http://www.nerc.com/pa/RAPA/ra/Pages/default.aspx "Planning Reserve Margins", p. 159.

hydropower generation, ancillary services, and capacity benefits for each comprehensive plan relative to the No-Action Alternative. The average annual values are used in the NED benefits analysis. The estimated average annual increase in the value of power generation benefits are $6.8 million for CP1, $10.3 million for CP2, $11.1 million for CP3, $14.9 million for CP4, $14.4 million for CP4A, and $13.4 million for CP5.

For comparison, Table 5-2 shows the estimated dry year and wet year benefits for increased hydropower generation, ancillary services, and capacity benefits for comprehensive plans. As shown, the dry and wet year benefits are generally higher than the average annual benefits used in the NED analysis.

Table 5-1. Estimated Average Annual NED Hydropower Benefits for Comprehensive Plans

	6.5-Foot Raise (CP1)	**12.5-Foot Raise (CP2)**	**18.5-Foot Raise (CP3)**	**18.5-Foot Raise (CP4)**	**18.5-Foot Raise (CP4A)**	**18.5-Foot Raise (CP5)**
Estimated Increased CVP/SWP Hydropower Generation						
Increased CVP Generation (GWh)	**38.6**	**65.6**	**91.0**	**113.3**	**103.7**	**88.9**
Increased SWP Generation (GWh)	13.7	21.2	(5.3)	13.7	21.2	23.5
Estimated Hydropower Benefits						
Increased CVP Generation ($1,000)	**$2,580**	**$4,360**	**$5,990**	**$7,520**	**$6,880**	**$5,880**
Increased SWP Generation ($1,000)	$930	$1,450	($370)	$930	$1,450	$1,620
Ancillary Services Benefit ($1,000)	$180	$290	$410	$700	$540	$370
Capacity Benefit ($1,000)	$3,070	$4,140	$5,070	$5,740	$5,540	$5,550
Total Hydropower Benefits	**$6,800**	**$10,300**	**$11,100**	**$14,900**	**$14,400**	**$13,400**

Notes:

[1] Dollar values are expressed in thousands of dollars at January 2014 price levels.

[2] Power generation estimates represent the increased load center generation (accounting for transmission losses) at Central Valley Project and State Water Project facilities. Energy requirements for pumping and conveyance of increased water deliveries are accounted for in operations and maintenance costs for each alternative.

[3] Ancillary services and capacity benefits are based on at-plant hydropower parameters.

Key:
CP = comprehensive plan
CVP = Central Valley Project
GWh = gigawatt-hour
NED = National Economic Development
SWP = State Water Project

Table 5-2. Estimated Dry and Wet Year Benefits for Hydropower Generation, Ancillary Services, and Capacity Benefits for Comprehensive Plans

	6.5-Foot Raise (CP1)	12.5-Foot Raise (CP2)	18.5-Foot Raise (CP3)	18.5-Foot Raise (CP4)	18.5-Foot Raise (CP4A)	18.5-Foot Raise (CP5)
Dry Years						
Estimated Increased CVP/SWP Hydropower Generation						
Increased CVP Generation (GWh)	34.4	59.1	64.1	97.5	91.9	83.7
Increased SWP Generation (GWh)	25.6	36.9	(22.5)	25.6	36.9	37.8
Estimated Hydropower Benefits						
Increased CVP Generation ($1,000)	$2,290	$3,900	$4,160	$6,480	$6,080	$5,520
Increased SWP Generation ($1,000)	$1,990	$2,920	($1,760)	$1,990	$2,930	$3,010
Ancillary Services Benefit ($1,000)	$110	$140	$290	$990	$590	$160
Capacity Benefit ($1,000)	$3,070	$4,150	$5,070	$5,740	$5,540	$5,550
Total Hydropower Benefits	**$7,500**	**$11,100**	**$7,800**	**$15,200**	**$15,100**	**$14,200**
Wet Years						
Estimated Increased CVP/SWP Hydropower Generation						
Increased CVP Generation (GWh)	63.3	100	141	160	149	127
Increased SWP Generation (GWh)	3.7	(0.1)	(1.4)	3.7	(0.1)	0.7
Estimated Hydropower Benefits						
Increased CVP Generation ($1,000)	$4,160	$6,600	$9,220	$10,560	$9,810	$8,300
Increased SWP Generation ($1,000)	$220	($20)	($90)	$220	($30)	$20
Ancillary Services Benefit ($1,000)	$210	$330	$430	$430	$430	$430
Capacity Benefit ($1,000)	$3,070	$4,150	$5,070	$5,740	$5,540	$5,550
Total Hydropower Benefits	**$7,700**	**$11,100**	**$14,600**	**$17,000**	**$15,800**	**$14,300**

Notes:

[1] Dollar values are expressed in thousands of dollars at January 2014 price levels.

[2] Power generation estimates represent the increased load center generation (accounting for transmission losses) at Central Valley Project and State Water Project facilities. Energy requirements for pumping and conveyance of increased water deliveries are accounted for in operations and maintenance costs for each alternative.

[3] Ancillary services and capacity benefits are based on at-plant hydropower parameters.

Risk and Uncertainty

Traditionally, on-peak energy has been the most valuable electricity product. However, this is changing. In November 2013, CAISO and the NERC released a special assessment entitled *Maintaining Bulk Power System Reliability While Integrating Variable Energy Resources – CAISO Approach* (CAISO and NERC 2013). This report states, "integrating large quantities of variable energy resources (predominantly wind and photovoltaic solar) into the North American bulk power system requires significant changes to electricity system planning and operations to ensure continued reliability of the grid." Given that California has a legislative mandate to produce 33 percent of its electricity from renewable resources, many of which are variable energy resources, by the year 2020, California will have an increasing need for ancillary services, such as regulation-up and -down. Flexible capacity is a market product being initiated in 2014 to assure that sufficient flexible capacity is available when needed. This means that there will be a premium placed on the value of this type of capacity. Similarly, ancillary services are likely to become more valuable in California by the year 2020. In layperson's terms, ancillary services are defined as the attributes of certain generating resources to be able to quickly ramp up or down their generation production in response to fluctuations in variable energy resources generation to meet load in a reliable manner. Hydropower is considered to be one of the best power resources to provide flexible capacity and these types of ancillary services.

In addition, a variety of factors suggest that energy prices may change in value at some rate distinct from inflation over time. Population growth within California will increase the demand for electricity. In keeping with the State's recent policies aimed at reducing greenhouse gas (GHG) emissions, electricity-generating technologies, such as hydropower, that do not produce carbon dioxide will be at a premium. Further, global population increases and increasing incomes in developed and developing nations will likely to lead to increases in the demand for and price of energy. Finally, the most important factor influencing electricity prices is the price of natural gas. Natural gas prices have recently fallen because of the increasing supply made available through the use of fracking. However, fracking has become controversial and numerous efforts are underway to regulate this practice.

A qualitative evaluation of future natural gas prices was conducted to address risk and uncertainty of the NED benefit estimates in relation to the price of natural gas and is discussed below. In addition, a hydropower benefit sensitivity analyses was conducted to address risk and uncertainty of the NED benefit estimates related to possible changes in the value of energy if it were to increase over the project planning period and is discussed below. The natural gas price discussion and sensitivity analysis are for informational purposes only and not included in the calculation of the total benefits, NED benefits, or benefit-cost ratios.

