Appendix 30A Regional Economic Modeling

Appendix 30A Regional Economic Modeling

30A.1 Introduction

This appendix contains information that was presented in Appendices 22A, 22C, 22D, and 22F of the 2017 Draft EIR/EIS. These attachments explain the methodology used in the economic modeling conducted for the 2017 Draft EIR/EIS to evaluate impacts on regional economics (22A, Socioeconomics). The general methodology and findings of the previous regional economic modeling is summarized below.

30A.1.2. Regional Economics

The previous analysis estimated changes to regional labor income and employment to assess effects on regional economics (22C, Regional Economics Modeling). IMPLAN, the model used in this analysis, estimates changes to the region's labor income and employment based on specific economic drivers. These economic drivers include construction spending, operation and maintenance expenditures, temporary and permanent changes to agricultural production, and recreational expenditures. The magnitude of these effects depends on the initial changes in economic activity within the region (such as construction expenditure or loss of production from existing activities), the interactions within the regional economy, and the "leakage" of economic activity from the regional economy to the larger surrounding economy (e.g., state economy).

The previous modeling found that temporary effects from construction would consist of an increase in direct labor income between $43,788,000 and $49,020,000; the increase in total labor income would be between $59,676,000 and $66,607,000. The modeling projected that from 99 to 115 direct jobs and from 448 and 503 total jobs (i.e., direct, indirect, and induced jobs) would be generated by construction. The previous modeling also showed a projected decrease in agriculture-based labor income and jobs due to the temporary disturbance of agricultural land (particularly rice fields) for construction purposes. This effect consisted of an estimated loss of $691,000 in direct labor income and a loss of $1,350,000 in total labor income, which correlated to a temporary loss of 44 direct jobs and 62 total jobs.

The previous economic modeling quantified operational effects to labor income and jobs and indicated that the permanent change in direct labor income would range from $2,076,000 per year to $2,090,000 per year. The permanent change in indirect labor income would range from $2,368,000 per year to $2,384,000 per year. The modeling projected an increase of between 45 and 46 direct jobs and between 56 and 57 total jobs in Glenn and Colusa Counties. Table 30A-1 summarizes the simulated 2017 regional economic effects and those associated with the Project alternatives presented in this RDEIR/SDEIS.

Table 30A-1. Summary of Simulated 2017 Regional Economic Effects and RDEIR/SDEIS Alternatives

	Simulated 2017 Results	Alternatives 1, 2 and 3	Rationale
Construction	**+**	+	RDEIR/SDEIS relative trend similar to 2017 because of size of the reservoir, inclusion of Yolo County facilities and inclusion of additional infrastructure (e.g., South Road)
Operation	**+**	**+**	RDEIR/SDEIS relative trend same as 2017 because of negligible change in number of anticipated operation and maintenance employees

Table notes: symbols indicate relative positive beneficial economic effects.

30A.1.3. Recreational Economics

Recreational economic effects were also assessed using IMPLAN. These effects were based on estimated changes in recreational expenditures resulting from recreationists and related spending in Glenn and Colusa Counties. The previous modeling estimated that the recreational facilities would generate approximately 187,000 annual recreationalist visits, resulting in $2.44 million in revenue for local and regional economies. Table 30A-2 summarizes the simulated 2017 recreational economic effects and those associated with the Project alternatives presented in this RDEIR/SDEIS.

Table 30A-2. Summary of Simulated 2017 Recreational Economic Effects and RDEIR/SDEIS Alternatives

	Simulated 2017 Results	Alternatives 1, 2, and 3	Rationale
Operation	**+**	**+**	RDEIR/SDEIS relative trend same as 2017 because number of recreationists and location of recreation are the same

Table notes: symbols indicate relative positive beneficial economic effects.

30A.1.4. Agricultural Economics

The 2017 Draft EIR/EIS analyzed agricultural economic effects using estimates of the changes in agricultural acreage from construction and operation of Sites Reservoir, changes in water supply to agricultural users, and changes in costs associated with water quality (22F, Agricultural Supply Economics Modeling). The economic effects of changes in agricultural acreage were estimated based per-acre crop revenue. The economic effects from water supply changes were modeled using the Statewide Agricultural Production (SWAP) model, which simulates the decisions of agricultural producers, assuming that farmers maximize profit subject to available resources (including water) and economic conditions. The previous modeling indicated that, in an average year, the operation of Sites Reservoir would result in between $4.1 million and $4.7 million in additional crop production value. These results and the assessment for hydrologic modeling in Appendix 30B, Comparison of Regional Hydrologic Model Results to Inform Economic Analyses, indicate the economic benefit of deliveries based on simulated agricultural deliveries to various hydrologic regions would remain positive and beneficial, as previously disclosed in the 2017 Draft EIR/EIS and summarized below. The economic effects of water quality changes were also evaluated using an analysis of costs associated with managing salts in irrigation water. This long-term effect was previously described but not quantified.

The previous modeling projected that permanent conversion of agricultural land would result in a decrease of $1.4 million in annual crop production value from the permanent conversion of 26,200 acres of agricultural land. The amount of land assumed to be converted in the previous modeling for a reservoir with a larger footprint than that of Alternatives 1 and 3 totaled less than 3% of the total area of agricultural land in Glenn and Colusa Counties and represented approximately 0.1% of the total production value of the agricultural land in those counties. Of the 26,200 acres of permanently converted agricultural land, 25,300 acres (96.6% of the total converted acreage) were projected to be rangeland, which is of lower economic value than most other types of agricultural land.

Table 30A-3 summarizes the simulated 2017 agricultural economic effects and those associated with the Project alternatives presented in this RDEIR/SDEIS.

Table 30A-3. Summary of Simulated 2017 Agricultural Economic Effects and RDEIR/SDEIS Alternatives

	Simulated 2017 Results	Alternatives 1, 2, and 3	Rationale
Operation	**+**	+	RDEIR/SDEIS relative trend similar to 2017 because of size of reservoir; distribution and range of hydrologic modeling results related to agricultural water deliveries is similar but overall smaller volumes of water delivered; fewer acres of agricultural land would be temporarily or permanently removed from production

Table notes: symbols indicate relative positive beneficial economic effects.

30A.1.5. Municipal and Industrial Water Economics

The 2017 Draft EIR/EIS evaluated the socioeconomic effects of changes to municipal and industrial (M&I) water supply and water quality (22D, Urban Water Supply Economics Modeling). The previous analysis of M&I water use economics discussed the effect of the operation of Sites Reservoir on M&I water supply reliability and associated changes in the overall cost of water supply and treatment.

Models used to analyze economic effects related to M&I water supply included the Least Cost Planning Simulation Model (LCPSIM) and the Other Municipal Water Economics Model

(OMWEM). LCPSIM evaluates economic benefits and other effects of urban water supply changes in the two largest urban water use areas in the state: the South Coast and South San Francisco Bay regions. OMWEM evaluates these effects for the other affected SWP and CVP delivery regions. Both models use CALSIM II to provide inputs for SWP and CVP water deliveries. To analyze economic effects, these models assess the value of a proposed water supply change by estimating how that change would affect the lowest-possible cost of meeting supply and demand needs in a region. These models use an assumed demand based on 2010 Urban Water Management Plan, which is similar to that of other more recent M&I economic models (e.g., California Economic Spreadsheet Tool [CWEST]).

The previous modeling assumed that average annual distribution of M&I supplies from the Sites Reservoir would be between 88 TAF and 95 TAF. These hydrologic model results and the comparison of Alternatives 1, 2, and 3 with previous hydrologic modeling included in Appendix 30B indicate that the economic benefit (based on simulated deliveries to M&I users) would remain positive and beneficial, as previously disclosed. The previous economic modeling identified an annual economic value of between $144 million and $170 million on a long-term water year average basis. Appendix 22D provides further information on the previous economic modeling related to M&I water supply. Table 30A-4the simulated 2017 M&I economic effects and those associated with the Project alternatives presented in this RDEIR/SDEIS. The average annual value of Sites water delivery to M&I users under a 1.5-MAF reservoir capacity was refined as part of the WSIP application and was estimated to be approximately $89 million in 2030 and approximately $251.5 million in 2070 (Sites Project Authority 2017). These calculations were based on an average annual M&I delivery volume of 114 TAF.

Table 30A-4: Summary of Simulated 2017 Municipal and Industrial Economic Effects and RDEIR/SDEIS Alternatives

	Simulated 2017 Results	Alternatives 1, 2, and 3	Rationale
Operation	**+**	+	RDEIR/SDEIS relative trend similar to 2017 because of size of reservoir; distribution and range of hydrologic modeling results related to M&I water deliveries is similar but volumes would be smaller

Table notes: symbols indicate relative positive beneficial economic effects.

30A.1.6. Local Government Fiscal Conditions

The 2017 Draft EIR/EIS evaluated local government fiscal conditions based on an analysis of changes to property tax revenue resulting from land acquisition for Sites Reservoir. This effect was not modeled; rather, a GIS analysis identified affected parcels and associated property taxes using the tax roll data and parcel boundary information. The entire affected parcel was expected to be acquired if it was located in the Project facility footprint. The total annual change in tax revenue associated with the affected parcels was then calculated for each taxing entity for each alternative. Annual losses in property tax revenue were estimated to be $30,892 in Glenn County and $274,239 in Colusa County. These amounts totaled 0.04% and 0.33%, respectively, of the Counties' total revenue in the 2015–2016 fiscal year.

30A.2 References

Sites Project Authority. 2017. Water Storage Investment Program Application & Appeal Documentation. Attachment 1: Model Assumptions. Final. August.

Appendix 22
Socioeconomics

Line items and numbers identified or noted as “No Action Alternative” represent the “Existing Conditions/No Project/No Action Condition” (described in Chapter 2 Alternatives Analysis). Table numbering may not be consecutive for all appendixes.”

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APPENDIX 22A
Economics Analytical Framework

This document and the series of attached economics model technical memorandum describe the methods and assumptions for evaluating benefits in the Sites Reservoir Project (Project) investigation. The economics analysis for the Project investigation was developed from past water resource investigations by the California Department of Water Resources (DWR) and the Bureau of Reclamation (Reclamation). The methodology is consistent with analytical process for evaluating storage and conveyance options in California. Included in the economics evaluation is a set of economic analysis tools and assumptions to use for feasibility and impact analysis. This document summarizes the key economic analysis tools for evaluation of regional impacts, municipal and industrial (M&I) water supply and quality, and agricultural water supply. These economic analysis tools include:

- Reporting Metrics Tool
- Regional Economics
  - IMPLAN
- Municipal and Industrial Water Supply Economics
  - Least Cost Planning Simulation Model (LCPSIM)
  - Other Municipal Water Economics Model (OMWEM)
  - Lower Colorado River Basin Water Quality Model (LCRBWQM)
  - Bay Area Water Quality Economics Model (BAWQM)
- Agricultural Water Supply Economics
  - Statewide Agricultural Production Model

22A.1 Reporting Metrics Tool

The Reporting Metrics Tool (RMT) developed for the Project Feasibility Report and EIR/EIS is a spreadsheet model that reports system operations and economics metrics. The reports are a summary of system specifications for scenarios evaluated, modeled operations, and modeled economics impacts at a range of detail. The reported system operations metrics include yield and water supply, water quality, and hydropower. The reported economics metrics include project costs, agricultural and M&I water supply, and M&I water quality.

For additional description of the RMT and Project Feasibility Report and EIR/EIS results, see Appendix 22B Reporting Metrics Tool.

22A.2 Regional Economics

Regional economic effects include changes in characteristics like regional employment and income. The magnitudes of the economic effects depend on the initial changes in economic activity within the region (such as construction expenditure or loss of production from existing activities), the interactions within the regional economy, and the “leakage” of economic activity from this regional economy to the larger, surrounding economy. Economic linkages create multiplier effects in a regional economy as money is circulated by trade. These linkages are often modeled using a large mathematical model called an input-output model.

IMPLAN is a computer database and modeling system used to create input-output models for any combination of United States counties. IMPLAN is a widely used input-output model system in the United States. It provides users with the ability to define industries, economic relationships, and projects to be analyzed. It can be customized for any county, region, or state, and used to assess the “ripple effects” or “multiplier effects” caused by increasing or decreasing spending in various parts of the economy.

IMPLAN includes (1) estimates of county-level final demands and final payments developed from government data; (2) a national average matrix of technical coefficients; (3) mathematical tools that help the user formulate a regional model; and (4) tools that allow the user to change data, conduct analyses, and generate reports.

Economic impacts on a regional economy can result from construction and operation of facilities, changes in recreational uses, changes in agricultural production, changes in water quality to municipal and industrial users, and changes in other affected businesses. The direct effects of quantified changes (e.g., construction and operation spending or change in agricultural production or recreation expenditures) are input into IMPLAN regional economic models. Based on input from project cost estimators, local and non-local components of labor and non-labor (i.e., equipment and other materials) expenditures associated with construction and operation of Project facilities can be identified. Expenditures can be used as input into IMPLAN to determine the regional employment and income changes associated with construction and operation of Project facilities for all Project alternatives. The resulting output (employment and income) for each model run is the change from the base model run (Existing Conditions and the No Action Alternative are the same “base” IMPLAN model). A separate regional IMPLAN model is used to estimate the employment and income changes associated with changes in agricultural production in the selected region. Changes in employment and income associated with changes in recreation expenditures can also be estimated using a regional IMPLAN model by identifying changes in recreational expenditures.

An IMPLAN model of the Primary Study Area was used to estimate total changes in employment and income in the region. The model follows county lines and incorporates, to the extent allowed by available data, the employment and income characteristics of the economic sectors in the region modeled. Construction-related changes were modeled based on the expected year of expenditure. All other changes were assumed to be average annual changes. Estimates of direct employment during construction and operation for each alternative were derived from the total payroll estimate. With the exception of employment, all direct effects were expressed in dollar terms for all affected sectors. For example, agricultural effects were incorporated into the input-output models in dollar terms as changes in gross revenues or costs.

For additional description of model methods and assumptions see Appendix 22C Regional Economics Modeling.

22A.3 Municipal and Industrial Water Supply Economics

Economic benefits and costs on M&I users occur with changes in water supply and quality. Effects from changes in water supply are calculated using the LCPSIM and the OMWEM, briefly described below. These models were developed by DWR for use in planning and impact studies related to water supply for SWP and CVP contractors that may be affected by surface storage projects or re-operations. LCPSIM is used to estimate the benefits of changes in the water supply in the urban areas of the southern San

Francisco Bay – South and the South Coast regions. Other affected SWP and CVP contractors are included in OMWEM.

22A.3.1 Least Cost Planning Simulation Model (LCPSIM)

LCPSIM is an annual time-step urban water service system simulation/optimization model. Its objective is to find the least-cost water management strategy for a region, given the mix of demands and available supplies. It uses shortage management measures, including the use of regional carryover storage, water market transfers, contingency conservation, and shortage allocation rules to reduce regional costs and losses associated with shortage events. It also considers the adoption of long-term regional demand reduction and supply augmentation measures that reduce the frequency, magnitude, and duration of shortage events.

For additional description of model methods and assumptions see Appendix 22D Urban Water Supply Economics Modeling.

22A.3.2 Other Municipal Water Economics Model (OMWEM)

A number of relatively small M&I water providers receive SWP or CVP water but are not covered by LCPSIM. A set of individual spreadsheet calculations, collectively called OMWEM, can be used to estimate economic benefits of changes in SWP or CVP supplies for these potentially affected M&I water providers. The model includes CVP M&I supplies north of Delta, SWP and CVP supplies to the Central Valley and the Central Coast, and SWP supplies or supply exchanges to the desert regions east of LCPSIM's South Coast region. The model estimates the economic value of M&I supply changes in these areas as the change in cost of shortages and alternative supplies (such as groundwater pumping or transfers).

For additional description of model methods and assumptions see Appendix 22D Urban Water Supply Economics Modeling.

22A.3.3 Lower Colorado River Basin Water Quality Model (LCRBWQM)

LCRBWQM is an M&I water quality economics model that covers almost the entire urban coastal region of southern California. LCRBWQM was developed by Reclamation and Metropolitan Water District of Southern California (MWD). LCRBWQM divides MWD's service area into 15 sub areas to reflect the unique water supply conditions and benefit factors of each. The salinity model is designed to assess the average annual salinity benefits or costs based on demographic data, water deliveries, TDS concentration, and cost relationships for typical household, agricultural, industrial, and commercial water uses. It uses mathematical functions that define the relationship between TDS and items in each affected category, such as the useful life of appliances, specific crop yields, and costs to industrial and commercial customers.

For additional description of model methods and assumptions see Appendix 22E Urban Water Quality Economics Modeling.

22A.3.4 Bay Area Water Quality Economics Model (BAWQM)

BAWQM is an M&I water quality economics model that includes the portion of the Bay Area region from Contra Costa County south to Santa Clara County. The model was developed and used for the economic evaluation of a proposed expansion of Los Vaqueros Reservoir (Reclamation, 2006). It uses estimated relationships between salinity and damages to residential appliances and fixtures to estimate the benefits from changes in salinity. Specific model outputs compare change in average salinity and change in annual salinity costs.

For additional description of model methods and assumptions see Appendix 22E Urban Water Quality Economics Modeling.

22A.4 Agricultural Water Supply Economics

The economic analysis of changes in agricultural production in areas receiving irrigation water uses changes in SWP and CVP water delivery provided by CALSIM II. Agricultural economic effects are evaluated using a regional agricultural production model developed specifically for large-scale analysis of agricultural water supply and cost changes. Groundwater and water quality effects have been evaluated using a separate analysis of groundwater conditions and costs associated with managing salts in irrigation water.

22A.4.1 Statewide Agricultural Production Model (SWAP)

The SWAP model is the evolution of a series of production models of California agriculture developed by the University of California at Davis and DWR. SWAP and the Central Valley Production Model (CVPM) have been used for numerous policy analyses and impact studies over the past 15 years, including the impacts of the Central Valley Project Improvement Act (Reclamation and USFWS, 1999), Upper San Joaquin Basin Storage Investigation (Reclamation, 2008), the SWP drought impact analysis (Howitt et al., 2009), and the economic implications of Delta conveyance options (Lund et al., 2007).

SWAP is a regional model of irrigated agricultural production and economics that simulates the decisions of agricultural producers (farmers) in California. Its data coverage is most detailed in the Central Valley, but it also includes production regions in the Central Coast, South Coast, and desert areas. The model assumes that farmers maximize profit subject to resource, technical, and market constraints. Farmers sell and buy in competitive markets, and no one farmer can affect or control the price of any commodity. The model selects those crops, water supplies, and other inputs that maximize profit subject to constraints on water and land, and subject to economic conditions regarding prices, yields, and costs.

For additional description of model methods and assumptions see Appendix 22F Agricultural Supply Economics Modeling.

22A.5 References

Bureau of Reclamation (Reclamation). 2008. Upper San Joaquin River Basin Storage Investigation. Plan Formulation Report. Mid-Pacific Region. Sacramento, California.

Bureau of Reclamation (Reclamation). 2006. Initial Economic Evaluation for Plan Formulation. Los Vaqueros Expansion Investigation. Mid-Pacific Region. Sacramento, California.

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Howitt, R. E., D. MacEwan, and J. Medellín-Azuara. 2009. Measuring the Employment Impact of Water Reductions. 10. Davis, CA: University of California at Davis.

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Appendix 22C
Regional Economics Modeling

APPENDIX 22C
Regional Economics Modeling

22C.1 Introduction

Direct economic impacts due to changes in water supply and other factors from the Sites Reservoir Project (Project) will have effects in other parts of the state economy. Increased revenues in one sector increases employee compensation and, in turn, spending in other parts of the economy. These are frequently referred to as "multiplier" effects and correspond to changes in the regional economy based on linkages between industry sectors. For example, if crop acreage increases due to additional Project water supply, farmers purchase more seed, chemicals and labor, and these businesses and workers in turn increase their purchases. The shares of these inter-industry purchases that are from regional businesses represent additional changes in economic activity. These inter-industry transactions continue until limited by the shares of purchases that are imported into the region.

Input-output (I-O) models are used to estimate direct, indirect, and induced effects. The Project analysis uses the IMpact Analysis for PLANning (IMPLAN) model. IMPLAN is a widely-used and accepted regional economic model that can measure the effect of projects or policies on local economic conditions. The IMPLAN model can estimate changes in regional output, labor income, value added, employment, and tax base. Total economic effects within a region equal the sum of direct, indirect, and induced effects.

22C.2 Impact Analysis for Planning (IMPLAN) Model

22C.2.1 Description

The IMPLAN model was originally developed by the U.S. Department of Agriculture Forest Service to assist in land and resource management planning, but its role has expanded to serve clients in federal, state, and local governments, universities, as well as the private sector. The primary advantages of IMPLAN include a comprehensive underlying dataset, opportunities for customization, robust multipliers based on a complete set of social accounts, and detailed trade-flow data that allows for multi-regional analysis.

The 2008 IMPLAN dataset for California (and all counties) was used to develop both the state and regional-level models used in the Project analysis. IMPLAN estimates changes in the local and related sectors of the regional economy. The Project analysis considers changes in the state economy and changes in the regional economy directly around the Project. The former is used to estimate changes stemming from the agricultural economy, since agriculture is a large component of California's economy. The regional effects are those directly around the Project area, including Glenn and Colusa counties.

The IMPLAN model estimates include direct and indirect and induced (multiplier) effects. Direct effects include the primary effects on revenues, employment, and value added on the sectors that are directly affected by changes due to the Project. Multiplier effects include both indirect effects on the businesses in related sectors and induced effects of changes in household spending on the overall economy. For example, consider an increase in agricultural water supply due to the Project. Direct effects include reduced agricultural production, revenues, and incomes of farmers, landowners, and farm employees. Indirect effects include increased demand for farm inputs in addition to increased supply of agricultural outputs to processing plants, facilities, business that sell produce and related goods. This also affects the individual business, as revenues and income fall. In turn, employees of these establishments earn less and reduce spending, which is an induced effect.

Because IMPLAN is an annual model, all model inputs were converted into average annual values (undiscounted) based on a straight-line extrapolation of project effects between 2025 and 2060 levels of development.

22C.2.1.1 IMPLAN Model Geographic Scope

It is necessary to define the relevant geographic area for I-O analysis. For the Project, two regions are considered, requiring the development of two separate IMPLAN models. The first is a local-level model that is intended to capture effects in close proximity to the Project. The local model covers Colusa and Glenn counties, the two counties within which the Project would be located. This model will be referred to as the two-county model throughout the rest of this Appendix. The second model is a statewide model that covers the entire state of California. This second model, also referred to as the California model, was developed to capture the large geographic extent of effects anticipated under the Project. For each type of impact evaluated, the appropriate model was selected based on the location of direct effects and geographic extent of economic linkages. It is acknowledged that effects evaluated at the local, two-county level would also likely generate statewide effects as a result of imports of capital and labor into the region.

The Project would generate a range of economic effects. Many of these effects, in turn, would also support regional economic activity in both the local two-county area (surrounding Sites Reservoir) and throughout the state. For this analysis, the following drivers of regional economic effects are evaluated:

- Construction expenditures (local model)
- O&M expenditures (local model)
- Recreation spending (local model)
- Agricultural production (statewide model)

22C.2.1.2 Interactions with Other Models[1]

The Statewide Agricultural Planning model (SWAP) model output is used as part of the input to regional economic analysis using the IMPLAN model. SWAP model output includes gross farm revenue losses by region and crop and is used in the statewide IMPLAN model analysis.[2]

A separate set of agricultural output estimates is available from SWAP based on endogenous prices in the model. These values represent output changes resulting from price-level effects in agricultural markets. Generally, holding all else constant, future agricultural prices tend to decrease with the Project resulting in lower income levels for affected farmers. These endogenous price changes reduce agricultural production values by up to $1.9 million per year in 2025 and $1.3 million by 2060. Because these revenues are not attributed to physical changes in production, and instead reflect changes in revenues due to market conditions, these values were modeled as a household income change in IMPLAN.

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[1] For further discussion of IMPLAN modeling and interactions with other models, see the NODOS Feasibility Report.

[2] For further discussion of the SWAP model, see Chapter 22 Agricultural Economics Technical Appendix.

22C.2.1.3 Assumptions and Limitations[3]

The IMPLAN model provides a "snap-shot" representation of a regional economy and, as such, tends to be more rigid than an economy may be in practice. Thus, IMPLAN tends to provide upper bound estimates of the annual economic gain/loss from a proposed policy. More flexible transitions and adjustments are likely to occur over time, thus benefits (costs) may be over (under) stated.

22C.2.1.4 Local, two-county IMPLAN Model – Project Construction

The local two-county IMPLAN model was used to evaluate changes in construction expenditures (Tables 22C-1, 22C-2, and 22C-3). The indirect and induced labor income; indirect and induced employment; and all of the output values for Alternative D (Table 22C-4) are assumed to be the same as those for Alternative C as the IMPLAN model was not run for Alternative D.

The development of the Project would require substantial capital investment, including land acquisition, construction of the facilities and mitigation-related costs. Project costs include payments to construction labor, as well as procurement of construction-related goods and services. To the extent that construction spending occurs locally, the Project would generate regional economic effects in the local study area (i.e., Colusa and Glenn counties). However, based on the small size of the local economy, it is anticipated that a substantial portion of the construction expenditures would be for labor and commodities imported into the region.

Since the local (i.e., within the two county region) labor pool is not large enough, it is expected that some portion of the construction workforce would be from outside this region. Some of these non-local workers may choose to temporarily relocate to the region for the duration of the Project or may choose to stay in local lodging in the region. Construction labor payments generate additional economic activity as workers spend money locally. For the analysis, it is assumed that 30 percent of the construction workers would come from the local area, and of the remaining non-local workforce, approximately 20 percent would reside (and spend) locally while employed by the Project. These labor payments are modeled in IMPLAN as a labor income change (Sector 5001, *Employee Compensation*).

Other Project expenditures consist primarily of purchases of construction materials (e.g., concrete and steel) and construction equipment required to develop Project facilities. A majority of materials are expected to be sourced within the local counties. However, other large capital equipment, such as power generating turbines, would need to be purchased from outside the two-county region and installed at the site. It is estimated that a portion of non-labor construction expenditures will be imported into the local two-county region (i.e., Colusa and Glenn counties). The extent to which the remaining construction expenditures filter through local industries is estimated by IMPLAN through the regional purchase coefficients (RPCs) implicit in the production function in the construction sector. Non-labor construction expenditures are modeled in IMPLAN as industry spending pattern change (Sector 36, *Construction of other new nonresidential structures*).[4]

The Project would require land acquisition in order to accommodate Project facilities, including land underlying Sites Reservoir. There are no regional economic effects associated with transfer of principal land values as such transactions represent a trade of cash assets for land assets. However, expenditures for

[3] For further discussion of IMPLAN modeling and assumptions and limitations, see the NODOS Feasibility Report.

[4] Using this approach, the production function coefficients were normalized to 1, thereby removing all value-added components as payroll impacts were modeled separately.

real estate and legal fees are expected to generate local economic effects. For the current analysis, it is assumed that non-principal costs account for 10 percent of total acquisition cost which is allocated equally to real estate and legal fees. In IMPLAN, real estate and legal costs were modeled as industry changes (Sector 360, *Real Estate Establishments* and Sector 367, *Legal Services*, respectively). Effects associated with land acquisition are assumed to be one-time effects occurring in a single year at the commencement of Project development.

There are several caveats to the IMPLAN analysis of Project construction effects. First, the effects attributed to the construction of the Project may be offset by reduced construction for water supply facilities and projects elsewhere in the state. The Least Cost Planning Simulation Model (LCPSIM) and SWAP models show that the Project would reduce spending for reclamation, conservation, local projects, and demand for groundwater in other parts of the state.[5] To the extent that the Project would reduce the need for other water projects, construction effects attributed to those other projects would be reduced accordingly; however, these other projects would be located primarily outside the local study area. In addition, to the extent that the Project is financed with local funding sources, the beneficial effects of construction may be offset by the negative effects of financing the Project, which may result in reduced expenditures on other public projects.

Project Construction Impact Summary Results

Table 22C-1
Alternative A Project Construction Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (Outside Model)	143	$44,479,167	$1,983,169,288
Indirect Effect	259	$11,985,703	$31,823,934
Induced Effect	108	$4,560,856	$16,231,836
Total Effect (w/o outside model)	367	$16,546,559	$48,055,771
Total Effect (w/ outside model)	510	$61,025,726	$2,031,225,059

Note:
Direct effect = total cost/employment/payroll
Income and output reported in 2015 dollars

Table 22C-2
Alternative B Project Construction Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (Outside Model)	144	$44,895,833	$1,983,169,288
Indirect Effect	490	$12,116,934	$32,172,371
Induced Effect	96	$4,605,124	$16,389,386
Total Effect (w/o outside model)	586	$16,722,058	$48,561,757
Total Effect (w/ outside model)	730	$61,617,891	$2,031,731,045

Note:
Direct effect = total cost/employment/payroll
Income and output reported in 2015 dollars

5 For further discussion of LCPSIM, see Chapter 22 Municipal and Industrial Water Supply Economics Technical Appendix

Table 22C-3
Alternative C Project Construction Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (Outside Model)	156	$48,638,542	$1,983,169,288
Indirect Effect	490	$13,123,033	$34,843,724
Induced Effect	96	$4,988,700	$17,754,510
Total Effect (w/o outside model)	586	$18,111,733	$52,598,234
Total Effect (w/ outside model)	742	$66,750,274	$2,035,767,522

Note:
Direct effect = total cost/employment/payroll
Income and output reported in 2015 dollars

Table 22C-4
Alternative D Project Construction Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (Outside Model)	159	$49,711,458	$1,983,169,288
Indirect Effect	490	$13,166,776	$34,959,869
Induced Effect	96	$5,078,728	$18,074,906
Total Effect (w/o outside model)	586	$18,245,505	$53,034,775
Total Effect (w/ outside model)	745	$67,956,963	$2,036,204,063

Note:
Direct effect = total cost/employment/payroll
Income and output reported in 2015 dollars

22C.2.1.5 Local IMPLAN Model – Project Operations

Once construction is complete, the Project would support hydropower production at Sites Reservoir and other ancillary generating facilities. The value of hydropower generation represents the direct output value of Project operations, which in itself does not generate regional effects as the Project is a net user of power. Instead, the regional economic effects of Project operations are solely attributed to local employment and spending to support ongoing O&M activities (Tables 22C-5, 22C-6, 22C-7, and 22C-8). The regional economic effects associated with Project operations under Alternative D were extrapolated from those under Alternative C.

It is assumed that all employees would reside in the local area. Similar to construction payroll, these labor payments are modeled in IMPLAN as a labor income change (Sector 5001, *Employee Compensation*). In addition, Project operations would require ongoing O&M expenditures on miscellaneous goods and services primarily to support the hydropower operations, but also maintenance of the reservoir's recreation facilities. Non-labor operations expenditures are modeled in IMPLAN as industry spending pattern changes for power production (Sector 31, *Electric Power Generation, Transmission and Distribution*) and recreation facility maintenance (Sector 39, *Maintenance and repair construction of nonresidential structures*).

Project Operations Impact Summary Results

Table 22C-5
Alternative A Project Operations Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (outside model)	35	$1,901,668	$0
Indirect Effect	6	$242,757	$705,711
Induced Effect	5	$158,908	$578,845
Total Effect (w/o outside model)	11	$401,665	$1,284,556
Total Effect (w/ outside model)	46	$2,303,333	$1,284,556

Note:
Direct effect = power value/employment/payroll
Income and output reported in 2015 dollars

Table 22C-6
Alternative B Project Operations Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (outside model)	30	$1,630,001	$0
Indirect Effect	6	$229,164	$666,261
Induced Effect	4	$137,800	$501,985
Total Effect (w/o outside model)	10	$366,964	$1,168,246
Total Effect (w/ outside model)	40	$1,996,966	$1,168,246

Note:
Direct effect = power value/employment/payroll
Income and output reported in 2015 dollars

Table 22C-7
Alternative C Project Operations Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (outside model)	35	$1,901,668	$0
Indirect Effect	6	$242,757	$705,711
Induced Effect	5	$158,908	$578,845
Total Effect (w/o outside model)	11	$401,665	$1,284,556
Total Effect (w/ outside model)	46	$2,303,333	$1,284,556

Note:
Direct effect = power value/employment/payroll
Income and output reported in 2015 dollars

Table 22C-8
Alternative D Project Operations Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect (outside model)	38	$1,901,668	$0
Indirect Effect	6	$242,757	$705,711
Induced Effect	5	$158,908	$578,845
Total Effect (w/o outside model)	11	$401,665	$1,284,556
Total Effect (w/ outside model)	46	$2,303,333	$1,284,556

Note:
Direct effect = power value/employment/payroll
Income and output reported in 2015 dollars

22C.2.1.6 Local IMPLAN Model – Recreation

The development of Sites Reservoir would draw recreational visitors to the region and induce recreation-related spending at local businesses. Typical recreation-related expenditures include food, lodging, fuel, recreation equipment and services, and other miscellaneous retail goods. To the extent that recreation spending is attributed to visitors from outside the region, the retail will represent new income added to the local economy, which would generate regional economic effects by supporting jobs and generating income for local residents (Tables 22C-9, 22C-10, 22C-11, 22C-12). Recreation spending under Alternative D is assumed to be the same as that under Alternative C.

For the Project analysis, the level of recreation visits and the proportion of visits from outside of the region are estimated. It is assumed that roughly 26 percent of future visitors to Sites Reservoir will come from outside the region. Expenditures by these visitors serve as inputs to IMPLAN. Expenditures by category were assigned to applicable IMPLAN sectors as follows:

- Lodging: Sector 411, Hotels and motels, including casino hotels
- Restaurants: Sector 413, Food services and drinking places
- Groceries: Sector 324, Retail stores–food and beverage
- Gas and oil: Sector 326, Retail stores–gasoline stations
- Other transportation: Sector 320, Retail stores–motor vehicle and parts
- Entry fees: Sector 432, Other state and local government enterprises
- Recreation and entertainment: Sector 410, Other amusement and recreation industries
- Sporting goods: Sector 328, Retail stores–sporting goods, hobby, book, and music
- Souvenirs and other: Sector 329, Retail stores–general merchandise

Recreation Impact Summary Results

Table 22C-9
Alternative A Recreation Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	15	$395,344	$1,525,659
Indirect Effect	1	$39,052	$17,653
Induced Effect	1	$39,052	$13,291
Total Effect	17	$477,544	$1,556,603

Note:
Income and output reported in 2015 dollars

Table 22C-10
Alternative B Recreation Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	15	$392,712	$1,515,606
Indirect Effect	1	$39,052	$17,654
Induced Effect	1	$39,052	$13,292
Total Effect	17	$473,639	$1,546,552

Note:
Income and output reported in 2015 dollars

Table 22C-11
Alternative C Recreation Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	16	$409,557	$1,580,644
Indirect Effect	1	$39,052	$17,654
Induced Effect	1	$39,052	$13,292
Total Effect	18	$494,280	$1,611,590

Note:
Income and output reported in 2015 dollars

Table 22C-12
Alternative D Recreation Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	16	$409,557	$1,580,644
Indirect Effect	1	$39,052	$17,654
Induced Effect	1	$39,052	$13,292
Total Effect	18	$494,280	$1,611,590

Note:
Income and output reported in 2015 dollars

22C.2.1.7 State IMPLAN Model – Agricultural Production[6]

Agriculture is a key industry in California, directly supporting a large number of jobs and income at the farm level and indirectly generating economic activity across the state based on a wide range of inter-industry linkages with the agricultural sector. Additional water supplies from the Project would increase the number of irrigated acres in the state, thereby increasing crop production levels and related agricultural output (revenues) holding prices fixed at base levels. In addition, the Project would also affect agricultural markets through changes in commodity supplies resulting in reductions in market prices for affected crops and associated revenues received by farmers. These two effects are modeled separately using the IMPLAN state model for California.

The SWAP model estimates the value of agricultural output across a range of different crops (under base price levels). These figures reflect the change in farm gate production values attributed to changes in irrigated acreage and excludes market effects on prices. These direct effects serve as inputs to the applicable agricultural sectors in IMPLAN based on crop type as shown in Table 22C-13.

Table 22C-13
Agricultural Sectors – SWAP and IMPLAN
Regional Economics Modeling

SWAP Crop Code	IMPLAN Sector
Almonds	Sector 5: Tree nut farming
Alfalfa Hay	Sector 10: All other crop farming
Grain Corn	Sector 2: Grain farming
Cotton	Sector 8: Cotton farming
Summer Squash	Sector 3: Vegetable and melon farming
Dry Beans	Sector 10: Tree nut farming
Fresh Tomatoes	Sector 3: Vegetable and melon farming
Wheat	Sector 2: Grain farming
Dry Onions	Sector 3: Vegetable and melon farming
Walnuts	Sector 5: Tree nut farming
Sudan Grass Hay	Sector 10: All other crop farming
Broccoli	Sector 3: Vegetable and melon farming
Irrigated Pasture	Sector 10: All other crop farming
White Potatoes	Sector 3: Vegetable and melon farming
Processing Tomatoes	Sector 3: Vegetable and melon farming
Rice	Sector 2: Grain farming
Safflower	Sector 1: Oilseed farming
Sugar Beets	Sector 9: Sugar cane and sugar beet farming
Oranges	Sector 4: Fruit farming
Wine Grapes	Sector 4: Fruit farming

[6] For further discussion of IMPLAN modeling and state agricultural impact summary results see the NODOS Feasibility Report.

As a result of the Project's additional water supplies for farming, agricultural output values are also expected to increase due to reduced land fallowing for water transfers to environmental and urban water users. This effect is not captured in the SWAP model. Instead, estimated changes in agricultural production attributed to reductions in water transfers can be inferred based in part on modeling output from LCPSIM (for M&I supplies) while changes in water transfers for environmental purposes are expected to have a negligible impact. The source supplies from these water transfers are concentrated in the San Joaquin Valley and Sacramento Valley and to a lesser extent in the Colorado River Basin.

The proportion of water transfers that would affect agricultural production is unknown. In addition to crop idling, water supplies made available for transfer can also be derived from groundwater pumping and storage. Therefore, it is difficult to estimate the net increase on agricultural production, which could generate regional economic effects based on inter-industry linkages with agricultural-support and other industries across the state.

Further, any potential positive effects realized in the agricultural industry must be balanced with reductions in revenues to farmers from water transfer payments. Such payments represent an income stream to farmers that would help offset losses in agricultural revenues. In such instances, instead of money filtering through the agricultural sector, lost revenues from water transfers represent a decrease in household income, which is typically spent in accordance with representative household spending patterns. In the case of farmers, these funds may also be used for capital investment in their agricultural operations (e.g., purchase of new farm machinery). Without such revenues, there would be some decline in regional economic activity.

Without specific information on sources of water transfers, types of crops grown, idled croplands and farmer spending patterns, the net effect on income and employment levels in the state is unknown. Conceptually, these effects would partially offset one another depending on the magnitude of multipliers across affected industries. Overall, it is anticipated that the net effect on the regional economy would be minor.

Increased water supplies from the Project would reduce groundwater pumping and increase net incomes for farmers. This effect is not included because the offsetting cost for supplying Project water is not considered. It is expected that the Project's variable water supply costs would be less than variable groundwater pumping costs since water users must have incentive to take the water. The cost differential, however, is unknown.

In addition to water transfers and costs, discussed above, that are excluded from the analysis, the following categories of impacts are not included in the IMPLAN analysis:

- **Changes in water rates.** Changes in water costs required for repayment of the Project could result in changes in customer water rates. Increased rates should decrease household and business spending, and all else equal, regional economic activity would be reduced. However, rate changes would depend on how the Project is financed, which is unknown at this time. Also, increased Project water costs would be largely offset by reduced costs for other water supplies.
- **Changes in costs attributable to improved water quality.** Reduced salinity in the South Coast would result in real cost savings for consumers by extending the life of fixtures and appliances and reducing purchases of water softeners, bottled water and other substitutes. Cost savings would also be realized by agricultural producers in areas with salinity issues. These savings increase the amount of disposable income of consumers and farmers, which may be offset by reduced expenditures

addressing water quality impacts. In addition, the beneficiaries of water quality improvements may be responsible to repay the water quality-related costs of the Project. For example, rates may increase to water users in the service area of agencies that water quality improves.

- **Increased value of output in the South Coast region.** Increased water supplies for the South Coast could increase industrial output during drought periods. However, hydrologic data indicate that even in dry/critical years, available water supplies without the Project would meet 75 percent of demand. At this level of reductions, minimal disruption to industrial output may be expected since public landscaping and residential users would bear most of the cost of shortage.
- **Increased value of hydroelectric production in the Central Valley.** The Project operations analysis for the reservoir captures the hydropower generation effects at the local level from future operations and maintenance of the hydroelectric facilities. Given the relatively small magnitude of the electrical production by the Project (even under the optimized and pumpback operations), the regional economic effects associated with changes in hydropower production throughout the rest of the system would likely be negligible. There are not likely to be income and job effects at other SWP/CVP power facilities since no additional hiring and minimal operational costs may be expected to accommodate the Project's incorporation into the utility system.

22C.2.1.8 Local IMPLAN Model – Agricultural Production

Local agriculture is temporarily and permanently removed from production to accommodate Project construction and operation, respectively. A reduction in the number of irrigated acres in the local region would decrease crop production levels and related agricultural output (revenues) reducing employment and labor income (Tables 22C-14, 22C-15, 22C-16, 22C-17, 22C-18, 22C-19, 22C-20, and 22C-21).

Local Temporary Agricultural Impact Summary Results

Table 22C-14
Alternative A Local Temporary Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-44	-$691,162	-$7,708,584
Indirect Effect	-15	-$562,084	-$1,190,381
Induced Effect	-3	-$96,234	-$353,438
Total Effect	-62	-$1,349,480	-$9,252,403

Note:
Income and output reported in 2015 dollars

Table 22C-15
Alternative B Local Temporary Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-44	-$691,162	-$7,708,584
Indirect Effect	-15	-$562,084	-$1,190,381
Induced Effect	-3	-$96,234	-$353,438
Total Effect	-62	-$1,349,480	-$9,252,403

Note:
Income and output reported in 2015 dollars

Table 22C-16
Alternative C Local Temporary Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-44	-$691,162	-$7,708,584
Indirect Effect	-15	-$562,084	-$1,190,381
Induced Effect	-3	-$96,234	-$353,438
Total Effect	-62	-$1,349,480	-$9,252,403

Note:
Income and output reported in 2015 dollars

Table 22C-17
Alternative D Local Temporary Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-44	-$691,162	-$7,708,584
Indirect Effect	-15	-$562,084	-$1,190,381
Induced Effect	-3	-$96,234	-$353,438
Total Effect	-62	-$1,349,480	-$9,252,403

Note:
Income and output reported in 2015 dollars

Local Permanent Agricultural Impact Summary Results

Table 22C-18
Alternative A Local Permanent Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-5	-$222,194	-$1,666,382
Indirect Effect	-4	-$162,618	-$315,615
Induced Effect	-1	-$29,444	-$108,055
Total Effect	-10	-$414,256	-$2,090,053

Note:
Income and output reported in 2015 dollars

Table 22C-19
Alternative B Local Permanent Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-5	-$216,324	-$1,638,986
Indirect Effect	-4	-$159,349	-$310,903
Induced Effect	-1	-$28,746	-$105,492
Total Effect	-10	-$404,420	-$2,055,380

Note:
Income and output reported in 2015 dollars

Table 22C-20
Alternative C Local Permanent Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-5	-$222,194	-$1,666,382
Indirect Effect	-4	-$162,618	-$315,615
Induced Effect	-1	-$29,444	-$108,055
Total Effect	-10	-$414,256	-$2,090,053

Note:
Income and output reported in 2015 dollars

Table 22C-21
Alternative C Local Permanent Agricultural Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	-4.7	-$222,194	-$1,666,382
Indirect Effect	-5	-$162,618	-$315,615
Induced Effect	-4	-$29,444	-$108,055
Total Effect	-1	-$414,256	-$2,090,053

Note:
Income and output reported in 2015 dollars

22C.2.1.9 Local IMPLAN Model – Land Acquisition

The Project would increase economic activity related to land acquisition in the Primary Study Area. This regional economic impact would be temporary (Tables 22C-22, 22C-23, 22C-24, and 22C-25).