Natural Gas Price Influence on Hydropower Values

The price of natural gas influences the U.S. power market and is a source of uncertainty in relation to SLWRI comprehensive plan hydropower benefit estimates. Fracking has led to an abundance of natural gas and reduced U.S. power industry electricity prices. Regulation of fracking may increase the price of natural gas and electricity prices throughout the U.S., and the value of hydropower.

A number of entities forecast the price of natural gas including government agencies such as the Northwest Power and Conservation Council (NWPCC) and the California Energy Commission (CEC), and also private companies such as CME Group, which forecasts natural gas futures. These entities' natural gas price forecasts are discussed below. Table 5-3 displays the NWPCC natural gas price forecast from July 2014.[11] These natural gas price projections are at Henry-Hub and do not include variable transportation and distribution charges.

[11] "Fuel Price Forecast", Revised Fuel Price Forecasts for the Seventh Power Plan, July 2014,www.nwcouncil.org/media/7113626/Council-FuelPriceForecast-2014.pdf.

Table 5-3. Northwest Power and Conservation Council Forecasted Natural Gas Prices at Henry-Hub

Selected Year	Forecasted Natural Gas Price ($[1]/mmBtu)		
	Low	Medium	High
2013	$3.70	$3.70	$3.70
2014	$3.90	$4.70	$4.90
2015	$4.00	$4.60	$5.10
2020	$3.90	$5.00	$6.00
2025	$3.80	$5.70	$7.30
2030	$3.50	$6.60	$8.90
2035	$3.20	$7.40	$10.80
Average Price (2015-2035)	$3.80	$5.80	$7.50

Note:
[1] Values are expressed at a 2012 price level.
Key:
mmBtu = million British thermal units

Additionally, the CEC Staff Report entitled "2013 Natural Gas Issues, Trends, and Outlook" (released in July 2014[12]) compares the natural gas price forecast from the NWPCC's Seventh Power Plant to the CEC's most recent forecast. As shown in Figure 5-1, below, the CEC's reference case is somewhat higher than the NWPCC's forecasted medium price.

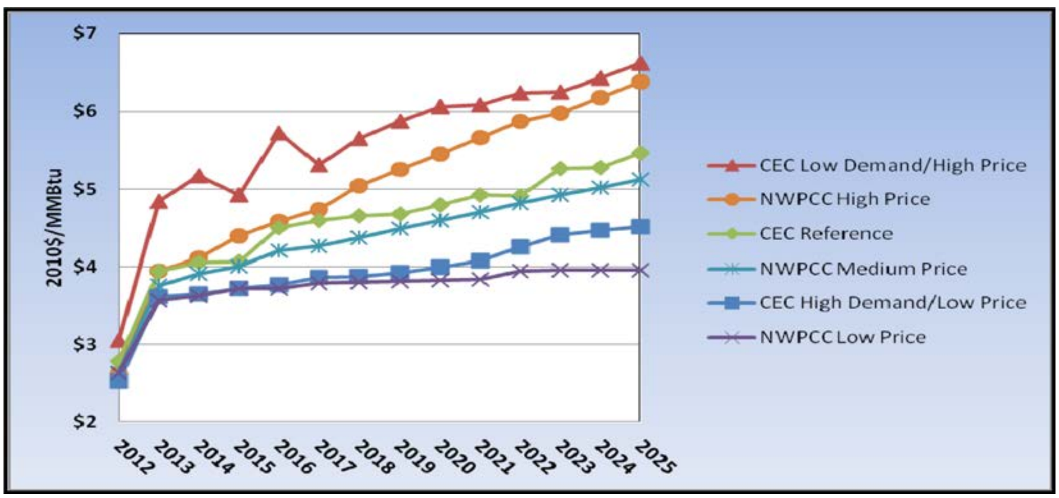

Figure 5-1. Henry-Hub Prices, NWPCC versus Energy Commission

Forecasted natural gas price futures reported by the CME Group[13] indicate that the average nominal price at Henry-Hub in July may be $4.559 and $4.769 per million British thermal units (mmBtu) in 2020 and 2022, respectively. These

[12] http://www.energy.ca.gov/serp.html?q=natural+gas+price+forecast&cx=001779225245372747843%3Actr4z8fr3aa&cof=FORID%3A10&ie=UTF-8&submit.x=19&submit.y=10
[13] Natural Gas (Henry Hub) Physical Futures Quotes, Globex, CME Group, www.cmegroup.com/trading/energy/natural-gas.html.

forecasted price futures would likely be higher though with an adder to the settled price.

The price of natural gas will influence the U.S. power market in the future and have bearing on the values of additional hydropower benefits due to SLWRI comprehensive plans. Natural gas price forecasts above indicate that the $5.80 per mmBtu price of natural gas assumed in PLEXOS for the year 2020 is within the medium range of examined price forecasts. New regulations for fracking may lead to increased natural gas prices and the value of energy within the U.S. power market.

Energy Price Increase Hydropower Sensitivity Analysis

A variety of factors suggests that energy prices may grow in value at some rate distinct from inflation over time. The NED hydropower benefit analysis, above, assumes that energy prices remain constant across the 100-year period of analysis. This section considers changes in hydropower generation benefits if energy prices were to increase over time, a possibility suggested by a variety of demographic and economic factors. These computations are intended solely for the purpose of sensitivity analysis. The hydropower generation benefits estimated in this sensitivity analysis are not included in the calculation of the NED benefits, net benefits, or benefit-cost ratios.

If the price of electricity were to increase at 1 percent increase per year above inflation, assuming a discount rate of 3.5 percent and a project life of 100 years, the annualized value of net energy changes relative to without-project conditions would be $8.9 million for CP1; $13.5 million for CP2; $14.7 million for CP3; $19.7 million for CP4; $19.0 million for CP4A; and, $17.7 for CP5 (Table 5-4). For a 2-percent increase in the price of energy above inflation, the annualized value of net energy changes relative to without-project conditions would be $12.5 million for CP1; $19.0 million for CP2; $20.6 million for CP3; $27.6 million for CP4; $26.7 million for CP4A; and, $24.8 for CP5 (Table 5-4).

Table 5-4. Sensitivity Analysis for Estimated Change in Hydropower Benefit Relative to Without-Project Conditions

Change in Price of Electricity	CP1 ($1,000)	CP2 ($1,000)	CP3 ($1,000)	CP4 ($1,000)	CP4A ($1,000)	CP5 ($1,000
One Percent Above Inflation						
Hydropower Benefit	8,943	13,539	14,672	19,680	19,035	17,727
Two Percent Above Inflation						
Hydropower Benefit	12,530	18,969	20,557	27,573	26,670	24,837

Notes:
Values are expressed in thousands of dollars, January 2014 price levels.
Key:
CP = comprehensive plan

Chapter 6
NED Recreation Benefits

This chapter presents an examination of potential changes in recreational participation and associated economic benefits at Shasta Lake due to proposed comprehensive plans. The recreation benefit estimate presented in the following sections relies on historic information, simulated comprehensive plan reservoir water elevations and surface area, quantification of visitor-day estimates documented in the Modeling Appendix, and the benefits transfer method for applying economic values. The benefit transfer method is applied due to limited available recreation participation data for Shasta Lake. In addition, a recreation benefit sensitivity analysis was conducted to address risk and uncertainty of the benefit estimates and is also discussed.