Land Acquisition Impact Summary Results

Table 22C-22
Alternative A Local Land Acquisition Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	15	$679,105	$2,259,643
Indirect Effect	1	$43,864	$149,707
Induced Effect	2	$56,008	$206,107
Total Effect	18	$778,976	$2,615,459

Note:
Income and output reported in 2015 dollars

Table 22C-23
Alternative B Local Land Acquisition Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	14	$668,494	$2,224,337
Indirect Effect	1	$43,179	$147,368
Induced Effect	2	$55,133	$202,887
Total Effect	17	$766,806	$2,574,591

Note:
Income and output reported in 2015 dollars

Table 22C-24
Alternative C Local Land Acquisition Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	15	$679,105	$2,259,643
Indirect Effect	1	$43,864	$149,707
Induced Effect	2	$56,008	$206,107
Total Effect	18	$778,976	$2,615,459

Note:
Income and output reported in 2015 dollars

Table 22C-25
Alternative D Local Land Acquisition Impact Summary Results
Regional Economics Modeling

Impact Type	Employment	Labor Income	Output
Direct Effect	15	$679,105	$2,259,643
Indirect Effect	1	$43,864	$149,707
Induced Effect	2	$56,008	$206,107
Total Effect	18	$778,976	$2,615,459

Note:
Income and output reported in 2015 dollars

Appendix 22F
Agricultural Supply Economics Modeling

Line items and numbers identified or noted as “No Action Alternative” represent the “Existing Conditions/No Project/No Action Condition” (described in Chapter 2 Alternatives Analysis). Table numbering may not be consecutive for all appendixes.”

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APPENDIX 22F
Agricultural Supply Economics Modeling

22F.1 Introduction

Economic impacts to agricultural production in regions of California, including benefits and costs, occur with changes in agricultural water supply. This study focuses on changes in areas served by the State Water Project (SWP) and Central Valley Project (CVP) in California. Changes in agricultural production, as a result of changes in agricultural water supply, are estimated using an economic optimization modeling framework. The model used in this study is the Statewide Agricultural Production (SWAP) model. The SWAP model is the most current in a series of production models of California agriculture developed by researchers at the University of California at Davis under the direction of Professor Richard Howitt in collaboration with the California Department of Water Resources (DWR) with supplemental funding provided by the United States (U.S.) Department of the Interior (Interior), Bureau of Reclamation (Reclamation). The SWAP model is used to estimate changes in producer and consumer surplus to the agricultural economy in California.

22F.2 Statewide Agricultural Production (SWAP) Model

22F.2.1 Description

The SWAP model is a regional agricultural production and economic optimization model that simulates the decisions of farmers across 93 percent of agricultural land in California. The model assumes that farmers maximize profits (revenue minus cost) by choosing total input use (e.g., total crop acres) and input use intensity (e.g., applied water per acre) subject to market, resource, and technical constraints. Farmers are assumed to face competitive markets, where no one farmer can influence crop prices, but an aggregate change in production can affect crop price. This competitive market is simulated by maximizing the sum of consumer and producer surplus.

The SWAP model was developed by Professor Richard Howitt and collaborators and has been used in a wide range of policy analysis. At the time of preparation of this appendix, a documentation manuscript is under review at the *Journal of Environmental Modeling and Software* (Howitt et al., 2012). The original use for the model was to estimate the economic scarcity costs of water for agriculture in the statewide hydro-economic optimization model for water management in California, CALVIN.[1] The SWAP and CVPM models have been used for numerous policy analyses and impact studies over the past 15 years, including the impacts of the Central Valley Project Improvement Act, Upper San Joaquin Basin Storage Investigation, the SWP drought impact analysis, and the economic implications of Sacramento-San Joaquin (Delta) conveyance options. More recently, the SWAP model has been used to estimate economic losses due to salinity in the Central Valley, economic losses to agriculture in the Delta, economic losses for agriculture and confined animal operations in California's Southern Central Valley, and economic effects of water shortage to Central Valley agriculture. It is also being used in several ongoing studies of water projects and operations.

[1] CALVIN website and additional information: http://cee.engr.ucdavis.edu/CALVIN

The SWAP model estimates the changes in agricultural production using a simulation/optimization framework based on the principle of Positive Mathematical Programming (PMP) (Howitt, 1995). The model takes land allocation, input use, crop prices, yields, and costs as input and estimates how agricultural production will respond to changes in water supply, prices, costs, or other policy shocks. The benefit (or cost) of changes in water supply or other policies can be determined from the change it produces in the net value of agricultural production relative to a base (e.g., no action alternative) condition. Data have been developed, and updated under the Sites Reservoir Project (Project), to use the SWAP model for 27 homogenous agricultural regions in the Central Valley of California. Additional model data are available for agriculture along the Central Coast and Southern California, but these are omitted from this analysis.

The SWAP model was designed to be data-driven in order to easily represent different analytical circumstances without changing the model code. For example, the model can be linked to agronomic crop yield models by incorporating this information into the economic production functions. If unique situations require recoding, the source has been well documented and written with an emphasis on flexibility to facilitate different analytical needs.

22F.2.1.1 SWAP Model Theory

The SWAP model self-calibrates using a three-step procedure based on PMP (Howitt, 1995) and the assumption that farmers behave as profit-maximizing agents. In a traditional optimization model, profit-maximizing farmers would simply allocate all land, up until resource constraints become binding, to the most valuable crop(s). In other words, a traditional model would have a tendency for overspecialization in production activities relative to what is observed empirically. PMP incorporates information on the marginal production conditions that farmers face, allowing the model to exactly replicate a base year of observed input use and output. Marginal conditions may include inter-temporal effects of crop rotation, proximity to processing facilities, management skills, farm-level effects such as risk and input smoothing, and heterogeneity in soil and other physical capital. In the SWAP model, PMP is used to translate these unobservable marginal conditions, in addition to observed average conditions, into a cost function.

Unobserved marginal production conditions are incorporated into the SWAP model through increasing land costs. Additional land into production is of lower quality and, as such, requires higher production costs, captured with an exponential “PMP” cost function. The PMP cost function is both region and crop specific, reflecting differences in production across crops and heterogeneity across regions. Functions are calibrated using information from acreage response elasticities and shadow values of calibration and resource constraints. The information is incorporated in such a way that the average cost data (known data) are unaffected.

PMP is fundamentally a three-step procedure for model calibration that assumes farmers optimize input use for maximization of profits. In the first step, a linear profit-maximization program is solved. In addition to basic resource availability and non-negativity constraints, a set of calibration constraints is added to restrict land use to observed values. In the second step, the dual (shadow) values from the calibration and resource constraints are used to derive the parameters for the exponential PMP cost function and Constant Elasticity of Substitution (CES) production function. In the third step, the calibrated CES and PMP cost function are combined into a full profit maximization program. The exponential PMP cost function captures the marginal decisions of farmers through the increasing cost of bringing additional land into production (e.g., through decreasing quality). Other input costs, (supplies, land, and labor) enter linearly into the objective function in both the first and third steps. Calibrating production models using PMP has been reviewed extensively in the peer-reviewed literature. These models are widely accepted and used for policy analysis (Heckelei et al., 2012).

The SWAP model, and calibration by PMP, is a complicated process; thus, sequential testing is very useful for model validation, diagnosing problems, and debugging the model. At each stage in the SWAP model, there is a corresponding model check. In other words, the calibration procedure has particular emphasis on the sequential calibration process and a parallel set of diagnostic tests to check model performance. Diagnostic tests are discussed in Howitt et al. (2012).

22F.2.1.2 Interactions with Other Models

The SWAP model has important interactions with other models. In particular, CALSIM II, DWR’s project operations model for the SWP and the CVP, is used to estimate SWP and CVP supplies, which are inputs into SWAP. CALSIM II operates over the 1922-2003 hydrologic period, and deliveries are driven by specified target delivery quantities that the model tries to meet based on available inflows and storage on the SWP and CVP systems for each year of hydrology used. An existing linkage tool has been developed to translate CALSIM II delivery output to a corresponding SWAP input file.

Changes in depth to groundwater affect pumping costs and agricultural revenues. Changes in groundwater depth and resulting changes in groundwater pumping costs are included from CVHM model output.

The SWAP model includes endogenous sub-routines that the analyst can choose to include. These sub-routines are self-contained modules within the model and may be included/excluded without changes to a single line of code within the model. The sub-routines include crop demand shifts, technological production innovation, changes in power costs, and changes in groundwater levels and pumping costs.

The SWAP model can be linked to agronomic or hydrologic models; however, this is not the case for this analysis. In previous studies, SWAP has been linked to agronomic crop yield models to estimate effects of climate change. Additionally, SWAP has been linked to hydrologic models like CALVIN to evaluate water markets in California. The SWAP model can be used to incorporate a range of exogenous information through linkage to other models.

SWAP output can be used as part of the input to regional economic analysis using the IMPLAN model. SWAP can estimate changes in agricultural revenues, and these changes can be provided to IMPLAN. Agricultural revenue losses (or gains) translate into upstream and downstream changes in the local economy.

22F.2.1.3 Assumptions and Limitations

The SWAP model is an optimization model that makes the best (most profitable) adjustments to water supply and other changes. Constraints can be imposed to simulate restrictions on how much adjustment is possible or how fast the adjustment can realistically occur. Nevertheless, an optimization model can tend to over-adjust and minimize costs associated with detrimental changes or, similarly, maximize benefits associated with positive changes.

SWAP does not explicitly account for the dynamic nature of agricultural production; it provides a point-in-time comparison between two conditions. This is consistent with the way most economic and environmental impact analysis is conducted, but it can obscure sometimes important adjustment costs.

SWAP also does not explicitly incorporate risk or risk preferences (e.g., risk aversion) into its objective function. Risk and variability are handled in two ways. First, the calibration procedure for SWAP is designed to reproduce observed crop mix; so to the extent that crop mix incorporates risk spreading and risk aversion, the starting, calibrated SWAP base condition will also. Second, variability in water delivery, prices, yields, or other parameters can be evaluated by running the model over a sequence of conditions or over a set of conditions that characterize a distribution, such as a set of water year types.

Groundwater is an alternative source to augment SWP and CVP delivery in many subregions. The cost and availability of groundwater therefore has an important effect on how SWAP responds to changes in delivery. However, SWAP is not a groundwater model and does not include any direct way to adjust pumping lifts and unit pumping cost in response to long-run changes in pumping quantities. Economic analysis using SWAP must rely on an accompanying groundwater analysis or at least on careful specification of groundwater assumptions.

22F.2.1.4 SWAP Regions and Crop Definitions

The SWAP model has 27 base regions in the Central Valley. The current model covers agriculture in the original 21 CVPM regions, the Central Coast, the Colorado River region that includes Coachella, Palo Verde and the Imperial Valley and San Diego, Santa Ana and Ventura and the South Coast. There are a total of 37 regions in the current model, and only 27 regions in the Central Valley are considered for this analysis. Figure 22F-1 shows California agricultural area covered in SWAP. Table 22F-1 details the major water users in each of the regions.

22F.2.1.5 SWAP Data

SWAP model data include land use, crop prices, yields, input costs, water costs, use, and availability, and relevant elasticity estimates. In order to highlight the important aspects of the SWAP model inputs, data are summarized by three regions: Sacramento, North San Joaquin, and South San Joaquin. All input data were reviewed and, where applicable, updated under this analysis. The current version of the model (6.0) calibrates to land use data for 2005. DWR is in the process of developing more detailed annual time series data on agricultural land use, but the current version of the SWAP model calibrates to 2005 as a relatively normal base year.

Crop yields and production costs are from current University of California Cooperative Extension (UCCE) Crop Budgets, and crop prices are from County Crop Reports prepared by Agricultural Commissioners in each county. The UCCE Crop Budgets are designed based on best, or at least above average, management practices for a representative field. This is reflected in the descriptive text accompanying the published budgets, and was verified by personal communication with UCCE specialists. For example, yields used in the crop budgets' net return analysis are determined based on the extension specialist's knowledge and judgment, and represent good growing conditions and best management practices. In contrast, crop prices and yields reported by Agricultural Commissioners represent average conditions and practices; thus, yields are average for the county, and are generally lower than those used in the Crop Budgets.

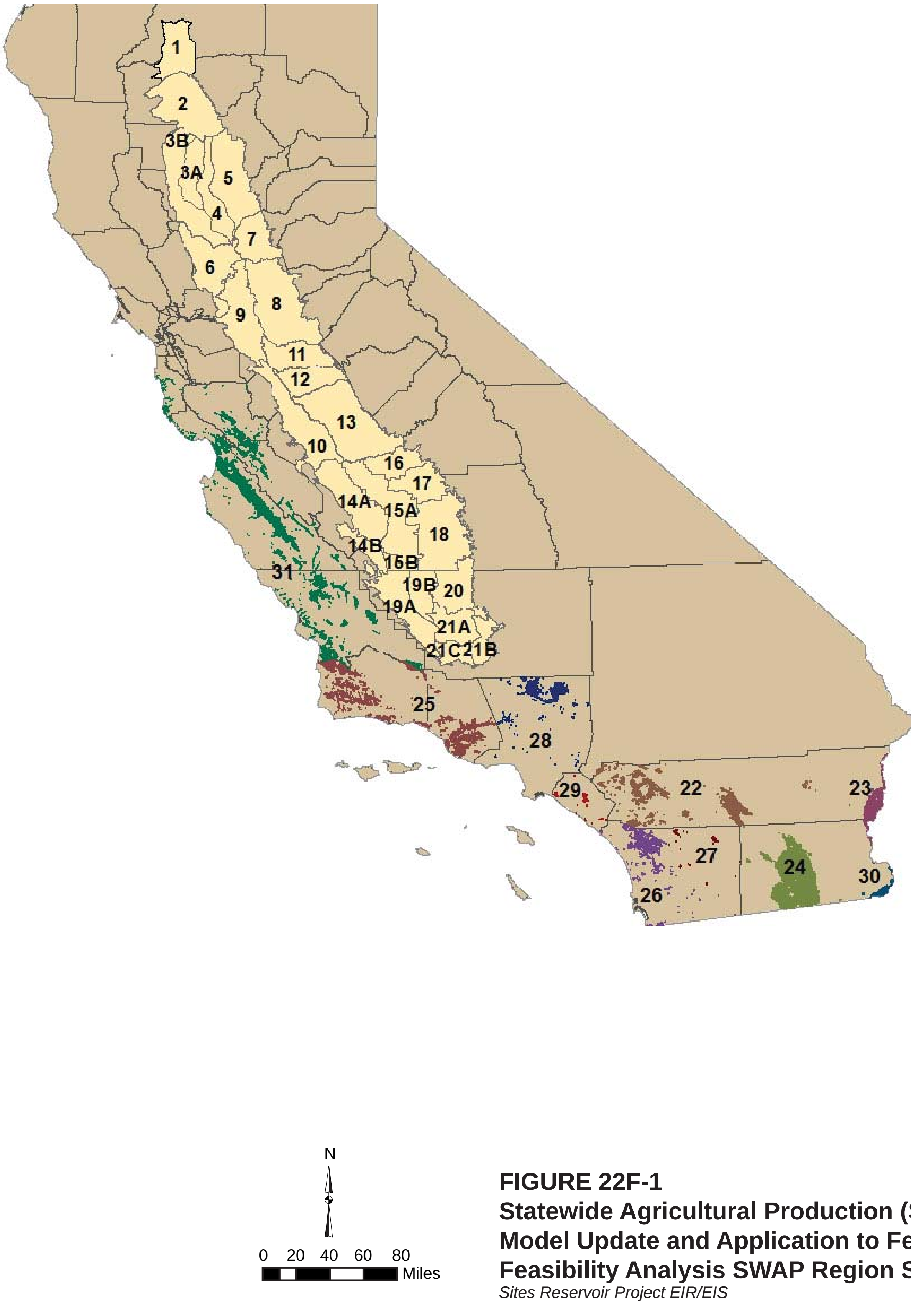

FIGURE 22F-1
Statewide Agricultural Production (SWAP) Model Update and Application to Federal Feasibility Analysis SWAP Region Summary
Sites Reservoir Project EIR/EIS

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Table 22F-1
SWAP Coverage of Agriculture in California
Agricultural Supply Economics Modeling

SWAP Region	Major Surface Water Users
1	CVP Users: Anderson Cottonwood I.D., Clear Creek C.S.D., Bella Vista W.D., and miscellaneous Sacramento River water users.
2	CVP Users: Corning Canal, Kirkwood W.D., Tehama, and miscellaneous Sacramento River water users.
3a	CVP Users: Glenn Colusa I.D., Provident I.D., Princeton-Codora I.D., Maxwell I.D., and Colusa Basin Drain M.W.C.
3b	Tehama Colusa Canal Service Area. CVP Users: Orland-Artois W.D., most of Colusa County, Davis W.D., Dunnigan W.D., Glide W.D., Kanawha W.D., La Grande W.D., and Westside W.D.
4	CVP Users: Princeton-Codora-Glenn I.D., Colusa Irrigation Co., Meridian Farm W.C., Pelger Mutual W.C., Reclamation District 1004, Reclamation District 108, Roberts Ditch I.C., Sartain M.D., Sutter M.W.C., Swinford Tract I.C., Tisdale Irrigation and Drainage Co., and miscellaneous Sacramento River water users.
5	Most Feather River Region riparian and appropriative users.
6	Yolo and Solano counties. CVP Users: Conaway Ranch and miscellaneous Sacramento River water users.
7	Sacramento County north of American River. CVP Users: Natomas Central M.W.C., miscellaneous Sacramento River water users, Pleasant Grove-Verona W.M.C., and Placer County W.A.
8	Sacramento County south of American River and northern San Joaquin County.
9	Direct diverters within the Delta region. CVP Users: Banta Carbona I.D., West Side W.D., and Plainview.
10	Delta Mendota service area. CVP Users: Panoche W.D., Pacheco W.D., Del Puerto W.D., Hospital W.D., Sunflower W.D., West Stanislaus W.D., Mustang W.D., Orestimba W.D., Patterson W.D., Foothill W.D., San Luis W.D., Broadview, Eagle Field W.D., Mercy Springs W.D., San Joaquin River Exchange Contractors.
11	Stanislaus River water rights: Modesto I.D., Oakdale I.D., and South San Joaquin I.D.
12	Turlock I.D.
13	Merced I.D. CVP Users: Madera I.D., Chowchilla W.D., and Gravely Ford.
14a	CVP Users: Westlands W.D.
14b	Southwest corner of Kings County
15a	Tulare Lake Bed. CVP Users: Fresno Slough W.D., James I.D., Tranquility I.D., Traction Ranch, Laguna W.D., and Reclamation District 1606.
15b	Dudley Ridge W.D. and Devils Den (Castaic Lake)
16	Eastern Fresno County. CVP Users: Friant-Kern Canal, Fresno I.D., Garfield W.D., and International W.D.
17	CVP Users: Friant-Kern Canal, Hills Valley I.D., Tri-Valley W.D., and Orange Cove.
18	CVP Users: Friant-Kern Canal, County of Fresno, Lower Tule River I.D., Pixley I.D., portion of Rag Gulch W.D., Ducor, County of Tulare, most of Delano-Earlimart I.D., Exeter I.D., Ivanhoe I.D., Lewis Creek W.D., Lindmore I.D., Lindsay-Strathmore I.D., Porterville I.D., Sausalito I.D., Stone Corral I.D., Tea Pot Dome W.D., Terra Bella I.D., and Tulare I.D.
19a	SWP Service Area, including Belridge W.S.D., Berrenda Mesa W.D.
19b	SWP Service Area, including Semitropic W.S.D
20	CVP Users: Friant-Kern Canal. Shafter-Wasco, and South San Joaquin I.D.
21a	CVP Users: Cross Valley Canal and Friant-Kern Canal
21b	Arvin Edison W.D.

SWAP Region	Major Surface Water Users
21c	SWP service area: Wheeler Ridge-Maricopa W.S.D.
23-30	Central Coast, Desert, and Southern California

Note:

This list does not include all water users. It is intended only to indicate the major users or categories of users. All regions in the Central Valley also include private groundwater pumpers.

Using production costs from UCCE Crop Budgets (which are above average) together with average prices and yields reported in the County Agricultural Commissioner reports will generally lead to lower net returns than would be representative of California growers and, in some cases, results in negative net returns. Hence, policy analysis under this approach would be biased. More importantly, the SWAP model is designed to replicate actual growing conditions. To accurately estimate expected project benefits, UCCE Crop Budgets are used for both costs and yields, with prices still drawn from county averages reported in the Agricultural Commissioner crop reports. Under this approach, policy analysis reflects the net farm income that can be attained if extension specialists' recommendations were followed. This can result in both revenues and costs that are somewhat higher than average for a region, but that is more acceptable than systematically underestimating net revenues (benefits).

22F.2.1.6 SWAP Land Use Data

Crops are aggregated into 20 crop groups that are the same across all regions. Each crop group represents a number of individual crops, but many are dominated by a single crop. Irrigated acres represent acreage of all crops within the group, and production costs and returns are represented by a single proxy crop for each group. A proxy crop is used because UCCE budgets are only available for select crops and, as such, production data are not available for every crop group. The current 20 crop groups were defined in collaboration with DWR and updated in March 2011. For each group, the representative (proxy) crop is chosen based on four criteria: (i) a detailed production budget is available from U.C. Cooperative Extension, (ii) it is the largest or one of the largest acreages within a group, (iii) its water use (applied water) is representative of water use of all crops in the group, and (iv) its gross and net returns per acre are representative of the crops in the group. The relative importance of these criteria varies by crop. Crop group definitions and the corresponding proxy crop are shown in Table 22F-2.

Table 22F-2
SWAP Crop Groups
Agricultural Supply Economics Modeling

SWAP Definition	Proxy Crop	Other Crops
Almonds and Pistachios	Almonds	Pistachios
Alfalfa	Alfalfa Hay	
Corn	Grain Corn	Corn Silage
Cotton	Pima Cotton	Upland Cotton
Cucurbits	Summer Squash	Melons, Cucumbers, Pumpkins
Dry Beans	Dry Beans	Lima Beans
Fresh Tomatoes	Fresh Tomatoes	
Grain	Wheat	Oats, Sorghum, Barley
Onions and Garlic	Dry Onions	Fresh Onions, Garlic
Other Deciduous	Walnuts	Peaches, Plums, Apples

SWAP Definition	Proxy Crop	Other Crops
Other Field	Sudan Grass Hay	Other Silage
Other Truck	Broccoli	Carrots, Peppers, Lettuce, Other Vegetables
Pasture	Irrigated Pasture	
Potatoes	White Potatoes	
Processing Tomatoes	Processing Tomatoes	
Rice	Rice	
Safflower	Safflower	
Sugar Beet	Sugar Beets	
Subtropical	Oranges	Lemons, Misc. Citrus, Olives
Vine	Wine Grapes	Table Grapes, Raisins

The SWAP model calibrates to a base year of observed land use, 2005. The SWAP model includes 37 individual SWAP regions. Regions 1-21C represent the Central Valley, and 2005 land use data were prepared by analysts at DWR. DWR develops land use estimates for small regions that it calls Detailed Analysis Units (DAU). These are aggregated within a GIS to create land use for the individual SWAP regions, and further aggregated to the larger hydrologic regions that DWR reports in the California Water Plan Update (2009). Table 22F-3 summarizes land use in 2005 by Central Valley regions.

Table 22F-3
Crop Acreage in 2005
Agricultural Supply Economics Modeling

Crop Group	Sacramento	North SJV	South SJV	Crop Group	Sacramento	North SJV	South SJV
Alfalfa	180,140	167,350	351,900	Other Field	67,030	138,940	228,000
Almonds/Pistachios	150,050	328,340	325,600	Other Truck	32,990	52,950	123,600
Corn	165,800	176,890	326,400	Pasture	162,920	123,860	20,600
Cotton	6,090	115,100	542,800	Potato	1,860	100	23,300
Cucurbits	34,470	23,610	33,500	Processing Tomatoes	130,020	52,890	119,500
Dry Bean	32,730	15,920	13,700	Rice	552,110	12,710	0
Fresh Tomatoes	12,070	16,530	9,900	Safflower	41,740	2,200	5,100
Grain	152,910	30,030	181,700	Sugar Beet	0	7,900	13,100
Onions/Garlic	2,200	4,920	38,100	Sub-tropical	28,350	6,760	212,400
Other Deciduous	305,530	86,340	209,500	Grapes	138,370	114,470	339,400

Source: DWR, 2009.

22F.2.1.7 SWAP Crop Price Data

The SWAP model is designed to represent actual conditions growers faced in 2005. Growers make current planting decisions based on expectations of prices. The SWAP model does not attempt to model how growers form their price expectations; as an approximation, SWAP uses a 3-year simple average of county-level crop prices. Three-year 2005 to 2007 averages of crop prices are calculated using the counties in each of the three Central Valley regions within SWAP: Sacramento, North San Joaquin, and South San Joaquin. Crop prices for each of the SWAP regions within the Central Valley correspond to one of these three areas.

Data for county-level crop prices are obtained from the respective County Agricultural Commissioners' annual crop reports. These are compiled and released by the U.S. Department of Agriculture annually. Data are summarized by crop and Central Valley region in Table 22F-4.

Table 22F-4
Crop Price per Ton (2005 dollars)
Agricultural Supply Economics Modeling

Crop Group	Sacramento	North SJV	South SJV	Crop Group	Sacramento	North SJV	South SJV
Alfalfa	132.19	157.28	152.28	Other Field	141.84	141.84	141.84
Almonds/Pistachios	4234.96	4226.68	4258.90	Other Truck	582.00	582.00	582.00
Corn	121.04	156.06	156.06	Pasture	220.00	220.00	220.00
Cotton	2016.50	2016.50	2016.50	Potato	224.60	224.60	224.60
Cucurbits	464.10	464.10	464.10	Processing Tomatoes	51.10	52.25	53.80
Dry Bean	796.73	778.92	758.19	Rice	245.66	220.87	222.40
Fresh Tomatoes	463.65	463.65	560.60	Safflower	299.41	315.56	315.56
Grain	142.68	162.69	163.00	Sugar Beet	41.50	41.50	41.50
Onions/Garlic	600.90	600.90	600.90	Sub-tropical	452.10	452.10	452.10
Other Deciduous	1502.47	1601.28	1674.88	Grapes	610.00	610.00	610.00

Source: County Agricultural Commissioners, various years.

22F.2.1.8 SWAP Crop Yields

Crop yields for each crop group in the SWAP model correspond to the proxy crops and are based on best management practices. The corresponding costs of production, discussed previously, are based on cost studies that also reflect best management practices. Thus, crop yields in SWAP are slightly higher than those estimated by calculating county averages, but are more consistent with the production costs.

Crop yield data are compiled from the UCCE production cost budgets prepared by University of California at Davis and Extension Researchers. Yields for each region are based on the most recent proxy crop cost study available in the closest region. For example, if a cost study is not available for a particular crop in the Sacramento Valley, the North San Joaquin Valley study may be used. Crop yield data are summarized by crop and Central Valley region in Table 22F-5.

Table 22F-5
Crop Yield in Tons per acre
Agricultural Supply Economics Modeling

Crop Group	Sacramento	North SJV	South SJV	Crop Group	Sacramento	North SJV	South SJV
Alfalfa	7.00	8.00	8.00	Other Field	6.50	6.50	6.50
Almonds/Pistachios	1.10	1.00	1.40	Other Truck	6.53	6.53	6.53
Corn	6.50	6.57	6.55	Pasture	2.50	2.50	2.50
Cotton	0.63	0.58	0.58	Potato	25.00	25.00	25.00
Cucurbits	16.80	16.80	16.80	Processing Tomatoes	35.00	40.00	40.00
Dry Bean	1.25	1.25	1.25	Rice	5.00	5.00	5.00
Fresh Tomatoes	13.00	13.00	13.00	Safflower	1.30	1.30	1.55
Grain	3.00	3.25	3.28	Sugar Beet	42.00	42.00	42.00
Onions/Garlic	13.00	13.00	13.00	Sub-tropical	12.20	12.20	13.13
Other Deciduous	2.70	2.70	2.70	Grapes	7.00	6.50	6.50

Source: UCCE, various years.

22F.2.1.9 SWAP Interest Rates and Land Costs

Each UCCE budget uses interest rates for capital recovery and interest on operating capital specific to the year of the study. These range from 4 percent to over 8 percent and, as such, require adjustment to a common base year interest rate. Since the SWAP model is designed to replicate base 2005 conditions, interest rates are adjusted to reflect conditions in 2005.

Capital costs are currently included in the SWAP input data as annual capital recovery values in "other supply costs." Capital recovery costs are the annual costs of interest and depreciation on capital investments. For each capital investment, the UCCE budget estimates the purchase price, useful life of the equipment, and salvage value. A scaling of 60 percent is used to reflect a mix of new and used equipment. The sum across all capital investments represents the total capital recovery costs. The interest portion of the capital recovery is adjusted to a rate of 6.25 percent, based on interest rates used in UCCE budgets prepared in 2005. No adjustments are made to the other components of the capital recovery cost calculation.

Interest on operating capital is the interest paid on money used for annual operating costs, such as purchase of seed, fertilizer, and fuel. It is included as part of the other supply costs within SWAP input data. The UCCE crop budgets use a nominal interest rate, which reflects the typical market rate for the year the budget represents. For use in SWAP, the interest on operating capital is adjusted to a rate of 6.25 percent, based on rates used in UCCE budgets prepared in 2005.

Land costs are derived from the respective UCCE crop budget, and include land-related cash overhead plus rent and land capital recovery costs. Where appropriate, interest rates are adjusted as described above. Table 22F-6 summarizes the land costs in SWAP, in 2005 dollars, by Central Valley region.

Land-related cash overhead includes office expenses, taxes, insurance, management salaries, and other land-specific cash expenses. For some budgets, this includes a portion of the farm that is rented. For these budgets, this expense is included in the cash overhead category; thus, no interest rate adjustment is necessary. As such, it is grouped into the land-related cash overhead component of land costs.

Land capital recovery cost corresponds to the rent value of the land, as calculated by the capital recovery cost of the land. This category is adjusted to reflect a consistent interest rate of 6.25 percent.

The land input costs are based on the UCCE crop budgets, and reflect the assumptions contained in these budgets. For example, grain (wheat as the proxy budget) in the Sacramento Valley is based on a hypothetical 2,900-acre farm that cultivates field and row crops. On the farm, 900 acres are planted to wheat, which are part of a tomato-, alfalfa-, safflower-, corn-based rotation. The assumptions for the hypothetical farm differ by crop and region. Different assumptions may alter the costs of production; however, the UCCE budgets represent the common best management practices in the region.

Table 22F-6
Land Costs per Acre (2005 dollars)
Agricultural Supply Economics Modeling

Crop Group	Sacramento	North SJV	South SJV	Crop Group	Sacramento	North SJV	South SJV
Alfalfa	249	317	317	Other Field	180	180	180
Almonds/Pistachios	453	812	515	Other Truck	220	220	220
Corn	181	168	168	Pasture	92	92	92
Cotton	196	217	217	Potato	680	680	680
Cucurbits	204	204	204	Processing Tomatoes	344	298	298
Dry Bean	154	209	209	Rice	269	269	269
Fresh Tomatoes	308	308	308	Safflower	102	102	102
Grain	95	194	194	Sugar Beet	149	149	149
Onions/Garlic	336	336	336	Sub-tropical	612	612	612
Other Deciduous	526	526	526	Grapes	1,024	1,352	1,352

Source: UCCE, various years.

22F.2.1.10 Other Supply and Labor Costs

Supplies are one of four production inputs into the SWAP model. This category includes all inputs not explicitly included in the other three input categories (land, labor, and water), including fertilizers, herbicides, insecticide, fungicide, rodenticide, seed, fuel, and custom costs. Additionally, machinery, establishment costs, buildings, and irrigation system capital recovery costs are included.

Each sub-category of supply costs is broken down in detail in the respective crop budget. For example, safflower in the Sacramento Valley requires pre-plant Nitrogen as aqua ammonia at 100 pounds per acre in fertilizer costs. Application of Roundup in February and Treflan in March account for herbicide costs. The sum of these individual components, on a per-acre basis, is used as base supply input cost data in the SWAP model.

The supply input costs are based on the UCCE cost of production budgets and, as such, reflect the assumptions contained in these budgets. Different assumptions may alter the costs of production; however, the UCCE budgets represent common best management practices in the region.

Table 22F-7 summarizes supply costs per acre, in 2005 dollars, by Central Valley region.

Labor is one of four production inputs into the SWAP model. This category includes both machine and non-machine labor.

Labor wages per hour differ for machine and non-machine labor and, as such, are reported separately in the UCCE budgets. Both machine and non-machine labor costs include overhead to the farmer of federal and state payroll taxes, workers' compensation, and a small percentage for other benefits, which varies by budget. Additionally, a percentage premium (typically around 20 percent) is added to machine labor costs to account for equipment setup, moving, maintenance, breaks, and field repair. The sum of these components, reported on a per-acre basis, is used as input data into the SWAP model.

Table 22F-7
Other Supply Costs per Acre (2005 dollars)
Agricultural Supply Economics Modeling

Crop Group	Sacramento	North SJV	South SJV	Crop Group	Sacramento	North SJV	South SJV
Alfalfa	414	544	544	Other Field	465	465	465
Almonds/Pistachios	1,900	1,678	1,607	Other Truck	3,215	3,215	3,215
Corn	329	531	531	Pasture	138	138	138
Cotton	697	538	538	Potato	1,568	1,568	1,568
Cucurbits	2,919	2,919	2,919	Processing Tomatoes	840	1,200	1,200
Dry Bean	397	423	423	Rice	556	556	556
Fresh Tomatoes	4,480	4,480	4,480	Safflower	121	121	121
Grain	227	278	278	Sugar Beet	779	779	779
Onions/Garlic	2,625	2,625	2,625	Sub-tropical	4,333	4,333	4,333
Other Deciduous	1,427	1,427	1,427	Grapes	1,627	1,479	1,479

The labor input costs are based on the UCCE cost of production budgets and, as such, reflect the assumptions contained in these budgets. Different assumptions may alter the costs of production; however, the UCCE budgets represent common best management practices in the region.

Table 22F-8 summarizes labor costs in the SWAP model by Central Valley region.

Table 22F-8
Labor Costs per Acre (2005 dollars)
Agricultural Supply Economics Modeling

Crop Group	Sacramento	North SJV	South SJV	Crop Group	Sacramento	North SJV	South SJV
Alfalfa	18	21	21	Other Field	14	14	14
Almonds/Pistachios	274	318	107	Other Truck	207	207	207
Corn	101	50	50	Pasture	24	24	24
Cotton	130	199	199	Potato	410	410	410
Cucurbits	4,339	4,339	4,339	Processing Tomatoes	373	276	276
Dry Bean	106	55	55	Rice	81	81	81
Fresh Tomatoes	143	143	143	Safflower	35	35	35
Grain	33	14	14	Sugar Beet	65	65	65
Onions/Garlic	682	682	682	Sub-tropical	239	239	239
Other Deciduous	223	223	223	Grapes	828	756	756

Source: UCCE, various years.

22F.2.1.11 Surface and Groundwater Costs

SWAP includes five types of surface water: SWP delivery, three categories of CVP delivery, and local surface water delivery or direct diversion (LOC). The three categories of CVP deliveries are: water service contract, including Friant Class 1 (CVP1); Friant Class 2 (CL2); and water rights settlement and exchange delivery (CVPS)[2].

[2] CVP Settlement water is delivered to districts and individuals in the Sacramento Valley based on their pre-CVP water rights on the Sacramento River, and San Joaquin River Exchange water is pumped from the Delta and delivered to four districts in the San

CVP and SWP water costs have two components, a project charge and a district charge. The sum of these components is the region-specific cost of the individual water source.

Over time, the goal is to identify these components of costs for all applicable regions within the SWAP data. The current version of SWAP is capable of handling the water cost components; however, the data, especially district charges, are not available. The surface water cost data gathered for the current version of SWAP represent total costs to growers, but are not broken into the two components.

Table 22F-9 summarizes surface water costs by source, averaged across SWAP regions in the three Central Valley regions.

Table 22F-9
Surface Water Costs in SWAP ($ per acre-foot)
Agricultural Supply Economics Modeling

Source	CVP1	CVPS	CL2	SWP	LOC
Sac	23.53	13.45	14.75	23.25	14.15
NSJV	31.63	15.00	28.00	45.38	16.56
SSJV	60.46	15.00	28.00	67.00	43.92

Source: Reclamation, various years(a); Reclamation, various years(b); DWR, 2008; and various individual district reports. For further information regarding the information cited here, please contact the California Department of Water Resources, Economic Analysis Section, Section Supervisor.

A key source of irrigation water, and often the most costly, is groundwater pumping. Groundwater pumping costs are broken out into fixed, energy, and operations and maintenance (O&M) components in the SWAP model. Energy and O&M components are variable. This breakdown and cost update was completed in May.

Pumping costs are calculated as two components, the fixed cost per acre-foot based on typical well designs and costs within the region, plus the variable cost per acre-foot. The variable cost per acre-foot is O&M plus energy costs based on average total dynamic lift within the region.

Energy costs depend on the price of electricity. Power costs can be varied by region and according to the time horizon of the relevant analysis depending on the projected cost of power. The current version of SWAP uses the same unit cost of electricity per kilowatt-hour across all regions. Base electricity costs are derived from PG&E rate books and consultation with power officials at the Fresno, California, office. Energy cost is 18.9 cents per kilowatt-hour, which is an average of PG&E's AG-1B and AG-4B rates. Overall well efficiency is assumed to be 70 percent.

The total dynamic lift (TDL) for each region is in feet, and includes both static lift and additional dynamic drawdown when pumps are operating. Total dynamic lift varies by region and water-year type on SWAP. Thus, in dry years groundwater pumping costs per acre-foot increase due to an increase in depth to groundwater, plus additional drawdown caused by greater regional pumping rates. Base groundwater depth (static pumping lift) estimates are from the CVPM model, which in turn were provided by the Central Valley Groundwater-Surface Water Model (CVGSM). For scenario and projections analysis, changes in groundwater depths must be provided by external analysis, such as a groundwater model. SWAP itself does not project changes in groundwater storage and depth.

Joaquin Valley in exchange for water rights diversion eliminated when Friant Dam was constructed. These two delivery categories are geographically distinct but for convenience are combined into one water supply category in SWAP.

Table 22F-10 summarizes components of groundwater pumping costs by Central Valley region.

Table 22F-10
Groundwater Cost Components in SWAP
Agricultural Supply Economics Modeling

Source	Fixed Cost ($/acre-foot)	TDL (feet)	Efficiency (%)	$/Kwh
Sac	19.80	80.87	0.7	0.189
NSJV	27.00	88.92	0.7	0.189
SSJV	34.85	222.72	0.7	0.189

Source: PG&E, various years; and various individual district reports. For further information regarding the information cited here, please contact the California Department of Water Resources, Economic Analysis Section, Section Supervisor.

22F.2.1.12 Crop Water Requirements (Applied Water per Acre)

Applied water is the amount of water applied by the irrigation system to an acre of a given crop for production in a typical year. Variation in rainfall and other climate effects will alter this requirement. Additionally, farmers may stress irrigate crops or substitute other inputs in order to reduce applied water. The latter effect is handled endogenously by the SWAP model through the respective CES production functions.

Applied water per acre (base) requirements for crops in the SWAP model are derived from DWR estimates. DWR estimates are based on Detailed Analysis Units (DAU). An average of DAUs within a SWAP region is used to generate a SWAP region specific estimate of applied water per acre for SWAP crops.

Table 22F-11 summarizes applied water per acre by crop and Central Valley region.

Table 22F-11
Applied Water (acre-feet per Acre)
Agricultural Supply Economics Modeling

Crop Group	Sacramento	North SJV	South SJV	Crop Group	Sacramento	North SJV	South SJV
Alfalfa	4.11	4.84	3.56	Other Field	2.23	2.86	2.27
Almonds/Pistachios	3.12	4.07	3.22	Other Truck	2.11	0.93	0.81
Corn	2.48	2.74	2.30	Pasture	4.27	4.84	3.88
Cotton	2.98	3.43	2.52	Potato	0.00	1.41	n/a
Cucurbits	1.27	2.01	1.36	Processing Tomatoes	2.49	2.60	1.84
Dry Bean	2.03	2.60	1.83	Rice	4.84	8.00	n/a
Fresh Tomatoes	2.75	2.03	1.23	Safflower	0.77	1.89	1.65
Grain	0.75	0.79	1.01	Sugar Beet	n/a	3.5	4.09
Onions/Garlic	3.14	3.58	2.19	Sub-tropical	2.29	2.98	2.84
Other Deciduous	3.01	3.47	3.60	Grapes	1.53	2.89	2.12

Source: DWR, 2009

22F.2.1.13 Regional Water Constraints

Regional water constraints vary under each alternative. Base water availability, by region, is discussed here.

CVP water deliveries were derived from Reclamation operations data. Contract deliveries were obtained from Reclamation; the difference between total and contract deliveries indicates deliveries for water rights settlements.

SWP water deliveries are obtained from DWR Bulletin 132 (DWR, 2008). Kern County Water Agency provides additional details on SWP deliveries to member agencies by region.

Local surface water deliveries were obtained from individual district records and reports, DWR water balance estimates prepared for the California Water Plan Update (DWR, 2009), and where needed, data from the CVPM model. CVPM data were, in turn, provided by CVGSM.

Groundwater pumping capacity estimates are from a 2009 analysis by DWR in consultation with individual districts. Groundwater pumping capacity is intended to represent the maximum that a region can pump in a year given the aquifer characteristics and existing well capacities. For long run analysis, additional pumping capacity could be installed, but careful groundwater analysis should be made to determine hydraulic feasibility. If groundwater analysis is not available, existing capacity constraints are assumed to hold.

Table 22F-12 summarizes available regional water supply, in TAF, by water supply classification.

Table 22F-12
Available Water by Source (thousand acre-feet)
Agricultural Supply Economics Modeling

Source	CVP1	CVPS	CL2	SWP	LOC	GW
Sac	409.47	1323.23	0.00	0.00	3320.30	2537.90
NSJV	370.09	768.20	78.61	3.90	2312.70	1245.00
SSJV	1959.81	0.00	197.85	1372.90	2844.20	3116.30

Source: Reclamation, various years(a), and DWR, 2008. Local supplies (LOC) are from various individual district reports and Groundwater (GW) is from a 2009 internal unpublished study by DWR analysts. For further information regarding the information cited here, please contact the California Department of Water Resources, Economic Analysis Section, Section Supervisor.

22F.2.1.14 SWAP Model Elasticities

SWAP uses a number of economic response parameters, called elasticities, to estimate rates of change in variables. An elasticity is the percent change in a variable, per unit of percent change in another variable or parameter. Acreage response elasticity is one component of supply response. It is the percentage change in acreage of a crop from a 1 percent change in that crop’s price. The SWAP model contains both long- and short-run estimates, and the analyst decides which of the elasticities to use. Long-run acreage response elasticities are used for this analysis.

Income, own price, and population elasticities govern the shape of the crop-specific demand functions and the nature of demand shifts over time. Own price elasticities of demand were updated in 2009 based on a survey of recent literature (Green et al., 2006). Population elasticities are assumed at unity. Income elasticity estimates are from Green et al. (2006).

Under specific conditions, not satisfied here, the price flexibility is the reciprocal of the absolute lower-bound own-price elasticity (Houck, 1965). The price flexibility is used to calibrate the individual crop demand functions.

Table 22F-13 summarizes the elasticities used in the SWAP model.

Table 22F-13
Various Elasticities by Crop Group
Agricultural Supply Economics Modeling

Crop Group	Flexibility	Income	Population	Own Price	Acreage Response LR	Acreage Response SR
ALFAL	-0.50	0.20	1.00	-0.86	0.51	0.24
ALPIS	-0.70	0.51	1.00	-1.20	0.11	0.03
CORN	0.00	0.00	1.00	0.00	0.45	0.21
COTTN	-0.05	0.05	1.00	-0.95	0.64	0.36
CUCUR	-0.20	0.99	1.00	-0.16	0.05	0.05
DRYBN	-0.20	0.20	1.00	-0.86	0.17	0.13
FRTOM	-0.62	0.89	1.00	-0.25	0.31	0.16
GRAIN	0.00	0.00	1.00	0.00	0.38	0.36
ONGAR	-0.21	0.99	1.00	-0.16	0.19	0.11
OTHDEC	-0.25	0.50	1.00	-1.25	0.11	0.03
OTHFLD	-0.20	0.20	1.00	-0.86	1.89	0.63
OTHTRK	-0.20	0.99	1.00	-0.16	0.19	0.11
PASTR	-0.50	0.00	1.00	0.00	0.51	0.24
POTATO	-0.10	0.20	1.00	-0.16	0.19	0.11
PRTOM	-0.17	0.89	1.00	-0.25	0.28	0.15
RICE	-0.05	0.00	1.00	0.00	0.96	0.96
SAFLR	-0.20	0.20	1.00	-0.86	0.34	0.34
SBEET	-0.10	0.00	1.00	0.00	0.19	0.11
SUBTRP	-0.80	0.50	1.00	-1.25	0.50	0.30
VINE	-0.80	0.51	1.00	-0.28	0.11	0.03

22F.2.2 Modules for Policy Analysis (Levels of Development)

The SWAP model includes a number of endogenous routines to project future economic conditions. Future economic conditions such as changing crop prices, technological innovation, and increased urban development are expected to affect the future of agricultural production in California.