Shasta Lake is the centerpiece of the Shasta Unit of the Shasta-Trinity National Forest. The combination of water surface and lands provides the opportunity for many types of outdoor recreation, with water oriented recreation as the main attraction. Raising the height of Shasta dam, higher average annual reservoir surface area, and decreasing reservoir drawdown (drop) during the peak recreation season (May to September) compared to without-project conditions, could all lead to increased recreational participation. To the extent that comprehensive plans cause net increase in recreational visits to Shasta Lake without an appreciable decrease elsewhere, the value of increased recreational activity will yield a net benefit to the Nation. In addition, although not quantified or monetized for the NED analysis, relocating and modernizing related recreation facilities may lead to increased recreational participation.

There are few alternate reservoir recreational sites in the Sacramento Valley and Northern California with similar attributes to Shasta Lake, and a boating carrying capacity study (Graefe et al 2005); indicates that boating may be near capacity in both Shasta and Trinity Lakes, which suggests that there is an excess unmet demand that would be associated with new visitors. Enlargement of Shasta Dam and reservoir capacity would provide an increase in water surface area during the peak recreation season available for recreational participation within the region and provide additional capacity to help meet any excess demand.

The change in recreational participation and associated economic value that potential visitors would attribute for enhanced recreation opportunities at Shasta Lake were not evaluated. Therefore, benefit transfer methods for applying economic values were used to determine the economic benefit of increased recreational participation. The following sections describe Shasta Lake primary recreation visitors by type, estimated increases in visitation due to comprehensive plans, economic benefits associated with recreational visitors, and comprehensive plan estimates of recreation economic benefits.

Primary Recreation Activity Visitor Types

A number of studies over the years have examined recreation participation at or near Shasta Lake, including: Bowker et al. (1994); Winter (2000); DWR (2004); Graefe et al. 2005; and, USDA Forest Service Region 5 (2012). Bowker et al. (1994) and Graefe et al. (2005) are studies specific to Shasta Lake while the other studies listed, above, describe recreation participation from regional perspectives. The USFS Shasta and Trinity Lakes Boating Carrying Capacity Study (Graefe et al. 2005) primarily focused on boating participation. Bowker et al. (1994) is the most comprehensive study of recreation participation at Shasta Lake and includes best available information for the site. Bowker et al. (1994) was used to predict changes in recreational visitation with comprehensive plans (documented in Chapter 10 of the Modeling Appendix of the accompanying EIS).

Bowker et al. (1994) researched the relationship between reservoir water elevations and recreational visitation at Shasta Lake and placed average annual visitation (1971 to 1991) at approximately 2.2 million visitors. The study involved an expert panel to estimate percentages of five primary recreation activities visitors participate in at Shasta Lake under different hydrologic conditions (drought and non-drought), listed below:

1. houseboating (owners and renters);
2. other boating (cruisers, super-patio boats, and speed boaters);
3. developed camping (with auto and boat access);
4. dispersed camping (undeveloped campsites accessible to boats); and
5. fishing

Primary activity percentages obtained from Bowker et al. (1994) represent recreation participation levels specific to Shasta Lake and are displayed in Table 6-1, below. Though other available studies are not specific to Shasta Lake or focus only on boating activities, descriptions of recreation participation levels are consistent with those described in Bowker et al. (1994).

Table 6-1. Shasta Lake Primary Recreation Activity Type Percentages and Potential Comprehensive Plan Recreation Activity Annual Visitation

Condition	Distribution of Primary Recreational Activities*				
	Houseboating	Other Boating	Developed Camping	Dispersed Camping	Fishing
Drought	33%	27%	10%	10%	20%
Non-drought	35%	27%	12%	10%	16%
Average	**34%**	**27%**	**11%**	**10%**	**18%**

**Source: Bowker, J.M, et. al. 1994. An Economic Assessment of Alternative Water-level Management for Shasta and Trinity Lakes. USDA Forest Service, Southeastern Forest Experiment Station, Outdoor Recreation and Wilderness Assessment Group. July.*

Comprehensive Plan Visitation Estimates

Raising Shasta dam and relocating recreation facilities could change recreation participation through modernization of recreational facilities, increased average annual reservoir surface area, and decreased reservoir drawdown during the peak recreation season (May to September) compared to without-project conditions. Two methodologies used to estimate increased recreational participation at Shasta Lake due to comprehensive plans are documented in the Modeling Appendix. For the purposes of the Feasibility Report and evaluation of NED benefit values, the lower bound future condition expected changes in annual visitation are used and displayed in Table-6-2, below.

Table 6-2. Future Condition Predicted Changes in Annual Visitation

Item	CP1	CP2	CP3	CP4	CP4A	CP5
Change in Visitor Days, Relative to Without-Project (1,000)	85	116	201	307	246	142

Key:
CP = comprehensive plan

Primary activity annual visitation estimates for each comprehensive plan are derived by applying average condition recreation activity type percentages from Table 6-1 to future condition predicted changes in annual visitation provided in the Modeling Appendix. Potential primary recreation activity visitation levels for each comprehensive plan are displayed in Table 6-3.

Table 6-3. Estimated Potential Change in Primary Recreation Activity Annual Visitation

Comprehensive Plan	Potential Change in Annual Visitor Days by Primary Activity Type[1], Relative to Without-Project (1,000)				
	Houseboating	Other Boating	Developed Camping	Dispersed Camping	Fishing
CP1	29	23	9	9	15
CP2	39	31	13	12	21
CP3	68	54	22	20	36
CP4	104	83	34	31	55
CP4A	84	66	27	25	44
CP5	48	38	16	14	26

Note:
[1] Distribution of primary recreational activities for comprehensive plans is based on average condition activity percentages displayed in Table 6-1.
Key:
CP = comprehensive plan

Following is an estimate of potential monetary benefits associated with increases in visitation with comprehensive plans displayed above.

Economic Values for Recreational Visitors

For recreation, the valuation of benefits follows a WTP framework, as required by the P&G. Recreation is primarily a non-market good, and non-market benefits quantification is often difficult and time consuming. Shasta Lake is an example of a natural resource that is used for recreational purposes that may not be accurately valued using user fees, access charges, or similar fees. Some natural resources may be “open access” resources with no charge assessed for access. For other natural resources, access fees may be determined administratively by an agency that does not charge an amount based on individuals’ WTP. In such cases, a variety of methods exist to estimate recreational user values, including the travel cost method, contingent valuation method, and administratively estimated values.

- **Travel Cost Method –** Travel cost methods value resources based on observable expenditures incurred in accessing and using the resources. A travel cost method for Shasta Lake might estimate the value for enlarging the reservoir based on visitors’ expenditures in reaching and recreating on the lake.

- **Contingent Valuation Method –** The contingent valuation method uses surveys or other methods of direct contact with respondents that solicit changes in behavior or WTP to conserve, maintain, or improve some amenity. An example of a contingent valuation application for Shasta Lake enlargement might be to ask current and potential recreationists about their WTP to increase the size of the reservoir.

- **Administratively Estimated Method –** Administratively estimated values are estimates of recreationists' WTP for recreational opportunities based on expert opinion and assessments according to government agency criteria. Examples include unit day values for a variety of outdoor recreational activities such as those that have been calculated by the U.S. Bureau of Land Management, the USFS, and the U.S. Water Resources Council. Unit day values may be used in the estimation of NED accounts according to the P&G, Chapter 1, Section VII (WRC 1983).