22F.2.2.1 Crop Demand Shifts

Crop demands are expected to shift in the future due to increased population, higher real incomes, changes in tastes and preferences, and related factors. The key changes that are included in this analysis are population and real income. An increase in real income is expected to increase demand for agricultural products. Similarly, population increase is expected to increase crop demand. Changes in consumer tastes and preferences will have an indeterminate effect on demand and are not included in this analysis.

The analysis is concerned with California agriculture and, as such, it is necessary to consider the entire market for California crops, which includes international exports. Increases in demand for crops produced in California may be partially offset by other production regions depending on changing export market conditions. For example, today California is the dominant producer of almonds but this may change if other regions in the U.S. or the world increase production. Thus an increase in almond demand could be partially met by other regions. However, additional demand growth from markets like China may offset this effect. The net effect is indeterminate. In the absence of data or studies demonstrating which effect would dominate, California export share is assumed to remain constant for all crops in the future. This is a key assumption that is consistent with peer-reviewed publications for the California Energy Commission and the academic journal *Climatic Change* in addition to the 2009 California Department of Water Resources Water Plan (Howitt et al., 2009a; Howitt et al., 2009b).

Crop demands are linear in the SWAP model, and population and real income changes induce a parallel shift in demand. Demand shifts are included for all of the alternative scenarios evaluated for this Project, including the No Action Alternative. Consequently, benefits estimates that compare No Action to one of the Action Alternatives compare identical future market conditions. We perform sensitivity analysis to estimate benefits with and without demand shifts.

For purposes of the demand shift analysis, a distinction is made between two types of crops grown in California: California specific crops and global commodities. Global commodity crops include grain, rice, and corn[3]; all other crop groups are classified as California crops. Global commodity crops are those for which there is no separate demand for California's production. For these crops, California faces a perfectly elastic demand, and is thus a price taker. This analysis does not consider the international trade market for these crops; it is assumed that California's export share will continue to remain small in the future. For California specific crops, California faces a downward sloping demand for a market that is driven by conditions in the United States and international export markets. Since we hold California's export share and international market conditions constant, we are able to estimate shifts based solely on United States conditions. This analysis does not model changes in tastes and preferences, only the shift in demand for these crops that will result from increasing population and real income. A routine in the SWAP model calculates the demand shift depending on the year of the analysis (2025 or 2060).

Since California is a small proportion of global production for commodity crops, the only necessary information to estimate the shift in future demand is the long run trend in real prices. Formally, this analysis assumes that California will retain its small share of the global market for these crops. The derivation of the demand shift equations can be found in Howitt et al. (2012).

We are aware that the assumption of constant export share and international market conditions is strong. As such, we perform sensitivity analysis and run the model with and without demand shifts. In an internal report, we find that total National Economic Development benefits decrease by less than 1.5 percent when demand shifts are not included in the analysis.

22F.2.2.2 Technological Change

Since WWII, crop yields have been increasing for most crops due to technological innovations. Innovations like hybrid seeds, better chemicals and fertilizer, improved pest management, and irrigation and mechanical harvesting advances are some examples. The expected future rate of growth in crop yields is a contentious topic among researchers. One argument is that yield increases have already started to level off and, at the same time, spending on agricultural research and development (R&D) has started to decrease. Thus yield increases are expected to level off in the future as R&D spending continues to decline. Alternatively, some researchers argue that yields are continuing to trend upward and there are

[3] Rice demand is very elastic but not perfectly elastic. For purposes of the demand shifting analysis, it is assumed to be perfectly elastic.

many opportunities for further increases, even with limited spending on R&D. There is no general consensus on the expected rate of yield growth in the future, both within California and globally.

For this analysis, the Principles and Guidelines allows for yield increases with several caveats. The most important requirement is that if yields increase, the cost of R&D needs to be incorporated. Furthermore, higher production costs need to be incorporated. No reliable and consistent data are available on the costs of R&D or expected production costs with higher yields; thus, this is omitted from the analysis.

It is important to note that the SWAP model does allow for some yield response to changing market conditions. This effect is referred to as endogenous yield changes. The SWAP model includes full CES production functions for each crop and region. As such, there is some endogenous yield change in response to changing market conditions. For example, the SWAP model allows for more inputs (e.g., labor, supplies, and water) to be applied to existing land in order to increase yields. The relationship between inputs and yield varies by crop and region. Each relationship is determined in the PMP routine and based on empirical data. The ability to adjust input use and generate marginally higher yields is consistent with observed practices. In general, this is plus/minus a few percentage points from the mean yield. Note that this is separate from technological (exogenous) yield change. There is no exogenous technological change included in this analysis.

Technological change is omitted from this analysis while demand shifts are incorporated. This means all of the increase in demand will be met with some combination of additional inputs applied to existing land (endogenous yield increases), additional land into production, and shifting crop mix. Supply response to higher prices is typically composed of several components, the largest of which include acreage and yield response. Exogenous technological change is not incorporated in the analysis, so endogenous yield effects and acreage responses may be overstated.

22F.2.2.3 Groundwater Pumping Power Costs

Groundwater pumping is typically the most expensive water supply. Real power costs are expected to increase in the future, and groundwater pumping relies heavily on the cost of electricity. SWAP model input data were updated under this analysis in order to break down groundwater pumping costs into fixed capital, energy, and O&M components. Energy pumping costs are escalated according to future marginal power cost estimates.

For this analysis, there are two future scenarios considered for each of the alternatives: 2025 and 2060. As such, a marginal power cost escalator is determined for each year and applied to the energy cost component of groundwater costs. The cost escalator is the ratio of the expected future power cost in 2025 or 2060 to the base power cost in 2005, in 2005 $/megawatt hour.

The power cost escalator for 2025 is 1.45. Power costs are expected to increase by 45 percent in real terms by 2025. The power cost escalator for 2060 is 2.24. Power costs are expected to more than double in real terms by 2060.

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Appendix 22D
Urban Water Supply Economics Modeling

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APPENDIX 22D
Urban Water Supply Economics Modeling

22D.1 Introduction

Economic impacts, including benefits and costs, occur with changes in amount of municipal and industrial (M&I) water supply. For areas served by the State Water Project (SWP) and Central Valley Project (CVP) in California, these impacts are estimated using the Least Cost Planning Simulation Model (LCPSIM) and the Other Municipal Water Economics Model (OMWEM). These models were developed by the Department of Water Resources (DWR) for use in planning and impact studies related to water supply for SWP and CVP contractors. LCPSIM is used to estimate the benefits of changes in the water supply for M&I purposes in the urban areas of the San Francisco Bay – South and the South Coast regions. OMWEM covers other affected SWP and CVP delivery regions.

22D.2 Least Cost Planning Simulation Model

22D.2.1 Description

LCPSIM estimates economic benefits and other impacts of changes in urban water supply using a simulation/optimization framework. The model takes annual water supplies over a hydrologic period as input and estimates how local storage operations, conservation, recycling, transfers, contingency shortage and other local management will work together to minimize total economic costs of water acquisition and distribution and shortage. The value of available supply from a proposed project can be determined from the change it produces in this least-cost mix of demand and supply measures and shortages. The reduction in all costs associated with a water supply increment is the benefit of the increment.

Data has been developed to use LCPSIM for the two largest urban water use areas in the State. The South Coast model corresponds to the DWR South Coast Hydrologic Study Area. The San Francisco Bay – South model was expanded somewhat beyond the DWR South Bay Planning Study Area boundary to include all customers served by Contra Costa Water District (CCWD), the Santa Clara Valley Water District, Alameda County Water District, and Alameda County Zone 7. As a result, it includes all Bay Area SWP and CVP M&I users.

For each model area, several model data versions have been developed corresponding to carefully defined “development conditions” that describe the level of demands and facilities in place to manage supplies. Development conditions are normally defined and named according to a recent or future year. The assumptions for each development condition are selected according to local plans for demands, facilities and operations, and they include what is allowed and required for the type of study at hand; for example, NEPA/CEQA or federal Principles and Guidelines (P&Gs). Like CALSIM II, LCPSIM provides a distribution of results that reflect the development condition as well as hydrologic variability over the hydrologic period.

LCPSIM has been developed and applied for more than 25 years. Model development began in 1985 as a means to provide a systematic evaluation of projects and programs in the context of existing and forecasted regional water management. It has been used since 1990 to evaluate urban reliability benefits for DWR planning and environmental impact documents. It was also used for the CALFED Water

Management Strategy Evaluation Framework (2002). The model has been updated almost continuously since then as planning assumptions have changed.

An LCPSIM review group consisting of DWR and Bureau of Reclamation (Reclamation) staff, economics-engineering consultants, and water agency staff was convened in July 2004 and met periodically for over a year. The review group issued its final report in October 2005. The review found that “LCPSIM can provide usable information on economic benefits for use in surface storage evaluations,” but noted some qualifications. These qualifications included regular modifications and refinements and additional work on the San Francisco Bay – South model. A number of changes to LCPSIM were made in response to the group’s input. The San Francisco Bay – South model was revised and improved as recommended, and periodic updates have been made to water use efficiency costs and adoption rates, recycling costs, water transfer costs, and other data and assumptions.

LCPSIM was designed to be data-driven in order to easily represent different analytical circumstances without changing the model code. For example, adding a line of parameters to the carryover storage input text file is all that is necessary to create a new carryover storage operation. If unique situations require recoding, the source has been written with an emphasis on modularity to facilitate different analytical needs.

22D.2.1.1 Interactions with Other Models

The model has important interactions with other models. In particular, CALSIM II, DWR’s project operations model for the SWP and the CVP, is used to estimate SWP and CVP supplies which are inputs into LCPSIM. CALSIM II and LCPSIM both currently operate over the 1922 to 2003 hydrologic period. CALSIM II deliveries are driven by specified target delivery quantities that the model tries to meet based on available inflows and storage on the SWP and CVP systems for each year of hydrology used. An existing linkage tool has been developed to translate CALSIM II delivery output to a corresponding LCPSIM input file.

LCPSIM model requires annual water supply estimates from other sources such as the Colorado River Aqueduct (CRA), the Los Angeles (LA) Aqueduct, the Mokelumne Aqueduct and the Hetch-Hetchy system. These inputs are provided by annual time series provided by local agencies. The State maintains databases and models that estimate and forecast urban water demands. These demands, including detailed forecasts of conservation savings, provide input to LCPSIM.

The Characterization and Quantification (C&Q) process provides inputs directly to LCPSIM and indirectly, through CALSIM II. The C&Q process obtains demand and conservation information from other processes such as the Water Plan and provides information on base use, or adopted, conservation as well as quantities and costs of conservation options. Similarly, the C&Q process provides baseline recycling estimates and the costs and amounts of recycling options. The C&Q process is used to document water transfer assumptions including detailed evaluations of water rights transfers, long-term temporary transfers, and the cost and availability of short-term temporary transfers.

LCPSIM output can be used as part of the input to regional economic analysis using the IMPLAN model. LCPSIM can estimate changes in water supply, treatment, and distribution costs within M&I regions, and these changes can be provided to IMPLAN. Increases in regional water supply costs reduce disposable income of water consumers to spend elsewhere in the local economy.

22D.2.1.2 LCPSIM Model Theory

LCPSIM simulates economically efficient regional water use in that the total cost of supply and demand management is minimized. This feature is critical for unbiased benefits estimation because it means that new water supplies will always replace the lowest-cost increment of shortage or regional long-term water supply and demand management options available in any year. Total cost is the sum of two costs: 1) the cost of long-term reliability augmentation, and 2) the cost of shortage. The latter includes shortage contingency measures such as water market transfers and is inversely related to the former.

Figure 22D-1 shows the relationship between shortage costs and reliability augmentation costs, and it shows their least-cost combination. At the least-cost point, the cost of additional reliability augmentation is more than the reduction in shortage costs, but the cost savings from less reliability augmentation is less than the additional shortage cost.

The addition of new water supplies to this mix will reduce the total cost of shortage and reliability augmentation. That is, the new total cost curve will be lower than the curve in Figure 22D-1. At the new equilibrium, costs of shortage and reliability augmentation will both be less and the least cost point will lie to the left of the point in Figure 22D-1.

In LCPSIM, the cost of additional supply reliability and the cost of shortages affect the level of the use of long-term conservation measures beyond those included in the base use values. This is because the economic optimization logic used in LCPSIM depends on comparing the marginal cost of regional long-term conservation measures, the marginal cost of regional long-term supply augmentation measures and the marginal expected cost of shortages. Quantity demanded is therefore a function of the overall regional economic efficiency of water management.

22D.2.1.3 Types of Water Demands and Uses

Water demands are separated into four categories: priority uses, base use, deliveries for contingency conservation affected use, and interruptible use deliveries. For the 2009, 2025, and 2060 development conditions, the South Coast LCPSIM includes between 4 and 6 million acre feet (MAF) of demand, respectively, with another 1 to 1.6 MAF in the San Francisco Bay – South model.

- Priority Uses: Some uses are assumed to be required before supplies are available for allocation to urban demands. These uses are non-interruptible agricultural use, environmental use, and conveyance losses. Environmental use and conveyance losses are aggregated from local DWR Detailed Analysis Unit (DAU) studies. The net supply needed to meet these uses is obtained by reducing by the regional reuse that occurs in the process of applying water for these purposes.
- LCPSIM uses a forecast of irrigated acreage, forecasted average applied water use, and a time series file of annual variation from average crop ETAW (Evapotranspiration of Applied Water) to generate time series agricultural use data. Information on annual crop water use variation comes from a simulation model of unit crop ETAW that was developed to create a historical agricultural water use pattern for the 1922 to 2003 hydrologic period by water year (September through October). A reuse factor from the parameter file is used to generate the annual net agricultural use data used by LCPSIM.

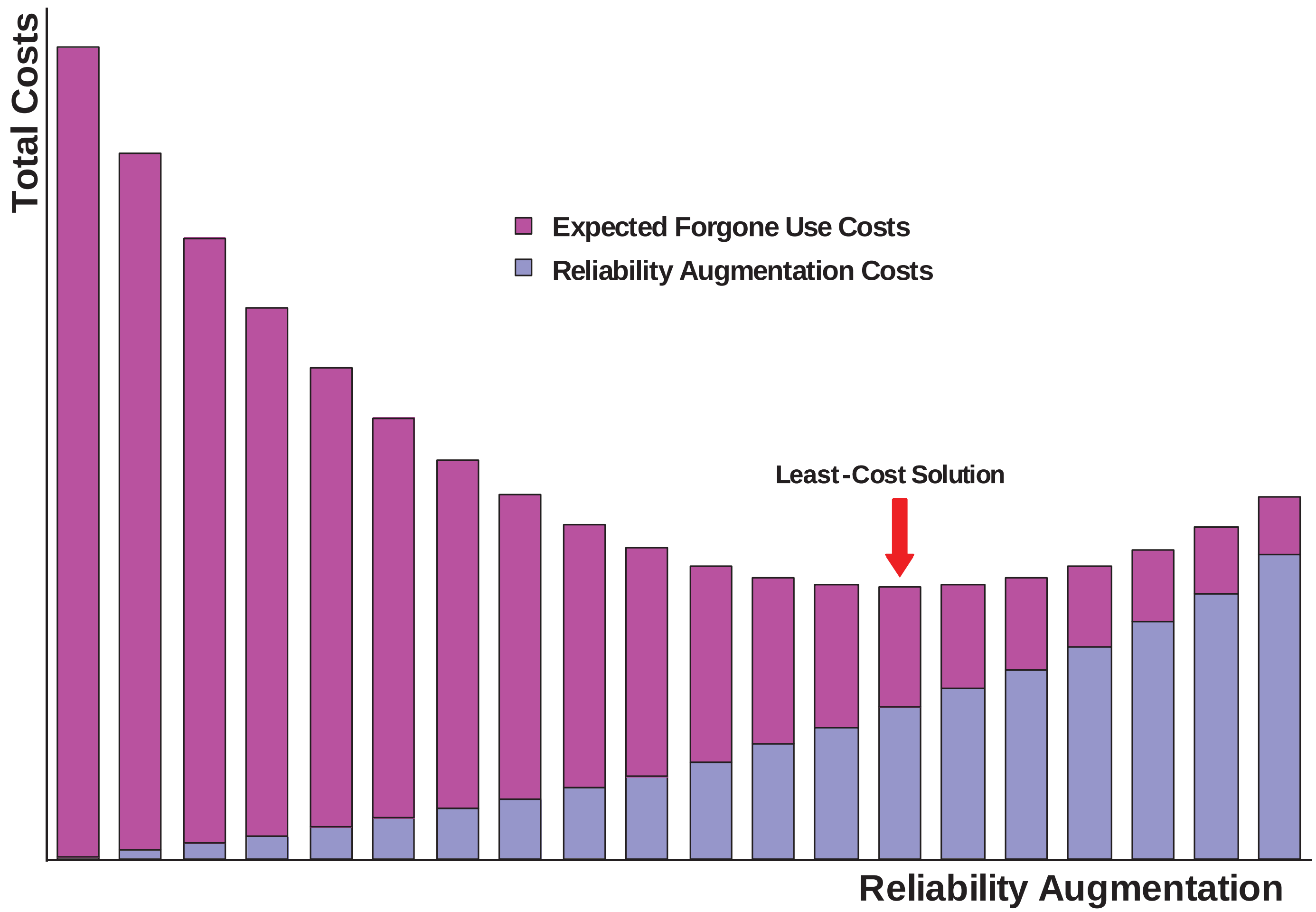

FIGURE 22D-1
The Effect of Increasing Reliability on Total Costs
Sites Reservoir Project EIR/EIS

- Base Use Demands: The demand sequence for non-interruptible urban deliveries is developed from a forecasted quantity demanded for the development condition (e.g., 2025) being investigated. The annual interior and average annual exterior urban demand quantities are calculated using the interior and exterior urban demand share values. Interior demand is assumed to have the same value for all years. Exterior use is separated into two components, a fixed component, which is assumed to have the same value for all years, and a variable component, which is assumed to be directly proportional to the ETAW for each year.
- A simulation model of urban turfgrass water use was developed to allow the creation of an annual ETAW variation time series for the 1922 to 2003 hydrologic period by water year (September through October). A variable exterior use component time series demand is generated using this time series and the average variable exterior demand. Adding the variable exterior demand time series to the sum of the fixed exterior demand component and interior demand produces the total urban applied water demand sequence.
- Because the demand sequence consists of applied water quantities, they must be converted to net quantities for use in the mass balance logic. All of the variation in total applied water demand is assumed to arise from exterior applied water use. While the regional reuse associated with interior use is consequently constant, reuse associated with exterior applied water use varies from year to year.
- Contingency Conservation Affected Use. Contingency conservation affected use is that amount of non-interruptible use which can be expected to be eliminated on a short-term basis in response to programs such as drought alerts and conservation advice in the media, local agency water-waster patrols and alternate-day watering rules, etc.
- Interruptible Demands. The interruptible component of demand for the South Coast was developed from information contained in the annual financial reports of the Metropolitan Water District of Southern California (MWDSC). This component is held constant for the hydrologic period and the quantity specified assumes that other sources of supply will not be used in-lieu. No interruptible delivery program was assumed for the San Francisco Bay – South.

22D.2.1.4 Types of Water Supplies

- Regional Yield Supply. Some supplies such as desalination, recycling, and recovery of native groundwater can be assumed to be available at the same level (defined by the development condition) every year of the hydrologic period. These water supplies include some within-region surface supplies and groundwater supplies exclusive of carryover operations. Annual supplies vary according to historical precipitation and local storage conditions.
- Import Supply Time Series. Annual deliveries from projects which import water from outside the region including the SWP, federal CVP service contracts, and regional projects. SWP and CVP deliveries are developed using CALSIM II.
- In the San Francisco Bay – South region, the CVP service contract delivery sequence represents CVP deliveries through the San Felipe Division to Santa Clara Valley Water District (SCVWD), to Contra Costa Water District (CCWD) and through the new Freeport diversion, to East Bay Municipal Utility District (EBMUD). Annual time series of deliveries through the Mokelumne Aqueduct and the Hetch-Hetchy system are also included. These time series are developed from modeling done by the

East Bay Municipal Utility District (Mokelumne Aqueduct) and the San Francisco Water Department (Hetch-Hetchy Aqueduct).

- For the South Coast region, federal deliveries made through the CRA, transfers and exchanges through the CRA, and the LA Aqueduct deliveries from the Owens Valley are included. LA Aqueduct deliveries are from modeling studies from the Los Angeles Department of Water and Power. CRA deliveries are based on the recent Quantification Settlement Agreement.
- Local Supply Time Series. Annual supplies available to the regions are included as annual quantities over the hydrologic period being represented (e.g., the 82 years represented by the period 1922 to 2003).
- Water Transfers. Water transfers are generally 1) permanent, as in water rights transfers, 2) long-term temporary, or 3) short-term temporary. In general, permanent and long-term temporary transfers are modeled in CALSIM II and temporary short-term (annual) transfers are modeled in LCPSIM. Some temporary transfers are included as fixed amounts within the CRA time series.

These four supply types are used, managed and stored as described below.

22D.2.1.5 Annual Water Supply Operations

This section describes how LCPSIM operates water supplies to meet demands and other uses on an annual basis. Operations are described in general order of their priority as supplies are reduced relative to demand. Modeled operations include deliveries to users, deliveries to and from carryover storage, water transfers, and shortage event-related conservation and water allocation programs.

Operations in Excess Conditions

Excess conditions exist when supplies are more than enough to meet the sum of current consumptive demand plus available carryover storage space and/or put capacity. The amount of supply remaining after carryover storage delivery constraints are considered is used to estimate how planned SWP operations might be reduced in specific years compared to the target deliveries set in CALSIM II.

- SWP Reallocated Water: The SWP and CVP water deliveries used by LCPSIM are generated by the CALSIM II project operations model. The CALSIM II deliveries are driven by specified target delivery quantities which it tries to meet based on available inflows and storages on the SWP and CVP systems for each year of the hydrology used. Because these targets are set independently of LCPSIM, an economically efficient water management plan can produce a level of reliance on regional supply and conservation measures which can result in the target deliveries for a region having been set too high for the wetter years. In these years, the capacity for deliveries to carryover storage can be exceeded, either because the volume to be stored exceeds the available space or the annual put rate is insufficient.
- This “excess” supply is assigned to the SWP because it is assumed by LCPSIM to be the marginal supplier. Provisions of the Monterey Agreement require that excess SWP supplies be offered for sale to other SWP Table A contract holders. If a portion of the SWP supply available to a region exceeds both current quantity demanded and available carryover storage constraints, a time series file of the excess quantities can be generated by LCPSIM for that region and used to augment SWP deliveries to other urban regions or agricultural users, or the target deliveries in CALSIM II can be reset.

- Local Storage Operations. Surplus conditions exist when supplies are more than enough to meet current consumptive demand but less than the sum of current consumptive demand and carryover storage delivery constraints. Water supply surplus to demand for current consumptive use is allocated to ground or surface storage. Deliveries to carryover storage are constrained by annual put ceilings and available carryover storage capacity after adjusting for put efficiencies (if less than 100 percent).

Regional Ground and Surface Carryover Storage

The general types of regional storage modeled in LCPSIM are:

- Banked Groundwater. A banking arrangement may involve an agreement between water agencies in two different regions of the State, for example, allowing one agency to operate a specified portion of the other agency's groundwater storage capacity (e.g., the agreement between the Santa Clara Valley Water District and the Semitropic Water Storage District). The stored water would be water that would otherwise be delivered for use under contract or water right but is stored for later delivery for use during shortage events.
- Puts involving groundwater storage can be accomplished by injection wells, spreading basins, or in-lieu deliveries (water users normally pumping groundwater are switched to surface water supplies). Conversely, takes from groundwater storage either can be accomplished by groundwater pumping or by switching water users who normally take surface water to groundwater pumping, allowing the now unused surface supplies to be delivered elsewhere. SWP project deliveries direct to San Joaquin Valley groundwater storage are also supported in LCPSIM. The stored water is then made available for delivery in subsequent years.
- Regional Carryover Storage. This may be conjunctive use storage that is physically located within the region or it may be located outside of the region (e.g., MWDSC's Lake Mead Project). Storage that uses a federal contract service conveyance facility (e.g., the CRA) is constrained by the conveyance capacity available (federal contract deliveries are given priority).
- Reserve Storage. In the South Coast Region, SWP terminal reservoir storage in the South Coast Region can be used for shortage management per contractual agreement. LCPSIM can place strict rules on the use and refill of this storage (i.e., the last to be used and the first to be refilled).
- SWP Carryover. If storage is available in San Luis Reservoir, SWP contractors can elect to have a portion of their SWP supply stored for delivery in the following year. The stored quantity is always assumed to be used to augment SWP deliveries. Available San Luis storage is determined using a file of time series data generated by CALSIM II.

Regional Ground and Surface Carryover Storage Characteristics

Carryover storage operations can involve storage capacities within the region or external to the region. Information entered into LCPSIM for individual carryover storage operations includes the capacity which can be operated, the initial fill, the annual put capacity, the annual take capacity, the conveyance facilities which will be used for puts and takes, any losses associated with storage operations, the on-site unit cost of the put and take operations, and whether one or more storage operations operate the same physical storage space.

The carryover storage element of the basic water management simulation algorithm was developed from information published by agencies within the study regions as well as discussions with their staff. This information was used to estimate the average amount of groundwater basin and reservoir storage capacities available for the purpose of storing currently available water for use in future years. The carryover storage capacities are the amounts over and above the capacities needed for regional intra-year operations. In the same manner, annual rate ceilings for deliveries to carryover storage (puts) and withdrawals from carryover storage (takes) were developed.

By default, LCPSIM uses take-capacity-to-stored-supply ratios to dynamically set put and take priorities. The put and take priorities for each storage operation are dynamically set by calculating the ratio of the stored supply to the take capacity for each storage operation for each annual time step. This ratio is then used to assign relative priorities for that time step: the lower the ratio, the lower the take priority and the higher the put priority. This strategy is designed to maximize supply availability from carryover storage when the desired deliveries to users exceed the supply available from other sources. Alternatively, these priorities can be set statically for each storage operation based on entries in the carryover storage data file.

Statically based priorities, in general, assume that when carryover supplies are needed to meet desired deliveries, water is preferentially taken from surface storage carryover supplies as opposed to groundwater storage carryover supplies. When supplies are available for refilling carryover storage, the supplies are preferentially used for groundwater storage carryover operations as opposed to surface storage carryover operations.

LCPSIM can trigger water market transfers to refill depleted carryover storage. These transfers can be triggered when the amount of stored supply is less than the available take capacity. The trigger can be set in LCPSIM parameter file as a percentage of take capacity. Dynamically set put priorities are always used for water market transfers made to replenish depleted carryover storage.

Operations in Deficit Conditions

Deficit conditions exist when imported plus local supplies are not enough to meet priority uses and demand including interruptible deliveries. If the supply from the sources other than carryover storage is less than desired deliveries to users, this balance can be achieved by deliveries from carryover storage, or by reducing use, or both. Deliveries from carryover storage are constrained by the annual take ceilings and the amount of stored water available.

Takes from carryover storage are constrained in LCPSIM to amounts accrued from puts in previous periods, with an allowance for a specified initial fill. LCPSIM has the capability of simulating groundwater bank take constraints based on either quantity limits for consecutive takes (e.g., Arvin-Edison WSD) or on percentage cutbacks in SWP Table A deliveries (e.g., Semitropic WSD, Mojave WA). The rules for simulating these constraints are stored as LCPSIM data files.

Takes from carryover can also be constrained by a hedging function within the model. This hedging function can be assigned to any or all carryover operations but only on a total capacity basis. Figure 22D-2 depicts the functional form used.

From the example function shown, if the amount in storage is 50 percent of the total storage capacity of the operations selected to be hedged and 25 percent of the stored amount is needed to meet demand, 90 percent of the needed amount will be supplied. If 75 percent of the stored amount is needed, 70 percent of the needed amount will be made available. Three input parameters affect this function, the storage capacity ratio at which hedging is employed and two parameters which affect the absolute and relative slopes of the curves which relate quantity needed to quantity supplied.

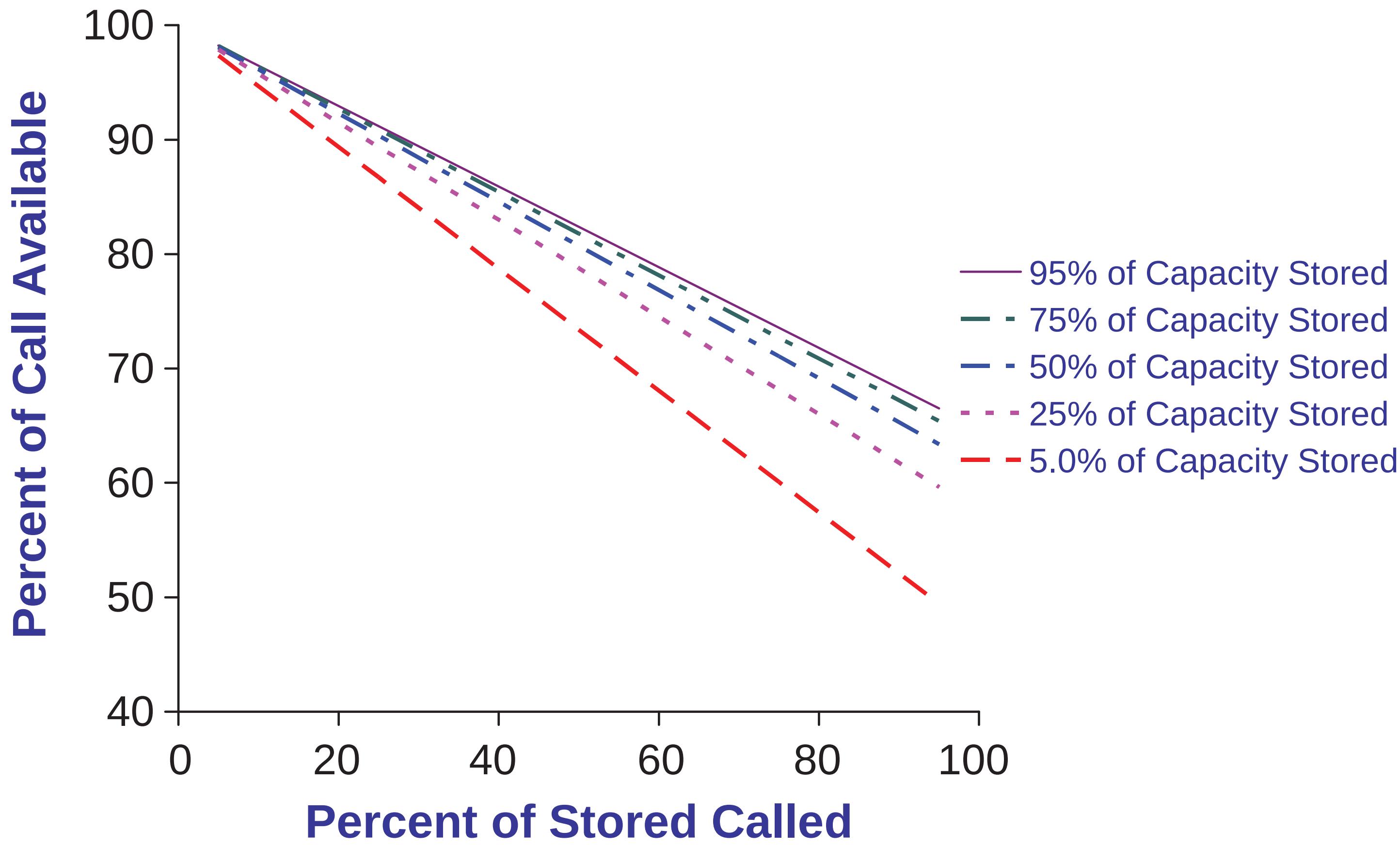

FIGURE 22D-2
LCPSIM Hedging Function Example
Sites Reservoir Project EIR/EIS

Take constraints set in the carryover storage data file for reservoir storage can also be used to represent a specific hedging strategy. LCPSIM also accepts water bank take constraint rules based on either reducing the allowed take in consecutive-year take situations (e.g., Arvin-Edison WSD banking program) or on the project delivery received by the bank operator as a percentage of their contract full-delivery quantity (e.g., Semitropic WSD and Mojave WA banking programs).[1]

Curtailment of Interruptible Deliveries

The economic losses assigned to users of interruptible supplies are assumed to be limited to the cost of that supply in accordance with their usual water rate. Interruptible program deliveries are assumed to be cut back along with non-interruptible deliveries but at a higher rate relative to non-interruptible cutbacks. The unit value of the losses incurred by interruptible supply customers in a current year is the same as the unit price paid for that supply. This is based on the assumption that the price reflects the value of that supply discounted for unreliability by knowledgeable users of that source of supply.

Contingency Conservation Measures

Examples of contingency conservation measures include; alternate day watering regulations, water waster patrols, emergency water pricing programs, and intensive public education campaigns. A specified reduction in quantity demanded can be expected upon implementation of a program which includes such measures. The model assumes that such a program is instituted whenever there is a shortage in available water supplies compared to current quantity demanded or in response to low carryover storage availability. An agency cost of implementing the contingency conservation programs is included.

The contingency conservation program allows supplies which would have been directed to this category of use to be allocated elsewhere. Figure 22D-3 shows the function used to implement this logic. The “take call ratio” relates desired deliveries to supply. The capacity use ratio relates the total amount of capacity available to store carryover supplies to the total amount of water in carryover storage. Both of these ratios are input parameters to LCPSIM.

Contingency Water Market Transfers

If current year supplies and withdrawals from carryover storage are insufficient to meet the quantity demanded the ability of annual water market transfers to augment current year supply is simulated. Water market transfers are modeled using constraints as well as costs by source. These constraints include conveyance capacity, carriage water and other conveyance losses. Conveyance of other supplies, including withdrawals from carryover storage, is given priority. Also, transfers are limited by a consideration of potential third party impacts and amounts historically made available.

Water transfer costs vary by year type. The information used to develop these costs considered actual transfer prices as well as shadow prices from the Statewide Agricultural Production (SWAP) model. Unit water purchase costs from each source are adjusted upward by their respective conveyance losses and augmented by their respective conveyance costs. The unit purchase costs from any source can be specified as coefficients of a quadratic function, representing a unit cost that increases linearly as the amount used is increased. Quantities available from each source are constrained by the applicable conveyance capacities. The quadratic programming solution which minimizes the sum of the forgone

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[1] Arvin-Edison’s MWDSC take limit is reduced for each consecutive year for which a take is made. Semitropic’s MWDSC take limit is equal to the bank’s pumpback capacity plus the product of MWDSC’s percentage share of the bank and Semitropic’s SWP Contract Table A delivery after subtracting Semitropic’s reserved amount of that allocation: Pumpback Capacity + Share of Bank * ((Table A Allotment * Percentage of Table A Delivered) - Reserved Table A).

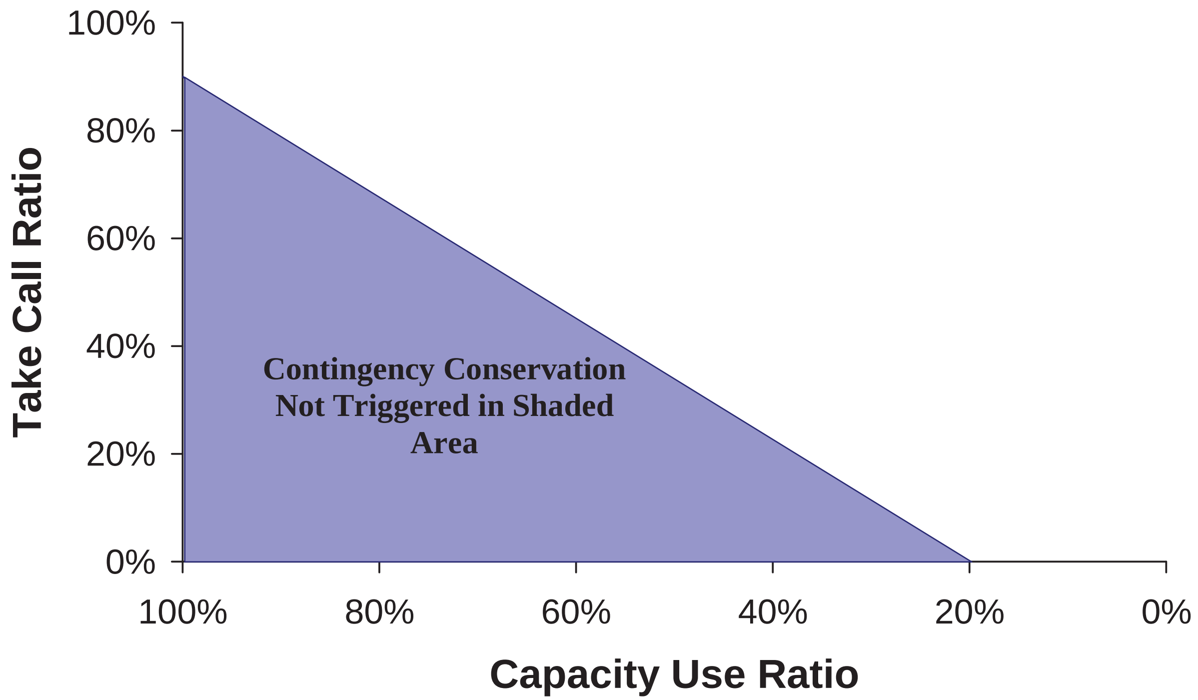

FIGURE 22D-3
Trigger Function for Contingency Conservation
Sites Reservoir Project EIR/EIS

use-related costs and losses and the minimized costs of transfers at alternative transfer quantities is used to determine the quantity transferred to reduce forgone use.

Water market transfer options are input into LCPSIM in terms of the quantity available from a specified source, the cost obtaining the water at the source, what facilities will be used to convey the transferred water, any losses during conveyance (e.g., carriage water for transfers involving the Delta), and any constraints on the frequency of use of the transferred water from that source. System conveyance capacity constraints and delivery efficiency factors for water market transfers in the form of time series files generated by CALSIM II or other system models can be used by LCPSIM. LCPSIM can use such files for transfers from the either Sacramento Valley, the San Joaquin Valley, or both.

Identification of the conveyance facility is needed to determine what capacity remains for moving the water to be transferred and to determine the conveyance cost. If the conveyance facility is a federal service contract facility that is used to convey exchanged SWP Table A contract deliveries then the aqueduct capacity for transfers is increased during those years when Table A deliveries are cut back. For example, MWDSC delivers Colorado River water to Desert Water Agency and Coachella Valley Water District through the CRA in exchange for their SWP contact deliveries.

Frequency of use constraints can be used to represent the need to respect the potential for serious third-party impacts. These constraints are specified by source and are in the form of a limit on the maximum amount of water that may be transferred during consecutive years and in terms of the maximum quantity to be made available over a 10-year period.

Simulated water market transfers include not only those made for shortage event management but also those made to augment carryover storage.

Shortage Modeling and Forgone Use Costs

A shortage event is the most direct consequence of water service system unreliability. LCPSIM estimates how new water supplies and management reduce the frequency, magnitude, and duration of shortage. Shortage is the difference between the quantity of current consumptive use and the supply available for use. The model uses a shortage loss function derived from contingent valuation studies and water agency shortage allocation strategies to value the forgone use.

LCPSIM includes a number of steps used to determine the management, amount, allocation and costs of shortage. Conservation and rationing operations are instituted 1) during shortage events or 2) when the total carryover storage quantity available is of serious concern.

Rationing

In LCPSIM, “rationing” is shorthand for a water allocation method designed to minimize the overall economic costs of a shortage by “balancing” the costs of forgone use among customer classes. The allocation method in LCPSIM is intended to mimic water agencies by maintaining provisions for exemptions due to serious adverse economic impacts, especially for businesses. Above a specified threshold level, compared to single-family residential users, multi-family residential customers are assumed forgo use at a lower rate, commercial users are assumed to forgo use at an even lower percentage rate, and industrial customers are assumed to forgo use at the lowest percentage rate. Above the specified threshold level, water use for the purpose of maintaining large landscaping is assumed to be curtailed at a greater percentage rate than single-family residential use.

LCPSIM logic accounts for the assumption that interior use is cut back at a lower rate than exterior use during shortage events and that the associated reuse factors differ. Because recycling options affect fixed reuse, this also has to be taken into account in calculating the overall annual reuse quantities needed to related applied water supply availability to net water supply availability. The effect of the adoption of conservation options on the relationship between a shortage in supply and the availability of applied water is also taken into account in the determination of economic losses.

Forgone Use Allocation

Forgone use resulting from rationing is allocated among the different user classes represented in the model; industrial users, commercial and governmental users, single family and multifamily residential users, and large landscape users.

This allocation is determined by input parameters for users not classified as single family residential. These parameters represent the respective fractions of the single family residential percentage of use forgone that will be allocated to them. For example, a parameter value of 25 percent for industrial users means that these users will be held to a forgone use equal to 25 percent of the percentage use forgone by single family residential users. This results in the single family residential users forgoing use, in percentage terms, larger than the overall forgone use. This effect can be moderated by specifying that deliveries to large landscape irrigators will be curtailed at a greater percentage rate compared to single family residential users. An input parameter determines the level of overall forgone use at which this allocation takes effect. This is intended to represent strategies used by water agencies to protect businesses and institutions from serious economic damage and job loss during shortage events. Some water agencies have explicit water allocation rules. Other agencies have hardship exemption programs that have a similar result.

Forgone Use Cost Function

The forgone use loss function assigns economic losses to forgone use. The loss function is input into LCPSIM either as:

- A polynomial function which relates a percentage forgone use to a total cost of that forgone use or
- A constant price elasticity of demand function.

Because the loss function is intended to approximate willingness-to-pay at the water user level, it is driven by the availability of applied water. For this reason, the net water supply availability generated by the mass-balance logic must be converted to applied water supply availability. This is done by adding reuse back to the net water supply.

LCPSIM has the ability to use a polynomial loss function. This functional form has the advantage of allowing “threshold effects” to be modeled. The intuition is that the inconvenience of dealing with water agency policies during shortage events (e.g., alternate day watering and gutter flooder regulations, water waster patrols, etc.) is perceived as a hardship over and above the value associated with the amount of water no longer available for use. Depending on how this phenomenon is specified as a polynomial, it can result in a loss function in which, at higher shortage values, associates a higher marginal value of supply at lower forgone use levels than at higher shortage levels. If this is the case, it is important to evaluate the model results to ensure that the model solves within the range of shortages where this is not considered an issue. The polynomial loss specification can also accommodate a linear cost function (i.e., polynomial of degree one).

The ability to use a constant price elasticity of demand function is also provided as an alternative, more conventional, means of deriving the shortage loss function. It has the advantage of using just three parameters that are readily available; the retail water price, the retail quantity, and the elasticity of demand. Because it is likely to assign much higher loss values to the larger shortage events, the CPED function can result in more regional reliability options being brought online, reducing the number of small shortage events compared to the use of a linear or polynomial function even though it may assign comparatively lower loss values to smaller shortages.

The loss function includes the marginal value of water to users for the no shortage condition. This is done by setting the intercept of the loss function equal to the variable component of the retail price of water. To avoid double counting, all costs are considered from perspective of the water user; any changes in costs or income to water purveyors resulting from changes in operations costs or from reduced water sales due to shortages are assumed to be passed on as water user costs or cost savings.

Demand elasticity can help to inform or validate forgone use loss functions. The steeper the demand function, the more that shortage costs increase with shortage amount. A 1996 elasticity study done for DWR Bulletin 160-98 found an average elasticity of -0.16 for urban residential users. In 1990, estimated price elasticities of demand for single-family, multifamily and non-residential users were -0.195, -0.163 and -0.159, respectively. A demand hardening factor of 52 percent by 2010 resulted in 2010 elasticities of -0.101, -0.085 and -0.083, respectively, with elasticities of -0.064, -0.054 and -0.052 by 2020. For the CPED shortage cost function, LCPSIM currently assumes a demand elasticity of -0.101 in 2009, and -0.064 in 2025 and 2060.