Site specific data for Shasta Lake is not available to apply either the travel cost or contingent valuation methods. Hence, use of the administratively estimated method, or unit-day method was considered, and an average-value "benefits transfer" approach was applied. The average value "benefits transfer" approach was used to derive an estimate of consumer surplus, by essentially "borrowing" estimates of value from locations with highly similar attributes of non-market commodities and applying them to comprehensive plan visitation estimates.

The literature contains a wide variety of studies that contain estimates of many types of recreational activity in a host of different locations and settings. Loomis (2005), in conjunction with the USFS Pacific Northwest Research Station, prepared and updated a report that summarizes some 30 years of literature on net economic value of recreation, including average net WTP or consumer surplus per day for 30 recreational activities. Estimates of relevance to the Shasta Lake recreation value estimate are shown in Table 6-4, in both 2004 dollars (as reported in the study) and updated to January 2014 dollars via the Consumer Price Index.

Table 6-4. Estimated Consumer Surplus Values per Visitor-Day

Recreational Activity	Value (2004 $)	Value (2014 $)
Camping	$37.19	$46.05
Fishing	$47.16	$58.40
Hiking	$30.84	$38.19
Motorboating	$46.27	$57.30
Picnicking	$41.46	$51.34
Swimming	$42.68	$52.85
Waterskiing	$49.02	$60.70

Source: Loomis, John. Updated outdoor recreation use values on national forests and other public lands. Gen. Tech. Rep. PNW-GTR-658. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 2005.

Houseboating represents a special case recreation activity worthy of further discussion because of its prominence and uniqueness at Shasta Lake. While houseboaters may reasonably be subsumed within the category of "motorboating," some characteristics of note create distinctions that could affect the valuation. For example, a survey on Shasta Lake (Graefe et al 2005) found that houseboat owners who recreate tend to do so as part of large groups (mean

= 6.11 persons per group), arrive in multiple vehicles per group (mean = 2.05), and have multiple watercraft (speedboat, fishing boat, or other) in the group (mean = 2.57). Those who rent commercial boats, the vast majority of which are houseboats, participate as even larger groups (mean = 8.88). Houseboat lease and operating expenses are typically much higher than other forms of motorboats, but the expenses may be shared or distributed over larger group sizes, so the daily per capita outlay may be higher or lower than other boating activities.

There are few studies that have attempted to estimate the WTP of motorboating that include separation of houseboating activities. Several (e.g., Shapiro and Kroll 2003, Reclamation TSC 2007) acknowledge that houseboats are an important or major part of the motorboating category, but do not estimate WTP specifically for houseboat recreation. One study (Hassall & Associates 2004) estimated the economic value of many different lake and river-dependent recreation activities across a region in Australia, but the results are too site-specific to have general applicability elsewhere. Finally, Bowker et al. (1994) developed economic estimates for all recreationists combined, while acknowledging that there are distinctions between houseboat and other motorboat participants. The differences were also evident when comparing expenditure patterns reported by survey respondents, organized as “houseboating,” “other boating,” and “fishing” (Bowker et al. 1994). Mean values for itemized expenditure categories were higher for houseboating than for other boating or fishing, except for equipment.[14] However, since the typical group size for houseboat recreationists is slightly higher than for other boaters, the per visitor expenditure may be comparable to other boating. In summary, given the limited available information on WTP for houseboat recreationists, it is considered reasonable to assume a value that is approximately the same as motorboating.

NED Estimate of Recreation Economic Benefits

By applying recreational visitor-day values from Table 6-4, the results of the analysis predict net economic benefits of increased recreation participation at Shasta Lake with comprehensive plans. Recreational benefits are calculated using a unit day value of $57.85, the midpoint between the Loomis (2005) benefit estimate for a unit day engaged in motorboating ($57.30 in 2014 dollars) and a unit day engaged in fishing ($58.40). This approach was applied because (1) studies specific to Shasta Lake indicate that boating (including houseboating) and fishing are the most popular recreational activities in Shasta Lake (Bowker et al. 1994, USFS 2012, Graefe et al 2005), (2) increased annual visitor-day estimates (documented in the Modeling Appendix) are not activity

[14] Equipment expenses were highest for other boating, followed by houseboating, and then fishing. The houseboat respondents include both owners as well as renters from commercial suppliers, and for the latter equipment expenses are negligible.

specific, and (3) available information on specific recreation activity participation levels at Shasta Lake is historic and limited in the number of activities represented. Recreational benefits displayed in Table 6-5 range from $4.9 million for CP1 (6.5-foot raise) to $17.8 million for CP4 (18.5-foot raise).

Table 6-5. Estimated Average Annual NED Recreation Benefits for Comprehensive Plans

Item	Change Relative to Without-Project					
	CP1	CP2	CP3	CP4	CP4A	CP5
Change in Visitor Days Relative to Without-Project (1,000)	85	116	201	307	246	142
Change in Value Relative to Without-project ($millions/year)[1]	4.9	6.7	11.6	17.8	14.3	8.2

Note:
[1] Dollar values are expressed in January 2014 price levels.
Key:
CP = comprehensive plan

Risk and Uncertainty

It is important to note that various factors affect potential changes in visitation at Shasta Lake other than reservoir water elevations and surface area. Existing local facilities, such as parking lots, docks, and boat ramps, may not be adequate to sustain large increases in recreational uses. However, all of the comprehensive plans include relocation/replacement of existing recreation facilities affected by the various dam raises to accommodate visitation. These recreation facility relocations would allow for modernization of marinas, resorts, boat launches, campgrounds, day use areas and related recreation features to accommodate the needs and requirements of contemporary recreational users. This modernization of facilities would likely result in increased occupancy. In addition, economic theory suggests that the supply of recreational resources would expand in the long term to meet the expected increase in demand.

It is conceivable that some of the increased recreation at Shasta Lake could represent a shift away from other locations. That is, the increase in recreation at Shasta Lake may be offset by a decrease in other nationally important recreational participation. The unique set of attributes and opportunities provided at Shasta Lake suggests that substitution from other locations may be limited.

The economic value attributed to predicted visitor days is also an area of uncertainty. By using the mid-point between average values of motorboating and fishing from other sites for all potential visitor types at Shasta Lake, over- or underestimation of potential economic benefits is possible. This does not appear to be a significant issue given the large expected proportion of new houseboating visitors and associated value.

A recreation benefit sensitivity analysis was conducted to address risk and uncertainty of the benefit estimates and is discussed below. The sensitivity analysis values are not included in the calculation of the total benefits, NED benefits, or benefit-cost ratios.

Recreation Benefit Sensitivity Analysis

The NED recreation benefit estimate described above is based on the lowerbound predicted changes in annual recreational visitation documented in the Modeling Appendix of the accompanying Final EIS, and valued with the unit day value of $57.85 (the midpoint between the Loomis (2005) benefit estimate for a unit day engaged in motorboating and a unit day engaged in fishing).

To address risk and uncertainty related to visitation estimates and consumer surplus values per visitor, two different approaches are applied and are described briefly below:

- **Sensitivity Approach 1 –** Lowerbound predicted changes in annual visitation by activity (displayed in Table 6-3, above) are valued by activity with values displayed in Table 6-4, above (i.e., motorboating, camping, and fishing).

- **Sensitivity Approach 2 –** Upperbound predicted changes in annual visitation (documented in the Modeling Appendix) are valued with a unit day value of $57.85 (the midpoint between the Loomis (2005) benefit estimate for a unit day engaged in motorboating and a unit day engaged in fishing).