For comparison, the CPED function with the elasticity value of -0.10 is used to estimate the forgone use losses and results are compared to losses estimated by the polynomial function in Tables 22D-1 and 22D-2 below. Average willingness to pay per unit water for the CPED function is lower at small shortage levels but more at large shortage levels.

Table 22D-1
Example Polynomial Loss Function Values
Urban Water Supply Economics Modeling

Forgone Use	Willingness to Pay to Avoid Event		
	Acre-Foot Use/Year/Household		
	0.75	0.65	0.55
0%	$0	$0	$0
5%	$49	$43	$36
10%	$145	$126	$106
15%	$278	$241	$204
20%	$439	$380	$322
25%	$618	$535	$453
30%	$804	$697	$590
35%	$990	$858	$726

Table 22D-2
Example CPED Loss Function Values
Urban Water Supply Economics Modeling

Forgone Use	Willingness to Pay to Avoid Event Acre-Foot Use/Year/Household		
	0.75	**0.65**	**0.55**
0%	$0	$0	$0
5%	$29	$25	$22
10%	$79	$69	$58
15%	$166	$144	$122
20%	$323	$280	$237
25%	$618	$535	$453
30%	$1,194	$1,034	$875
35%	$2,376	$2,059	$1,742

Consecutive Shortage Events

When they occur, the calculated forgone use costs can be increased by a specified percentage amount to reflect the more severe consequences of consecutive shortage events. This effect falls off as a power function of the number of years between events and does not apply if the next loss event follows by more than 2 years. The default inputs do not increase foregone use costs.

Demand Hardening

Long-term demand management measures that are adopted by water users can have a demand hardening effect. Although they can increase reliability by reducing the size, frequency and duration of shortage events, they can make these events relatively more costly when they do occur. A hardening factor can be set in LCPSIM to simulate this effect. If conservation decreases demand by a specific percentage then the economic impact of forgone use of a specified size is computed as if the forgone use was greater, based on the hardening factor. Hardening is computed from the ratio of the quantity of use reduction due to conservation to total quantity of use prior to that reduction and expressed as a percentage. This percentage is then multiplied by a percentage specified as a LCPSIM input parameter (the demand hardening adjustment factor) to get a forgone use adjustment factor. This factor is used to adjust the quantity of forgone use before the loss function is applied. For example, if pre-adjustment forgone use is 10 percent, the demand hardening percentage is 20 percent, and the demand hardening adjustment factor is 50 percent, then forgone use is increased to 11 percent for the purposes of determining economic losses.

Long-Term Conservation and Supply Options

LCPSIM includes the potential for cost-effective long-term conservation or local supply augmentation. Information on individual regional water management options used by LCPSIM includes: the amount available from that that option, the unit annualized capital and O&M cost of that option, and the type of option. The unit cost of any option can be specified as coefficients of a quadratic function, representing a unit price that increases linearly as the amount used is increased.

The type of option is used to determine how the option would affect the mass balance. Options such as ocean water desalting augment supply, conservation options decrease applied water demand, and recycling options augment reuse. With one exception, these options are assumed to provide a fixed level of supply enhancement or demand reduction each year.

The type of option is also used to determine either the cost of regional potable water and wastewater treatment and distribution, or, in the case of conservation, that these costs don't apply. To determine the effect of conservation on wastewater treatment costs, interior and exterior conservation options are identified separately. If a recycling option has a dedicated distribution system (e.g., "purple pipe"), the capital and operations and maintenance costs of that system must be included in the option data file as the cost of that option. The regional potable water treatment and distribution costs would not apply.

The applied water that is "lost" to surface return flows and deep percolation can help meet applied water demand through reuse. Conservation options, by definition, reduce this loss and, therefore reduce this source of applied water. To account for this, the option file includes percentage values to account for the effect of reuse on the ability of water conservation options to reduce the need for regional supplies (i.e., net demand) and on the cost of achieving that reduction. For example, exterior use conservation options which support the same plants (i.e., same ETAW) but reduce return flows and deep percolation will have a different effect on the need for regional supplies compared to conservation options which substitute different, lower water using plants. Conservation options which reduce the amount of deep percolation are credited with their associated pumping cost savings in LCPSIM, reducing their effective cost.

The exception to fixed nature of the options used by LCPSIM is exterior conservation. The value in the main parameter file that sets the share of exterior use that is unaffected by ETAW is also used to separate the effect of exterior use conservation into a fixed component and a variable component. The variable component is assumed to be directly proportional to the amount of exterior use in any year and is intended to capture the effect of actions which, for example, reduce the amount of water applied through better irrigation management.

Information about the potential quantities and costs of permanent options are largely from DWR's Water Plan process and are reviewed and selected within the C&Q process. Most water conservation opportunities are based on the Water Use Efficiency Comprehensive Evaluation. Recycling opportunities are based on a review of planned and potential projects. In both cases, amounts to include for a future development condition are included as regional fixed yield supplies, and this amount is subtracted from existing opportunities to obtain the remainder available as an option at the future development condition date.

Carryover Storage Augmentation Option

LCPSIM offers a limited ability to augment carryover storage capacity as an option. Only one existing carryover storage operation can be selected to be augmented. The augmentation assumes that annual put and take capacities are increased in proportion to the size of the augmentation. Information on which carryover storage operation is to be augmented and the cost of adding storage capacity to that operation is entered along with the data entered for the other regional management options.

Operations Cost Accounting

The economic costs and losses related include regional water management operations costs. These costs include SWP conveyance costs to the region, conveyance costs on other affected aqueducts supplying the region, and regional potable water and wastewater treatment and distribution costs. Conveyance costs include the cost of wheeling transferred water. The costs are from the perspective of statewide economic efficiency, generally compatible with a national accounting perspective, and are lifecycle costs whenever possible. Conservation option costs are adjusted to reflect any in-home energy costs savings which accrue to the user.

Unit costs of aqueduct conveyance, regional potable water and wastewater treatment and distribution costs are entered as LCPSIM parameters. Per-capita costs to regional water agencies for managing rationing programs, along with the forgone use threshold at which it assumed a rationing program will be instituted, are also inputs. Costs and maximum quantities of options including water transfers are input.

22D.2.1.6 Solution Method and Smoothing

LCPSIM uses several methods to find its least-cost solution over an entire hydrologic period. Quadratic programming algorithms are used to 1) find the least cost way of obtaining an increment of regional long-term option use, and 2) find the minimized cost of water market transfers at alternative transfer quantities and compare cost of water transfers to the value of transfers in terms of the amount of shortage avoided to identify the economically efficient quantity to transfer. The quadratic objective function can relate the amount of option use to the total cost of that amount of option use. For a particular level of option use, the options are assumed to be implemented in manner that minimizes the cost of achieving that level of use when both annualized capital and O&M costs and regional potable water and wastewater treatment and distribution costs are considered. Because quadratic option costs can be entered, a particular level of use may be achieved by implementing less than the total amount specified as being available from any one option.

The Priority-Weighted Mass-Balance Constrained Linear Optimization is used to find the least cost combination of long-term water management options, shortage contingency measures (including water market transfers), and shortages. A mass balance constraint is used to assure that supplies equal uses, but how this balance is achieved is set by assigning priority weights that affect how the water is moved. Storage operations are a critical component of the mass-balance logic. As was noted, priorities for take and refill are dynamic, depending on the status of the entire system, and are set to ensure maximum potential use of available supplies. The algorithm maximizes quantities weighted by priorities subject to the imposed system constraints.

The model water balance logic is used to balance water use with water supply, simulating regional water management operations. Using the mass-balance logic requires that the demand data, which are applied water quantities, be converted to net quantities by accounting for regional reuse. Reuse is either fixed (e.g., recycling) or variable (e.g., in-region pumping of deep percolation). In LCPSIM, variable reuse arises primarily from deep percolation of exterior urban use (e.g., residential landscaping and public parks). The other variable source is interior urban wastewater that is deep percolated from septic tanks. For this conversion, interior use is assumed to be constant and any year-to-year variation in total use is assumed to arise from variation in exterior use due to weather (e.g., temperature and effective precipitation).

Because of the complicated nature of multiple interacting supply sources and management decisions, one solution can be a local optimum that does not necessarily reflect the best least-cost result. Therefore, the model is run for a range of option use around the minimum point to obtain a curve whose variation reflects the variety of local optima. This curve is fit using regression and the minimum on this curve is used as the estimate of total costs.

The order of the polynomial smoothing function can be set by the model user based on the user's view of the trade-off between minimizing the rate of change in the slope of the function (i.e., a smoother function) and a function which is less smooth but more closely follows the path of the points (i.e., maximizes the goodness of fit). If LCPSIM user feels that, on average, the real world operations would be unlikely to duplicate the results of the threshold-based operating criteria incorporated in the model, then fitting the model-generated points too closely would be likely to bias the model results.

Selecting the starting and ending regional option use points for the simulation can also affect the results of smoothing. Adjusting the range of option availability is another trade-off that the user may make to exclude or include information that may or may not be useful for identifying an optimal solution point.

22D.2.1.7 Results Format

Figure 22D-4 shows results regarding amount of water supply and water storage over years of the hydrologic sequence. This type of output provides insights into the conditions that lead to different types of operations and storage. The hydrologic period includes two long-term droughts. In the South Coast region, these two periods account for most of the shortage costs.

22D.2.1.8 National Cost-Benefit Analysis with LCPSIM

LCPSIM was developed to provide state-level cost-benefit analyses for proposed SWP storage facilities. LCPSIM is used to find the economically efficient (i.e., least-cost) management strategy for the reservoir alternatives being considered, including the no-project alternative. The reduction in total regional costs when each with-project alternative is compared to the no-project alternative is the regional economic benefits ascribable to that alternative.

These benefits could then be used in a separable costs, remaining benefits (SC-RB) cost allocation analysis to determine the project costs allocable to that region. Comparing the allocated costs to the regional benefits for each alternative provides the benefit-cost ratio or the net benefits for that alternative, as appropriate.

In 2005, LCPSIM Review Group found that

> "in considering every aspect of the model, has determined that the model should be able to provide economic benefits information accurate enough for an economic benefits analysis of urban water supply from the perspective of the State or nation."

This finding was subject to several qualifications, including:

- Subject to some appropriate modification and refinements;
- Not appropriate for individual local water supply agencies, benefits not suitable for allocating costs among M&I users;
- Assumptions and results should be compared to local agency data and updated accordingly

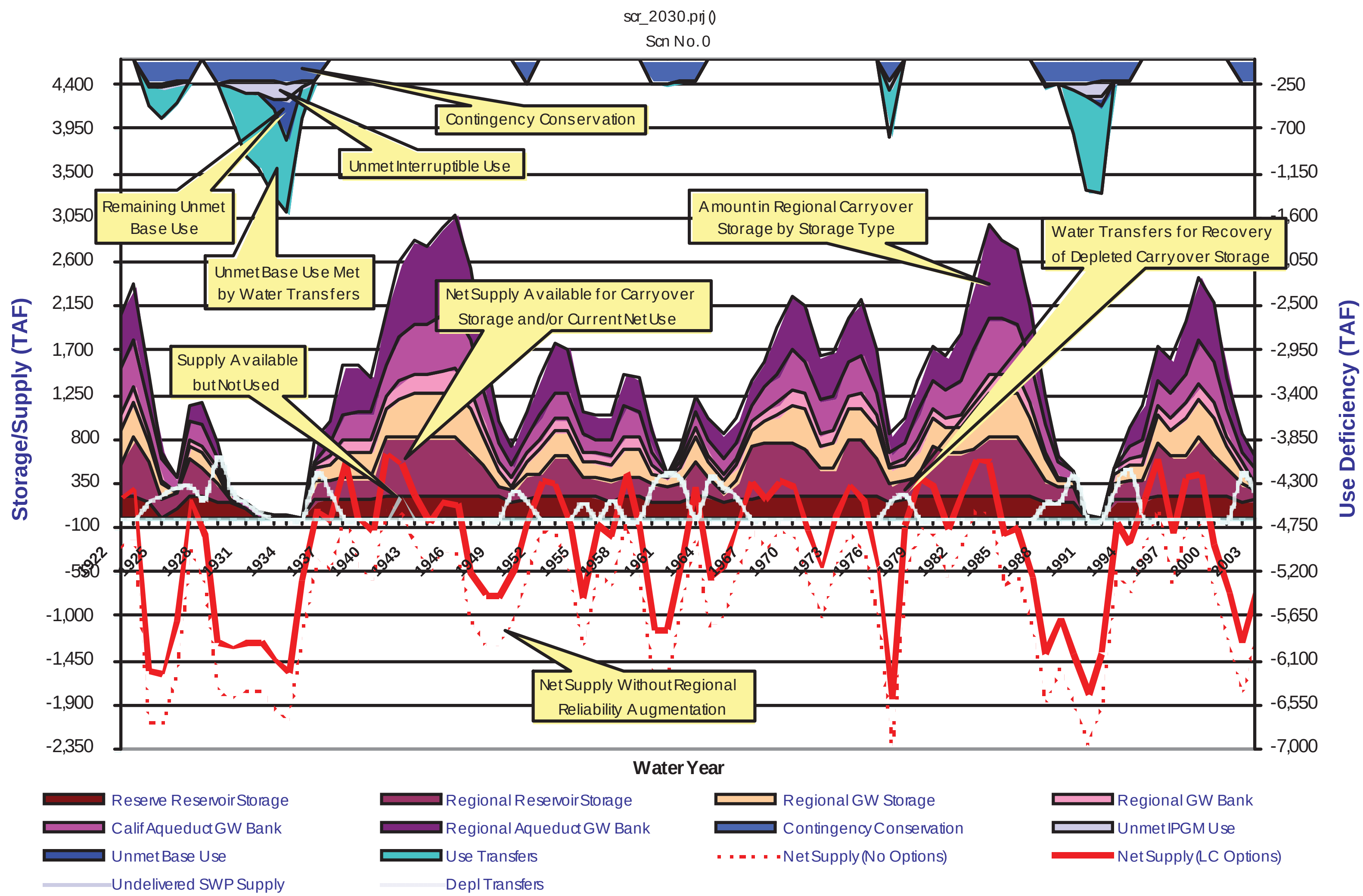

FIGURE 22D-4
Example Operations Trace Screen
Sites Reservoir Project EIR/EIS

- An expert group should be convened to evaluate the operation and results of any LCPSIM application proposed as a basis for benefits estimates
- Regular updating

A check of LCPSIM assumptions might be appropriate before use for national benefits analysis. In particular, some LCPSIM costs were developed using real discount rates and prices that should be adjusted for a national analysis.

Economic benefits from LCPSIM are computed at specifically identified development conditions. The model thereby conforms to CALSIM II hydrologic output which is also generated for specific development conditions and is tied to target deliveries and upstream depletions tied to those levels, rather than over a period of time.

National benefit-cost analysis requires a planning horizon analysis. Results from multiple development conditions can be used to develop planning horizon analyses as required by the P&Gs (U.S. Water Resources Council, 1983). Each year of the planning horizon corresponds to the development condition for that year. The needs of a planning horizon analysis can be met by LCPSIM by using LCPSIM results from two or more development conditions. The necessary information for years not modeled by LCPSIM can be obtained by interpolating between the two sets of LCPSIM results and extrapolating beyond. Information on specific planned events in the planning horizon might be used to design LCPSIM runs with specific facilities in place for desired years of the planning horizon.

22D.2.1.9 LCPSIM Parameters

Tables 22D-3 and 22D-4 list parameters specific to the San Francisco Bay – South and South Coast models, respectively. Recent changes to LCPSIM are also listed in Table 22D-5.

TABLE 22D-3
LCPSIM Inputs: San Francisco Bay Region–South
Urban Water Supply Economics Modeling

	Baseline
Planning horizon	2009, 2025 and 2060
Demarcation date	February 13, 2009[a]
Period of simulation	82 years (1922-2003)
Dollars	2007
Regional Supplies	
Local	
Average local surface supply	38 TAF/year for all levels of development
Average local groundwater supply	203 TAF/year for all levels of development
Imported	
Hetch-Hetchy Aqueduct deliveries	Annual time series from SFPUC PEIR Study WSIP1LT[b]
Mokelumne Aqueduct deliveries	Annual time series from EBMUD Freeport Regional Water Project EIS/EIR With Project EBMUDSIM study #6292[b]
SWP deliveries	Annual time series from CALSIM II simulation[c]
CVP deliveries	Annual time series from CALSIM II simulation
Water Management Actions (CALFED)	
Local recycling[a]	41 TAF/year for 2009 and 51 TAF/year for 2025 and 2060, respectively

	Baseline
Desalination[a]	0 TAF/year for all levels of development
Transfers	
San Joaquin Valley	Single-year transfers as determined through interaction with CALSIM II at acquisition cost of $325, $385, and $517 per AF[d,e] for 2009, 2025, and 2060, respectively
Sacramento Valley	Single-year transfers as determined through interaction with CALSIM II at acquisition cost of $197, $243, and $345 per AF[d,e] for 2009, 2025, and 2060, respectively
Regional Base Operations Cost	
Distribution cost	$24, $36, and $52 per AF for 2009, 2025, and 2060, respectively from CALFED, 1999
Treatment cost	$98, $99, and $100 per AF for 2009, 2025, and 2060, respectively from CALFED, 1999
Cost of Reuse and Deep Percolation	$30, $44, and $68 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
SWP Aqueduct Conveyance	
Groundwater bank	$35, $50, and $78 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
Regional conveyance	$60, $86, and $134 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
CVP Conveyance	
Groundwater bank	$0/AF
Regional conveyance	$59, $85, and $132 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
Annual Regional Base Use	
Urban demand target	1,085, 1,234, and 1,636 TAF/year for 2009, 2025, and 2060, respectively
Regional Demand Reductions	
Conservation	67, 142, and 167 TAF/year for 2009, 2025, and 2060, respectively from CALFED, 2006
Precipitation	Four station average annual rainfall 1884-2003 from National Weather Service[f]
Agricultural use	30 TAF/year for all levels of development from DWR Water Portfolio (on-farm applied water) 1998-2005
Environmental use	5 TAF/year for all levels of development from DWR Water Portfolio (managed wetlands) 1998-2005
Regional Reliability Management Options	
Conservation	108 TAF/year interior and 163 TAF/year exterior increasing in cost up to $1,800/AF for 2025 and 90.0 TAF/year interior and 156 TAF/year exterior increasing in cost up to $1,800/AF for 2060
Water recycling	72 TAF/year for all levels of development increasing in cost from $738 to $4,245/AF for 2025 and from $760 to $4,276/AF for 2060
Desalination	134 TAF/year for all levels of development at $1,527/AF for 2025 and $1,692/AF for 2060
Regional Ground and Surface Carryover Storage	
Groundwater spreading operations	30 TAF of storage, put limit of 30 TAF/year and take limit of 10 TAF/year
California Aqueduct groundwater banking operations	565 TAF of storage, put limit of 178 TAF/year, and take limit of 130 TAF/year from MWDSC

	Baseline
Arvin-Edison Project delivery constraint[g]	155 TAF of Table A allotment, 22 TAF of reserve Table A, 56% share of the bank, and 0 TAF base take available
Shortage Management Strategy	
Contingency conservation campaign	10.0 % of net urban demand target[h,i] for 2009 and 5.0% for 2025 and 2060
Point at which transfers to depleted carryover storage are triggered	80% of each facility's annual take capacity
Shortage allocation rule cut ratio	Industrial user 25%, commercial user 50%, multi-family residential 60%, landscape user 200%[i,k]
Demand hardening factor	52, 33, and 25%[i,l] in 2009, 2025, and 2060, respectively
Rationing program threshold	80% non-interruptible shortage triggers rationing cost of $0.50/person[i]
Take call ratio for using contingency conservation	100% call on available carryover to meet net delivery with conservation reduction[i]
Capacity use ratio for using contingency conservation	20% of capacity[i,m]
Threshold for shortage allocation	Below a 95.0% level of shortage, all users will experience the same percentage reduction[i]
Inverse power function exponent for loss value adjustment	Inverse power function of 1.0[i,n]
Regional urban population	5,982, 6,674, and 8,529 thousand in 2009, 2025, and 2060, respectively from DWR
Industrial customer size (% of total use)	2.7, 2.3, and 1.8% of total use in 2009, 2025, and 2060, respectively from WEAP Current Trends (DWR)
Commercial customer size (% of total use)	22.5, 23.8, and 25.1% of total use in 2009, 2025, and 2060, respectively from WEAP Current Trends (DWR)
Landscape customer size (% of total use)	9.1, 8.5, and 7.9% of total use in 2009, 2025, and 2060, respectively from WEAP Current Trends (DWR)
Multi-family residential customer size (% of total use)	21.5, 21.4, and 21.2% of total use in 2009, 2025, and 2060, respectively from WEAP Current Trends (DWR)
Economic Loss Function	
Polynomial loss function[o]	$830 (intercept), coefficients b_1 = 22,269, b_2 = -14,693, b_3 = -3,148 for 2009; $1,037 (intercept), coefficients b_1 = 21,994, b_2 = -14,782, b_3 = -3,149 for 2025; $1,688 (intercept), coefficients b_1 = 2,1093, b_2 = -1,5069, b_3 = -3,150 for 2060 from MWDSC, 2005

[a]A detailed description of the assumptions selection criteria and policy basis used is included in the Technical Memorandum: Characterization and Quantification of Water Management Actions (DWR)

[b]Time series extrapolated to 2003 using average value for water year type

[c]In the San Francisco Bay Region–South turnback from Table A and Article 21 are allocated to South Coast SWP water in LCPSIM.

[d]These values may change contingent on revisions to Mann and Hatchett, 2006

[e]Transfers costs are the average between Below Normal, Dry, and Critical year types. The cost shown is acquisition cost; delivered cost is higher because of Delta salinity and other operational losses.

[f]Historical rainfall records starting in 1883 are used to create a stochastic sequence for the hydrologic study period to estimate urban demand targets.

[g]The take limit for MWDSC from Arvin Edison is reduced for each consecutive year for which a take is made.

[h]Shortage management strategies were developed using MWDSC, 1999.

[i]A specified reduction in use can be expected upon implementation of a contingency conservation program that includes such measures as increased watering regulations, increased water waste patrols, emergency water pricing programs, and intensive public education campaigns. Contingency measures to meet shortages are implemented only after shortages exceed 5% of total urban use.

[j]If storage falls below this threshold, transfers are implemented to augment storage. Sacramento River Region, San Joaquin River Region, and Tulare Lake Region transfers can be used for this purpose.