Results of these two approaches are displayed in Table 6-6, below. Values estimated with sensitivity approach 1 are less than the NED benefit estimates for comprehensive plans, while values estimated with sensitivity approach 2 are greater than NED benefit estimates.

Table 6-6. Sensitivity Analysis of Estimated Average Annual Recreational Benefits for Comprehensive Plans

Item	With-Project					
	CP1	CP2	CP3	CP4	CP4A	CP5
Sensitivity Approach 1 – Change in Value Relative to Without-project ($ millions/year)[1]	4.7	6.4	11.1	16.9	13.6	7.8
Sensitivity Approach 2 – Change in Value Relative to Without-project ($ millions/year)[1]	5.1	7.7	11.9	21.4	15.0	10.1
NED Benefit Estimate – Change in Value Relative to Without-project ($ millions/year)[1]	4.9	6.7	11.6	17.8	14.3	8.2

Note:
[1] Dollar values are expressed in January 2014 price levels.
Key:
CP = comprehensive plan
NED = National Economic Development

Chapter 7
Summary of Estimated NED Benefits

This chapter presents a summary of the NED benefits addressed in the preceding Chapters 3 through 6 of this appendix. Project accomplishments and benefit estimates pertaining to the 6.5-, 12.5-, and 18.5-foot dam raise comprehensive plans relative to the without-project conditions are presented in Table 7-1. Each alternative achieves positive changes in the primary objectives of anadromous fish restoration and water supply reliability. Each alternative also provides increased benefits for secondary objectives.

Table 7-1. Summary of Total Estimated Average Annual NED Benefits for Comprehensive Plans

Item	CP1	CP2	CP3	CP4	CP4A	CP5
Primary Objective Accomplishments						
Water Supply Reliability (TAF/year)	31.0	51.3	61.7	31.0	51.3	75.9
Anadromous Fish Survival (HU/year) [1]	61.3	379.2	207.4	812.6	710.0	377.8
Secondary Objective Accomplishments[2]						
Hydropower (GWh/year)	52	87	86	127	125	112
Flood Control	Incidental	Incidental	Incidental	Incidental	Incidental	Incidental
Recreation (1,000 visitor days/year)	85	116	201	307	246	142
Annual Benefits ($ millions/year)[3]						
Water Supply Reliability	15.2	26.9	10.2	15.2	26.9	34.8
Anadromous Fish	2.9	17.8	9.7	38.1	33.3	17.7
Hydropower	6.8	10.3	11.1	14.9	14.4	13.4
Flood Control	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Recreation	4.9	6.7	11.6	17.8	14.3	8.2
Total[4]	**29.7**	**61.6**	**42.6**	**86.0**	**88.9**	**74.2**

Notes:
[1] Each habitat unit equals 1,000 additional salmon produced.
[2] Any dam raise could provide incidental benefits to secondary objectives.
[3] Dollar values are expressed in January 2014 price levels.
[4] Totals may not add because of rounding.
Key:
CP = comprehensive plan
GWh = gigawatt-hour
HU = habitat unit
TAF = thousand acre feet

The benefit values shown in Table 7-1 do not include escalation above the inflation rate over the project lifespan. Water supply reliability, hydropower generation, anadromous fish restoration, and recreational values are held constant relative to inflation across the 100-year lifespan of the project.

This assumed stability, however, may not be appropriate, especially in regards to hydropower generation and water supply reliability. Projected population and economic growth trends are likely to raise the value of hydropower generation, especially as concerns about climate change restrict the social willingness and resource capacity to meet future electricity generation through fossil fuel technologies. Water supply reliability is also likely to increase in value as future population and economic growth in California place increasing pressure on the State's water supplies.

Table 7-2 summarizes how total benefits vary following possible changes in water supply reliability and hydropower generation benefit values above the rate of inflation (see Table 3-15 and Table 5-3). These benefits estimates are included solely for the purposes of sensitivity analysis. They are not intended for inclusion in NED analysis.

Changes in hydropower generation have relatively minor impacts on total benefits. Changes in water supply reliability benefits, however, have more notable effects. If all other benefits remain the same, increases in the value of water supply reliability benefits of 1 percent above inflation raise total benefits by approximately $3 million to $11 million. Changes in the value of water supply reliability benefits of 2 percent above inflation increase total benefits by approximately $9 million to $30 million.

Table 7-2. Sensitivity Analysis of Estimated Total Average Annual Benefits Based on Potential Changes to Water Supply Reliability and Hydropower Benefits due to Inflation

Change in Value Above Inflation		Total Benefits ($ millions/year)[1]					
WSR	**Hydropower**	**CP1**	**CP2**	**CP3**	**CP4**	**CP4A**	**CP5**
No change	+ 1%	31.9	64.9	46.2	90.8	93.5	78.4
No change	+ 2%	35.5	70.4	52.1	98.7	101.2	85.5
+ 1%	No change	34.7	70.3	45.8	90.9	97.6	85.3
+ 1%	+ 1%	36.8	73.6	49.4	95.6	102.2	89.6
+ 1%	+ 2%	40.4	79.0	55.3	103.5	109.8	96.7
+ 2%	No change	42.7	84.5	51.2	98.9	111.8	103.7
+ 2%	+ 1%	44.8	87.9	54.8	103.7	116.5	108.1
+ 2%	+ 2%	48.4	93.3	60.7	111.6	124.1	115.2

Notes:
[1] Dollar values are expressed in millions, January 2014 price levels.

Key:
CP = comprehensive plan
WSR = Water Supply Reliability

Chapter 8
Regional Economic Development Account

This chapter addresses the findings of an analysis of regional economic benefits of SLWRI comprehensive plans' potential construction expenditure effects (documented in the Modeling Appendix to the accompanying Final EIS) and is included to address P&G requirements of the RED account. The results reflect changes in the local economy due to project construction activities for comprehensive plans. The average annual construction cost and construction duration for each of the alternatives is shown in Table 8-1. Please see the Engineering Summary Appendix to the accompanying Final EIS for descriptions of engineering features and associated costs.

Table 8-1. Estimated Project Construction Cost, Average Annual Required Investment

Category	CP1	CP2	CP3	CP4	CP4A	CP5
Average Annual Construction Cost ($ millions/year)[1]	220.0	217.8	251.4	252.8	253.0	256.6
Construction Duration (years)	4.5	5	5	5	5	5

Note:
[1] Dollar values are expressed in January 2014 price levels.
Key:
CP = comprehensive plan

An input-output (I-O) model was developed for regional economic analyses specific to the SLWRI with IMPLAN software that incorporated project construction-related economic activity. Please see the Modeling Appendix for a detailed description of the IMPLAN modeling procedure. Following is a brief regional economic impact model description, and summary of potential construction-related personal income and employment effects with each comprehensive plan.

Regional Economic Impacts Model Description

In general terms, an I-O model is used to estimate the effects of changes in output on the rest of the local economy. The direct effect is the change (or increase) in construction-related output determined from the engineering designs and cost estimates described in the Engineering Summary Appendix. Because the businesses within a local economy are linked together through the purchase and sales patterns of goods and services produced in the region, an action which has a direct effect on one industry is likely to have an indirect effect for firms providing production inputs and support services, as the demand for their products also increases. As household income is affected by the increases in regional economic activity, additional induced benefits are generated by increased household spending.

Regional economic impacts were modeled with IMPLAN software for construction-related economic activity in the four-county region surrounding Shasta Lake. The four counties are Shasta, Tehama, Trinity, and Siskiyou. The model is based on 2009 California County data, and estimated potential changes in industry output, personal income, and employment related to each comprehensive plans construction activity. Results of the analysis are summarized below. Please see the Modeling Appendix to the accompanying Final EIS for a detailed description of the IMPLAN modeling procedure and results.

The link from regional economic impact analysis to the RED account specified in the P&G is straightforward. The RED account considers changes in the distribution of regional economic activity through two measures:

1. Regional income, and
2. Regional employment.

From the regional impact analysis, regional income is derived directly from the measure of "personal income." Regional employment is associated with the measure of "employment" from the regional impact analysis.

It is estimated that construction activity associated with each of the comprehensive plans will take place over 4.5 to 5 years, depending upon the comprehensive plan. Because economic impacts are typically measured and reported in annual terms, the costs were converted to average annual expenditures. Therefore, the results should be interpreted as "dollars per year" or "jobs per year" for the duration of the construction period, and proper care must be taken when making direct comparisons among comprehensive plans.

Results of the Regional Impact Analysis

For each of the alternatives, the procedure was the same for estimating regional economic impacts. Construction-related direct expenses were entered, and the model then calculated the indirect, induced, and total effects on the regional economy. The following sections provide summarized results of regional impact analysis conducted for the SLWRI, with a focus on personal income and employment impacts associated with the RED account. Please see the Modeling Appendix for detailed results of the regional economic impact analysis.

Personal Income

The personal income measure of regional economic impacts is the sum of employee compensation and proprietor income, and a measure of benefit for the RED account. Results for this category are shown in Table 8-2.

Table 8-2. Estimated Annual Regional Economic Impacts of Construction Activity on Personal Income

Effects	CP1 ($ millions/ year)[1]	CP2 ($ millions/ year)[1]	CP3 ($ millions/ year)[1]	CP4 ($ millions/ year)[1]	CP4A ($ millions/ year)[1]	CP5 ($ millions/ year)[1]
Direct	85.9	85.1	98.2	98.7	98.8	100.2
Indirect	23.0	22.8	26.3	26.4	26.4	26.8
Induced	25.3	25.0	28.9	29.0	29.0	29.5
Total per Year[1]	134.2	132.8	153.3	154.2	154.3	156.5
Duration (years)	4.5	5.0	5.0	5.0	5.0	5.0
Aggregate Total[2]	**603.8**	**664.1**	**766.6**	**770.9**	**771.4**	**782.5**

Notes:
[1] Dollar values are expressed in January 2014 price levels.
[2] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Construction-related expenditures would lead to direct impacts on personal income in the region ranging from $85.1 million annually under CP2, to $100.2 million under CP5. This change in personal income would lead to indirect impacts of $22.8 million (CP2) to $26.8 million (CP5). Induced impacts on personal income would amount to an additional $25.0 million (CP2) to $29.5 million (CP5) annually. The total impact on personal income in the region ranges from $132.8 million for CP2 to $156.5 million for CP5 annually.

Accounting for the duration of construction, a similar ranking of comprehensive plans occurs for personal income impacts as for total industry output. CP5 is highest at $783 million, followed closely by CP4/CP4A ($771 million) and CP3 ($767 million) across 5 years. CP2 is next at $664 million (over 5 years), and CP1 is lowest in aggregate impact at $604 million over 4.5 years.

Employment

Employment impacts are measured in total jobs, whether full- or part-time, in the businesses producing the output. Direct impacts are those related to construction, and establishments that sell construction goods and perform construction services. Employment is included in the RED account. Table 8-3 summarizes regional employment impacts from the project based on construction activity.

Table 8-3. Estimated Annual Regional Economic Impacts of Construction Activity on Employment (Jobs)

Effects	CP1	CP2	CP3	CP4	CP4A	CP5
Direct	300	300	350	350	350	360
Indirect	400	400	460	460	460	470
Induced	610	610	700	710	710	720
Total per Year[1]	1,320	1,310	1,510	1,520	1,520	1,540
Duration (years)	4.5	5	5	5	5	5

Note:
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Approximately 350 additional construction-sector jobs in the region would be a direct result of project construction for CP3 and CP4/CP4A, and 360 additional construction-sector jobs for CP5. This would take place over a 5-year period. Approximately 300 jobs annually over 5 years would result from CP2. Finally, approximately 300 jobs would be added from CP1, but for only 4.5 years. An additional 400 jobs (CP1 and CP2) to 470 jobs (CP5) in the region would be generated in construction support and input industries annually during the construction period. As a result of increased household spending, an additional 610 jobs (CP1 and CP2) to 720 jobs (CP5) would result. In total, approximately 1,310 jobs (CP2) to 1,540 jobs (CP5) in the region would be generated annually during the construction period.

Chapter 9
Environmental Quality Account

The EQ account is a means of integrating information about the EQ resource and NEPA human environment effects (as defined in 40 Code of Federal Regulations (CFR) 1507.14) of alternative plans into water resources planning. This is essential to a reasoned choice among alternative plans.

A thorough evaluation of other positive and negative EQ benefits was performed as part of the NEPA environmental review and documentation process. A detailed discussion of potential effects of comprehensive plans and proposed mitigation measures are included in Chapters 4 through 25 of the accompanying Final EIS and summarized in Table S-3 in the Final EIS. The environmental commitments common to all comprehensive plans are described in Chapter 4 of this Feasibility Report. Also, Chapter 26 of the Final EIS describes short-term use of the human environment and the maintenance and enhancement of long-term productivity and presents potential irreversible or irretrievable commitments of resources for the comprehensive plans.

Table 9-1 summarizes key effects for all resource categories for the EQ account. All comprehensive plans are similar in terms of their potential environmental effects, although some adverse effects would be exacerbated by larger dam raises and by the associated scale of the effects, such as expanded construction areas and increased area of inundation around Shasta Lake. Generally, the adverse effects would be mitigated to less-than-significant levels with prescribed mitigation measures. Some adverse effects for all of the action alternatives – e.g., the short-term generation of construction-generated emissions in excess of Shasta County Air Quality Management District (SCAQMD) thresholds and generation of increased daytime glare and/or night time lighting – would remain unavoidable despite mitigation measures. Altered flow regimes along the upper Sacramento River, changes to the areas inundated by Shasta Lake, and disturbances associated with construction activities have the potential to affect environmental resources. However, these adverse effects would be mitigated to the extent practicable.

CP1 and CP2 would have less of an adverse effect on land uses within the dam inundation area than the other comprehensive plans because CP1 and CP2 would raise the dam by 6.5 feet and 12.5 feet, respectively, compared to the 18.5-foot increase proposed for CP3, CP4, CP4A, and CP5. However, a majority of the reservoir area relocations are required under any dam raise. The benefits associated with improved anadromous fish survival and increased water supply reliability would offset the localized adverse effects of the larger raises.

Table 9-1. Summary of Potential Environmental Effects in the Environmental Quality Account

Resource Area	Alternatives	Primary Study Area		Extended Study Area			Key Considerations and Exclusions
		Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBPP)	Sacramento River (RBPP to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Geology, Geomorphology, Minerals, and Soils	CP1 – CP5	■ (orange)	■ (green)	■ (green)	■ (green)	■ (green)	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation. Long-term adverse effects associated with operations reduced through mitigation.
Air Quality and Climate	CP1	■ (orange)	■ (green)	■ (green)	■ (green)	■ (green)	Long-term effects due to slight increase in net energy requirements. Short-term unavoidable adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
	CP2, CP3, CP4, CP4A, CP5	■ (orange)	■ (green)	■ (purple)	■ (purple)	■ (purple)	Long-term benefits related to reduced emissions due to increased hydropower generation. Short-term unavoidable adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Hydrology, Hydraulics, and Water Management	CP1-CP5	■ (green)	■ (green) ■ (blue)	■ (green) ■ (blue)	■ (green) ■ (blue)	■ (green) ■ (purple) ■ (blue)	Beneficial effects to groundwater levels in CVP/SWP water service areas. Long-term beneficial effects related to water supply reliability included in NED account. Long-term beneficial effects related to reduced flood risk included in OSE account.
Water Quality	CP1 – CP5	■ (green)	■ (green) ■ (blue)	■ (green) ■ (blue)	■ (green) ■ (blue)	■ (green) ■ (blue)	Long-term beneficial effects to reservoir water quality due to replacement of reservoir area septic systems with centralized wastewater treatment plants. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation. Long-term beneficial water quality effects in Sacramento River and Delta included in NED account.
Noise and Vibration	CP1 – CP5	■ (green)	■ (green)	■ (green)	■ (green)	■ (green)	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Hazards and Hazardous Materials and Waste	CP1 – CP5	■ (green)	■ (green)	■ (green)	■ (green)	■ (green)	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Agriculture and Important Farmland	CP1 – CP5	■ (green)	■ (green)	■ (green)	■ (green)	■ (green) ■ (blue)	Long-term beneficial effects from improved agricultural/irrigation water supply reliability included in NED account. Long-term adverse effects due to conversion of forest lands.

Table 9-1. Summary of Potential Environmental Effects in the Environmental Quality Account (contd.)

Resource Area	Alternatives	Primary Study Area		Extended Study Area			Key Considerations and Exclusions
		Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBDD)	Sacramento River (RBPP to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Fisheries and Aquatic Ecosystems	CP1 – CP5	■ green ■ purple	■ green ■ blue ■ purple	■ green ■ blue	■ green ■ blue	■ green	Long-term beneficial effect on cold-water fisheries habitat in Shasta Lake. CP4, CP4A, and CP5 provide ecosystem restoration benefits for fisheries and aquatic habitat through (1) augmenting spawning gravel in the upper Sacramento River, and (2) restoring riparian, floodplain, and side channel habitat in the upper Sacramento River. CP5 provides ecosystem restoration benefits for fisheries and aquatic habitat, including (1) restoring resident fish habitat in Shasta Lake, and (2) restoring fisheries and riparian habitat at several locations along the lower reaches of tributaries to Shasta Lake. Long-term beneficial effects on anadromous fisheries included in NED account.
Botanical Resources and Wetlands	CP1 – CP5	■ orange	■ green ■ purple	■ green	■ green	■ green	CP4, CP4A, and CP5 provide ecosystem restoration benefits for botanical resources through restoring riparian, floodplain, and side channel habitat in the upper Sacramento River. Long-term adverse effects due to inundation and relocations in primary study area. Short-term adverse effects due to construction in primary study area. Adverse effects reduced through mitigation.
Wildlife Resources	CP1 – CP5	■ orange	■ green ■ purple	■ green	■ green	■ green	CP4, CP4A, and CP5 provide ecosystem restoration benefits for wildlife resources through restoring riparian, floodplain, and side channel habitat in the upper Sacramento River. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Cultural Resources	CP1 – CP5	■ orange	■ green	■ green	■ green	■ green	Adverse effects due to construction in primary study area; adverse effects reduced through mitigation. Some adverse effects due to operations/inundation in the primary study area are unavoidable.
Socioeconomics, Population, and Housing	CP1 – CP5	■ green ■ blue	■ green ■ blue	■ green	■ green	■ green ■ blue	Long-term beneficial effects from improved agricultural/irrigation water supply reliability included in NED account. Short-term beneficial effects of construction activities included in RED account.
Land Use and Planning	CP1 – CP5	■ orange	■ green	■ green	■ green	■ green	Long-term adverse effects to land use in reservoir area are unavoidable; adverse effects reduced through mitigation.

Table 9-1. Summary of Potential Environmental Effects in the Environmental Quality Account (contd.)

Resource Area	Resource Area/ Alternatives	Primary Study Area		Extended Study Area			Key Considerations and Exclusions
		Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBPP)	Sacramento River (RBPP to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Recreation and Public Access	CP1 – CP5	green, blue	green, purple	green	green	green	Long-term beneficial effects on recreation included in NED account. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation. Long-term beneficial effects due to enhanced angling opportunities in the upper Sacramento River.
Aesthetics and Visual Resources	CP1 – CP5	orange	green	green	green	green	Long-term adverse effects to aesthetics in reservoir area are unavoidable; adverse effects reduced through mitigation.
Transportation and Traffic	CP1 – CP5	green, purple	green	green	green	green	Long-term beneficial effects due to modernized roadway/bridge relocations. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Utilities and Service Systems	CP1 – CP5	green, purple	green	green	green	green	Long-term beneficial effects due to replacing and modernizing utilities. Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Public Services	CP1 – CP5	green	green	green	green	green	Short-term adverse effects due to construction in primary study area; adverse effects reduced through mitigation.
Power and Energy	CP1 – CP5	blue	green	green	green	blue	Long-term beneficial effects from increased hydropower generation included in NED account.
Environmental Justice	CP1 – CP5	orange	green	green	green	green	Not disproportionately high and adverse effects to minority and low income populations in the vicinity of Shasta Lake and upper Sacramento River. Disproportionately high and adverse effects to Native American populations in vicinity of Shasta Lake. Not disproportionately high and adverse effects to Native American populations in the vicinity of the upper Sacramento River.

Table 9-1. Summary of Potential Environmental Effects in the Environmental Quality Account (contd.)

Resource Area	Alternatives	Primary Study Area		Extended Study Area			Key Considerations and Exclusions
		Shasta Lake & Vicinity	Sacramento River (Shasta Dam to RBPP)	Sacramento River (RBPP to Delta)	Delta	CVP/SWP Facilities and Water Service Areas	
Wild and Scenic Rivers	CP1 – CP5	[Orange]	[Green]	[Green]	[Green]	[Green]	Long-term adverse effects in wet years are unavoidable for up to 0.67 miles of the McCloud River, designated for special protection, but not as a Wild & Scenic River.

Note: For some resource categories, both no (or minimal) effects and beneficial effects are indicated for the same portion of the study area. This is because there may be differences between short-term environmental effects (from construction) and long-term environmental effects of project operations, or differences in effects to different portions of a resource category. Where multiple effects are indicated, an explanation is provided in the “Key Considerations and Exclusions” column.

Key:

[Green] No effect, minimal effect, not disproportionately high and adverse (environmental justice), and/or minimal effect after mitigation for the Environmental Quality account.

[Orange] Unavoidable and/or disproportionately high and adverse (environmental justice) for the Environmental Quality account.

[Purple] Beneficial effect for the Environmental Quality account.

[Blue] Beneficial effects associated with anadromous fish survival, agricultural/irrigation water supply reliability, municipal and industrial water supply reliability hydropower, and recreation accounted for in the NED account. Beneficial effects to regional economics (including jobs and income) included in RED accounts. Beneficial effects on life, health, and safety related to reduced flood risk are accounted for in the OSE account.

CP = comprehensive plan
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
NED = National Economic Development
RBPP = Red Bluff Pumping Plant
RED = Regional Economic Development
SWP = State Water Project

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Chapter 10
Other Social Effects Account

The OSE account is a means of displaying, and integrating into water resources planning, information on alternative plan effects from perspectives that are not reflected in the other three accounts. Categories of effects in the OSE account include the following: life, health, and safety factors; urban and community impacts; displacement; long-term productivity; and energy requirements and energy conservation. Both the beneficial and adverse effects in the OSE account are expected to be similar across all comprehensive plans, but generally proportional to the respective dam enlargement and newly inundated areas. Potential impacts of comprehensive plans to life, health, and safety, and communities, are discussed below.

Life, Health, and Safety

Threats to people, for loss of life and injury from flood events, are addressed for public safety. Although flood damage reduction benefits are a commonly analyzed NED benefit category, no flood damage reduction monetary benefit has been evaluated for the comprehensive plans. Comprehensive plan flood damage reduction benefits are described as improvements to public safety within the OSE account.

Flooding along the Sacramento River poses risks to human life, health, and safety. Urban development in flood-prone areas has exposed the public to the risk of flooding. While the existing flood management system has significantly reduced the frequency of flooding, large storms can result in river flows that exceed the capacity of the system or cause failures in the system. Threats to the public from flooding are caused by many factors, including overtopping or sudden failures of levees, which can cause deep and rapid flooding with little warning, threatening lives and public safety.

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

Even though a project to enlarge Shasta Reservoir has the potential to significantly reduce flood flows in the upper Sacramento River, influencing factors exist that can conflict with flood operation. Flood management operations at Shasta Dam, even with explicit rules provided in the flood control manual, are difficult to manage during a flood event. This is primarily due to the extreme inflow volumes to Shasta Reservoir that can occur over long periods, numerous points of inflow along the river downstream from Shasta Dam, and multiple points of operational interest downstream. The primary downstream control point along the Sacramento River that determines reservoir releases under real-time operation is Bend Bridge. Other unofficial factors enter into flood management decisions, such as the need to reduce peak flows at Hamilton City or other rural communities that are at risk of flooding.

While no additional storage will be explicitly dedicated to flood control under any of the comprehensive plans, any reservoir expansion is likely to effectively increase the amount of storage space available to capture flood flows for at least a portion of the flood control season, particularly during the early to middle part of the flood control season. Under the comprehensive plans, there will be additional storage space, relative to the without project alternative, to be filled by capturing reservoir inflows during the wet season. As a result, until the reservoir storage level reaches the maximum allowable storage according to the flood control rule curve, there will be an additional increment of storage space available to capture flood flows. Across all 82 years modeled with CalSim-II, the average monthly increase in empty storage space between December through March (the peak of the flood season), for all of the comprehensive plans compared to the without project alternative, ranges from 6 percent to 22 percent (Table 10-1).

Table 10-1. Estimated Change in Empty Storage Space Relative to Without Project (Average – All Years)

Month	Without Project	Additional Empty Storage Space (TAF) – All Years					
		CP1	CP2	CP3	CP4	CP4A	CP5
October	1,965	115 (6%)	198 (10%)	268 (14%)	115 (6%)	198 (10%)	283 (14%)
November	1,979	122 (6%)	209 (11%)	283 (14%)	122 (6%)	209 (11%)	296 (15%)
December	1,817	104 (6%)	180 (10%)	242 (13%)	104 (6%)	180 (10%)	257 (14%)
January	1,542	92 (6%)	164 (11%)	221 (14%)	92 (6%)	164 (11%)	237 (15%)
February	1,273	78 (6%)	144 (11%)	199 (16%)	78 (6%)	144 (11%)	210 (17%)
March	916	75 (8%)	136 (15%)	187 (20%)	75 (8%)	136 (15%)	198 (22%)
April	618	83 (13%)	145 (24%)	200 (32%)	83 (13%)	145 (24%)	210 (34%)
May	591	82 (14%)	144 (24%)	203 (34%)	82 (14%)	144 (24%)	211 (36%)
June	899	87 (10%)	152 (17%)	208 (23%)	87 (10%)	152 (17%)	220 (24%)
July	1,385	89 (6%)	160 (12%)	217 (16%)	89 (6%)	160 (12%)	233 (17%)
August	1,711	97 (6%)	170 (10%)	236 (14%)	97 (6%)	170 (10%)	247 (14%)
September	1,890	106 (6%)	183 (10%)	252 (13%)	106 (6%)	183 (10%)	265 (14%)

Note:
Highlighted months represent the flood control season, with darker highlighting indicating more critical periods for flood control when the maximum allowable storage may be at a minimum.
Key:
CP = comprehensive plan
TAF = thousand acre feet

On the basis of studies to date for the SLWRI, potential monetary benefits to flood damage reduction could be significant due to potential increases in storage space available to capture flood flows for at least a portion of the flood control season. However, by observation, it is believed that these benefits would be significantly less than the costs to provide them. This is primarily because Shasta already provides a significant reduction in flood threat downstream, particularly to the City of Redding. Tributary inflow to the Sacramento River further downstream lessens the effectiveness of Shasta Dam in reducing flood damage. Because of (1) a generally higher level of protection already provided by Shasta Dam, and (2) likely difficulty in changing existing river flow operation objectives along the upper Sacramento River, it is anticipated that benefits specifically for flood damage reduction would not be economically feasible. However, any increase in storage at Shasta Reservoir would likely result in a small and incidental decrease in flood damages. Accordingly, potential benefits to flood damage reduction resulting from reducing peak flood flows are not expressed in monetary terms in this appendix.

As a result of greater reservoir capacity and the reduced risk of flooding, the potential for loss of life would also be reduced. Flood control benefits of the dam enlargement would not be expected to change the existing floodplain or Federal Emergency Management Agency flood zone designations; therefore, the comprehensive plans would not remove an obstacle to development. Thus, flood protection benefits are not considered growth inducing.

Community Impacts

Environmental justice review is required to determine if a disproportionate share of a proposed project’s adverse socioeconomic and other environmental impacts are borne by low-income and minority communities. Analyses have shown the disturbance or loss of resources associated with locations considered by the Pit River Tribe and the Winnemem Wintu (a Native American group) to have religious and cultural significance. These disturbances would result in an unmitigable, disproportionately high and adverse effect on Native American populations in the vicinity of Shasta Lake.

All comprehensive plans are estimated to displace people and businesses in the Shasta Lake area because of expanded reservoir inundation areas. Any potential real estate acquisition, or necessary relocations of displaced parties, would be accomplished under Public Law 91-646.

All comprehensive plans would provide beneficial community impacts to health and safety in the Shasta Lake area and downstream along the Sacramento River. Under all comprehensive plans, relocated roadways, bridges, utilities, and recreation facilities would be replaced with modernized and upgraded facilities, using current design standards and construction practices. Additionally, many reservoir area septic systems would be replaced with centralized wastewater treatment plants. USFS emergency response facilities would also be relocated to a more centralized location adjacent to major transportation corridors.

Chapter 11
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