[k]User shortage percentage limited to X% of overall shortage percentage.

[l]Percentage increase in conservation (compared to base use levels) makes shortages effectively larger by 50% times the percentage increase in conservation.

[m]Limit on the fraction of carryover storage capacity filled before triggering contingency conservation.

[n]Adjustments to losses are made for shortage events with up to two intervening non-threshold years to account for residual damages.

[o]This model element assigns economic loss to foregone use.

Source: Information in the table was interpreted from various published and unpublished reports and mathematical modeling exercises. Some of this information is sensitive in nature and should be interpreted in the appropriate context. For further information regarding the information included here, please contact the California Department of Water Resources, Economic Analysis Section, Section Supervisor.

TABLE 22D-4
LCPSIM Inputs: South Coast Region
Urban Water Supply Economics Modeling

	Future Baseline
Planning horizon	2009, 2025, and 2060
Demarcation date	February 13, 2009[a]
Period of simulation	82 years (1922-2003)
Dollars	2007
Regional Supplies	
Local	
Average local surface supply	257 TAF/year for all levels of development
Average local groundwater supply	1,160 TAF/year for all levels of development
Imported	
LA Aqueduct deliveries	Annual time series provided by LADWP
Colorado River Aqueduct deliveries	1,050, 955, and 847 TAF/year[b] from MWDSC, 2005 and model output from Metropolitan's IRPSIM
SWP deliveries	Annual time series from CALSIM II simulation[c]
Colorado River Aqueduct capacity	1,200 TAF from MWDSC, 2005
Water Management Actions (CALFED)	
Local recycling[a]	318 TAF/year for 20099 and 345 TAF/year for 2025 and 2060
Desalination[a]	1 TAF/year for 20099 and 57 TAF/year for 2025 and 2060
Transfers	
Colorado River transfers	Net Aqueduct Capacity (TAF) available at acquisition cost of $340, $398, and $565 in 2009, 2025, and 2060, respectively
San Joaquin Valley transfers	Single-year transfers as determined through interaction with CALSIM II at acquisition cost of $325, $385, and $517 per AF[d,e] for 2009, 2025, and 2060, respectively
Sacramento Valley transfers	Single-year transfers as determined through interaction with CALSIM II at acquisition cost of $197, $243, and $345 per AF[d,e] for 2009, 2025, and 2060, respectively
Regional Base Operations Cost	
Distribution cost	$24, $36, and $52 per AF for 2009, 2025, and 2060, respectively from CALFED, 1999
Treatment cost	$98, $99, and $100 per AF for 2009, 2025, and 2060, respectively from CALFED, 1999

	Future Baseline
Cost of Reuse and Deep Percolation	$30, $44, and $68 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
SWP Aqueduct Conveyance	
Groundwater bank	$35, $50, and $78 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
Regional conveyance	$155, $225, and $347 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
East Branch conveyance	$242, $350, and $542 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
Colorado River Aqueduct conveyance	
Groundwater bank	$81, $118, and $182 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
Regional conveyance	$102, $147, and $147 per AF for 2009, 2025, and 2060, respectively from Electricity Price Forecasts (DWR)
Annual Regional Base Use	
Urban demand target	4,236, 4,943, 6,008 TAF/year in 2009, 2025, and 2060, respectively
Regional Demand Reductions	
Conservation	211, 463, 650 TAF/year in 2009, 2025, and 2060, respectively
Precipitation	Ten station average annual rainfall 1884-2004 from National Weather Service[f]
Agricultural use	772, 652, 389 TAF/year in 2009, 2025, and 2060, respectively from DWR
Environmental use	34 TAF/year for all levels of development from DWR Water Portfolios (managed wetlands) 1998-2005
Regional Reliability Management Options	
Urban conservation	392 TAF/year interior and 380 TAF/year exterior increasing in cost up to $2,000/AF for 2025 and 286 TAF/year interior and 299 TAF/year exterior increasing in cost up to $2,000/AF for 2060
Water recycling	973 TAF/year for all levels of development increasing in cost from $692 to $2,470/AF for 2025 and from $723 to $2,501/AF for 2060
Desalination	280 TAF/year for all levels of development increasing in cost from $1,577 to $2,583/AF for 2025 and from $1,743 to $2,583/AF for 2060
Regional Ground and Surface Carryover Storage	
Reservoir operations	807 TAF of storage, put limit of 786 TAF/year, and take limit of 385 TAF/year from MWDSC
Groundwater storage	2,437 TAF of storage, put limit of 772 TAF/year, and take limit of 495 TAF/year from MWDSC
Colorado River Aqueduct groundwater banking operations	1,400 TAF of storage, put limit of 240 TAF/year in 2009 and 400TAF/year in 2025 and 2060 and a take limit of 396 TAF/year from MWDSC
Semitropic Project Delivery Constraint[g]	155 TAF of Table A allotment, 22 TAF of reserve Table A, 35% share of the bank, and 31.5 TAF base take available
Shortage Management Strategy	
Contingency Conservation Campaign	5.0% of net urban demand target[h,i]
Point at which transfers to depleted carryover storage are triggered	80% of each facility's annual take capacity

	Future Baseline
Shortage allocation rule cut ratio	Industrial user 25%, commercial user 50%, multi-family residential 60%, landscape user 200%[i,k]
Demand hardening factor	52, 33, and 25%[i,l] in 2009, 2025, and 2060, respectively
Rationing program threshold	80% non-interruptible shortage triggers rationing cost of $0.50/person[i]
Take call ratio for using contingency conservation	100% call on available carryover to meet net delivery with conservation reduction[i]
Capacity use ratio for using contingency conservation	20% of capacity[i,m]
Threshold for shortage allocation	Below a 95.0% level of shortage, all users will experience the same percentage reduction[i]
Inverse power function exponent for loss value adjustment	Inverse power function of 1.0[i,n]
Interruptible program delivery cutoff point	At 35% non-interruptible shortage level
Regional urban population	20,314, 23,435, and 28,076 in 2009, 0225, and 2060, respectively from DWR
Industrial customer size (% of total use)	2.6, 2.2, and 1.7% of total use in 2009, 2025, and 2060, respectively from WEAP Current Trends (DWR)
Commercial customer size (% of total use)	25.4, 25.5, and 25.6% of total use in 2009, 2025, and 2060, respectively from WEAP Current Trends (DWR)
Landscape customer size (% of total use)	5.8, 5.5, and 5.1% of total use in 2009, 2025, and 2060, respectively from WEAP Current Trends (DWR)
Multi-family residential customer size (% of total use)	16.9% of total use in 2009 and 2025 and 16.8% in 2060 from WEAP Current Trends (DWR)
Economic Loss Function	
Polynomial loss function[o]	$830 (intercept), coefficients b_1 = 22,269, b_2 = -14,693, b_3 = -3,148 for 2009; $1,037 (intercept), coefficients b_1 = 21,994, b_2 = -14,782, b_3 = -3,149 for 2025; $1,688 (intercept), coefficients b_1 = 2,1093, b_2 = -1,5069, b_3 = -3,150 for 2060 from MWDSC, 2005a

[a]A detailed description of the assumptions selection criteria and policy basis used is included in the Technical Memorandum: Characterization and Quantification of Water Management Actions (DWR).

[b]Colorado River Aqueduct deliveries consists of base appointment (550 TAF/year) + All American Canal and Coachella Canal lining (94 TAF/year) + Imperial Irrigation District Transfer Water to San Diego County Water Authority (200 TAF/year) + Palo Verde Irrigation District (25 TAF/year) + Imperial Irrigation District/MWDSC conservation program (85 TAF/year) – Quantification Settlement Agreement (20 TAF/year) – Coachella Valley Water District (35 TAF/year) – 47 CRW present perfected rights.

[c]In the San Francisco Bay Region–South, turnback from Table A and Article 21 is allocated to South Coast SWP water in LCPSIM.

[d]These values may change contingent on revisions to the Mann and Hatchett, 2006.

[e]Transfers costs are the average between Below Normal, Dry, and Critical year types. The cost shown is acquisition cost; delivered cost is higher because of Delta salinity and other operational losses.

[f]Historical rainfall records starting in 1883 are used to create a stochastic sequence for the hydrologic study period to estimate urban demand targets.

[g]The take limit for MWDSC from Semitropic is equal to the bank's pumping capacity (base take available) plus the product of MWDSC's percentage share of the bank and Semitropic's SWP Contract Table A delivery after subtracting Semitropic's reserved amount of that allocation.

[h]Shortage management strategies were developed using MWDSC, 1999.

[i]A specified reduction in use can be expected upon implementation of a contingency conservation program that includes such measures as increased watering regulations, increased water waste patrols, emergency water pricing programs, and intensive public education campaigns. Contingency measures to meet shortages are implemented only after shortages exceed 5% of total urban use.

[j]If storage falls below this threshold, transfers are implemented to augment storage. Sacramento River Region, San Joaquin River Region, and Tulare Lake Region transfers can be used for this purpose.

[k]User shortage percentage limited to X% of overall shortage percentage.

[l]Percentage increase in conservation (compared to base use levels) makes shortages effectively larger by 50% times the percentage increase in conservation.

[m]Limit on the fraction of carryover storage capacity filled before triggering contingency conservation.

[n]Adjustments to losses are made for shortage events with up to two intervening non-threshold years to account for residual damages.

[o]This model element assigns economic loss to foregone use.

Source: Information in the table was interpreted from various published and unpublished reports and mathematical modeling exercises. Some of this information is sensitive in nature and should be interpreted in the appropriate context. For further information regarding the information included here, please contact the California Department of Water Resources, Economic Analysis Section, Section Supervisor.

Table 22D-5
LCPSIM Model Revisions
Urban Water Supply Economics Modeling

Version	Update
97.0.0	Removes the general interior and exterior conservation effectiveness parameters from parameter file and uses an added column to the option file to input conservation effectiveness parameters for the individual conservation options.
96.8.0	Improves the logic for calculating applied water shortages in the LC Increment Results display and for testing for exceeding the limit for the effect of exterior conservation on reuse.
96.7.0	Adds code to constrain market transfers to include the effect of Mojave WA banking operations on aqueduct capacity.
96.6.2	Corrects aqueduct conveyance capacity constraint for transfers.
96.6.1	Changes net use output in View LC Increment Results display to shortage adjusted net use.
96.6.0	Corrects the calculation of the effect of variable exterior applied use on net use and the calculation of the contribution of reuse to the availability of applied water.
96.5.2	Gives the user a warning that the use of local options will be truncated when the number of increments exceeds the existing program limit of 201 increments. The user is asked to increase the increment size or reduce the range.
96.5.1	Corrects LC Increment Results output display error.
96.5.0	Adds the ability to manage a Mojave WA water bank for MWDSC.
96.4.0	Fixes calculation of applied water shortage for multi-family residential use.
96.3.0	Zeros out option increment size and use range parameters when all quantities in option file are zero (e.g., existing conditions). Corrects an array initialization bug that introduced an error when making a single iteration (i.e., existing condition) run after making a multiple iteration (i.e., future condition) run without first exiting and restarting LCPSIM.
96.2.0	Fixes calculation of average net supply in the LC Increment Results display. Fixes reporting of SWP energy use when iteration is not used (e.g., existing conditions).
95.5.0	Incorporates a parameter to reduce the cost of conservation by the avoided groundwater pumping cost associated with reusing that portion of the conserved water which would have gone to deep percolation.
95.4.2	Corrects the display of the incremental option costs when the “View Cost Curve/Base Balance” menu item is selected.
95.4.1	Displays a warning and won’t allow the user to enter an end point option use quantity greater than the sum of the regional option quantities.

Version	Update
95.3.6	Fixes a dynamic storage operation logic bug that creates a priority assignment error when storage operations have a zero balance. Changes summary output to display the use of regional options broken out into three categories: supply/reuse augmentation, average net demand reduction, and average applied demand reduction.
95.3.1	Corrects a problem that prevented the water market transfer cost-benefit QP from being correctly set up for the solver when the use of QP logic is selected for evaluating transfers.
95.2.0	Incorporates a parameter which sets the weight given to the fixed component of urban exterior use conservation as compared to the conservation component which is assumed to vary in proportion to urban exterior use. Corrects logic used to calculate effect of the adoption of conservation options on reuse.
95.0.1	Fixes a bug that occurred when project data files are changed and the project was not reloaded before running.

22D.3 Other Municipal Water Economics Model (OMWEM)

There are a large number of urban areas outside of the south bay and south coast that receive SWP or CVP supplies but are not included in LCPSIM. The Other Municipal Water Economic Model (OMWEM) estimates economic benefits of changes in SWP and CVP supplies in these areas. The model includes CVP M&I supplies north of Delta, CVP and SWP supplies to the Central Valley and the Central Coast south of Santa Clara County, and SWP supplies or supply exchanges to the desert regions east of the South Coast. Ten providers who use SWP water and eight providers who use CVP water are included. CVP contractors on the American River are currently not included. The model includes some agricultural use that could not be separated from urban use. All of this agricultural water use is not included in SWAP or other common assumptions economic models.

22D.3.1 Description

Each of the eighteen service areas in OMWEM are independent each other so their benefits are additive, but they are all analyzed in a similar way. The 2005 Urban Water Management Plans (UWMPs), where available, provided water demand and supplies for recent and future development conditions. The UWMP data were often inadequate, so other local water supply planning documents were used. Most UWMPs included demand forecasts from 2005 to 2025 at 5-year increments, and supply forecasts for 2005 and 2025.

Table 22D-6 provides SWP Table A, CVP contract amounts, and demand forecasts used to develop water balance. The model includes about 828,000 AF of SWP Table A or CVP M&I contract. The model allows the user to input a selected year for analysis, either 2009 or 2025. Interpolation is used where needed to develop demand and supply estimates for 2009 and 2025. Total 2009 demand in OMWEM is about 1.3 million acre-feet (MAF) of which about 400,000 AF is agricultural and turf irrigation in Coachella Valley and 86,000 AF is irrigation in San Benito County and Mojave Water Agency. Demand is estimated to increase to 1.564 MAF by 2025.

Table 22D-6
Agencies Included in OMWEM, their SWP and CVP Contract Amounts, 2009 and 2025 Demand Forecast
Urban Water Supply Economics Modeling

SWP Service Areas	SWP Table A, AF	2009 Demand, AF/YR	2025 Demand, AF/YR	Notes
Antelope Valley – East Kern Water Agency	141,400	99,656	107,599	UWMP 2025
Coachella Valley Water District	133,100	505,178	625,567	Includes about 300 TAF ag water; SWP supply is CRA water by exchange with MWDSC
Crestline – Lake Arrowhead Water Agency	5,800	4,300	6,100	UWMP 2025
Desert Water Agency	54,000	54,400	70,400	SWP is CRA water by exchange
Mojave Water Agency	75,800	112,580	124,100	Demand includes 12,500 of ag water. Table A includes 25 TAF bought from Berrenda Mesa
San Luis Obispo County FCWCD	8,447	5,258	6,350	See note 1
County of Santa Barbara FCWCD and Central Coast Water Agency	62,039	63,136	76,255	Sum of individual demand estimates Table A includes SLO transfer
Kern County Water Agency (SWP) ID #4	134,600	43,704	52,785	Demand from 2005 UWMP
Napa County FCWCD	29,025	25,565	30,877	Estimated from 2020 and 2050 forecasts
Solano County Water Agency	47,756	254,806	255,106	Lake Berryessa is major supply
TOTAL SWP	691,967	1,168,581	1,355,139	
CVP Service Areas	CVP contract, AF	2009 Demand, AF/YR	2025 Demand, AF/YR	Notes
City of Redding	27,140	27,940	36,000	2025, Table 36 and 37 in 2005 UWMP
City of Shasta Lake and Shasta CWA	5,422	4,240	8,100	Future demand assumed double current
City of West Sacramento	23,600	20,770	29,120	Page 4-2 UWMP
San Benito County	43,800	42,530	89,345	Includes 74,880 ag, 3,000 losses. 2022, GW EIS/R
City of Tracy	20,000	19,620	28,200	See Note 2.
City of Avenal	3,500	3,500	3,500	Assumed demand = contract
City of Coalinga	10,000	10,000	12,000	Assumed demand = contract
City of Huron	3,000	3,000	3,000	Assumed demand = contract
TOTAL CVP	136,462	131,600	209,265	
TOTAL SWP and CVP	828,429	1,300,181	1,564,404	

Notes:

SWP serves Morro Bay, Pismo Beach, Oceano CSD, many small users. Current demand and growth unknown, for most SWP Table A amount assumed to be demand

2005 UWMP includes Tracy M&I contract, other CVP contracts 58% reliable, 10,000 is SCSWSP pre-1914.

For each service area, water supply benefits are avoided costs of shortage or other supplies. The model mimics LCPSIM but with a more simple representation of supplies, supply options, shortage and shortage costs. Data on water supply costs are from local planning documents, where available. In many cases, water transfers are assumed to be the marginal supply. Water transfer costs are obtained from studies conducted for DWR (Mann and Hatchett, 2006 and 2007). The evaluation of M&I water supply changes in the San Joaquin Water Delivery Region is based on the availability and cost of groundwater. Additional water supply for M&I use is assumed to replace groundwater pumping.

Table 22D-7 shows other baseline supplies in the 2009 average condition, and Table 22D-8 shows these supplies in the 2009 dry condition. These supplies in the future condition are not appreciably different. Table 22D-9 shows the marginal cost of new supplies in the average condition.

Table 22D-7
Other Water Supplies, Average Condition, Primarily from 2005 UWMPs, Acre-feet per Year
Urban Water Supply Economics Modeling

SWP Table A holder	Surface water	Natural Ground Water	Other Ground Water	Recycled Water	Transfers	Other
Antelope Valley – East Kern Water Agency	0	0	0	0	0	0
Coachella Valley Water District	310,800	102,380	0	21,519	0	800
Crestline – Lake Arrowhead Water Agency	433	0	0	0	0	0
Desert Water Agency	2,740	7,250	11,810	5,370	0	0
Mojave Water Agency	0	65,500	0	0	0	0
San Luis Obispo County FCWCD	1,199	1,900	0	0	0	0
County of Santa Barbara FCWCD and CCWA	31,777	16,449	14,300	1,800	0	8,909
Kern County Water Agency (SWP) ID #4	0	0	0	0	0	0
Napa County FCWCD	20,914	0	0	0	0	3,105
Solano County Water Agency	207,350	0	0	0	0	0
TOTAL SWP	575,213	193,479	26,110	28,689	0	12,814
CVP Contract Holder						
City of Redding	0	19,000	0	0	0	0
City of Shasta Lake and Shasta CWA	0	0	0	0	0	0
City of West Sacramento	0	0	0	0	0	0
San Benito County	0	49,925	0	0	0	0
City of Tracy	10,000	4,400	0	0	0	6,500
City of Avenal	0	0	0	0	0	0
City of Coalinga	0	0	0	0	0	0
City of Huron	0	0	0	0	0	0

SWP Table A holder	Surface water	Natural Ground Water	Other Ground Water	Recycled Water	Transfers	Other
TOTAL CVP	10,000	73,325	0	0	0	6,500
TOTAL	585,213	266,804	26,110	28,689	0	19,314

Table 22D-8
Other Water Supplies, Dry Condition, Primarily from 2005 UWMPs, Acre-feet per Year
Urban Water Supply Economics Modeling

SWP Table A holder	Surface water	Natural Ground Water	Other Ground Water	Recycled Water	Storage Depletion	Other
Antelope Valley – East Kern Water Agency	0	0	0	0	0	0
Coachella Valley Water District	310,800	102,380	0	21,519	0	800
Crestline – Lake Arrowhead Water Agency	433	0	0	0	0	0
Desert Water Agency	2,800	7,250	11,450	6,000	0	0
Mojave Water Agency	0	65,500	0	0	0	0
San Luis Obispo County FCWCD	1,199	1,900	0	0	0	0
County of Santa Barbara FCWCD and CCWA	23,603	16,449	14,300	1,800	0	0
Kern County Water Agency (SWP) ID #4	0	75,000	0	0	0	0
Napa County FCWCD	6,165	0	0	0	6,904	2,486
Solano County Water Agency	186,615	0	0	0	0	0
TOTAL SWP	531,615	268,479	25,750	29,319	6,904	3,286
CVP Contract Holder						
City of Redding	0	19,000	0	0	0	0
City of Shasta Lake and Shasta CWA	0	0	0	0	0	0
City of West Sacramento	0	0	0	0	0	0
San Benito County	0	49,925	0	0	0	0
City of Tracy	9,000	2,500	0	0	0	6,833
City of Avenal	0	0	0	0	0	0
City of Coalinga	0	0	0	0	0	0
City of Huron	0	0	0	0	0	0
TOTAL CVP	9,000	71,425	0	0	0	6,833
TOTAL	540,615	339,904	25,750	29,319	6,904	10,119

Table 22D-9
Marginal Water Supply Costs, Average Condition, 2009 and 2025
Urban Water Supply Economics Modeling

Agency	Type of Marginal Supply	Unit net Total Cost of additional supply, $ per AF per year, not delivery	
SWP		**2009**	**2025**
Antelope Valley – East Kern Water Agency	Transfer/exchange	$272	$323
Coachella Valley Water District (SWP is CRA)	Additional CRA water	$340	$398
Crestline – Lake Arrowhead Water Agency	Transfer/exchange	$272	$323
Desert Water Agency (SWP is CRA)	Additional CRA water	$340	$398
Mojave Water Agency average	Regional Aquifer Project	$233	$337
San Luis Obispo County FCWCD	Desalination	$950	$1,375
County of Santa Barbara FCWCD	Desalination	$950	$1,375
Kern County Water Agency (SWP) ID #4	Expand SWP Conj. Use	$232	$336
Napa County FCWCD	Conjunctive use	$150	$186
Solano County Water Agency	Conjunctive use	$150	$217
CVP			
City of Redding	Groundwater	$100	$145
City of Shasta Lake and Shasta CWA	Transfer/exchange	$181	$224
City of West Sacramento	Groundwater	$100	$145
San Benito County	Transfer/exchange	$272	$323
City of Tracy	Buy local water	$200	$237
City of Avenal	Transfer/exchange	$184	$218
City of Coalinga	Transfer/exchange	$184	$218
City of Huron	Transfer/exchange	$184	$218

For a water supply scenario, the model accepts CALSIM II results in term of annual water supply as input. Rather than input time series of water supply for all eighteen providers, the model can also use an annual time series of SWP or CVP supplies expressed as percent of SWP Table A or CVP contract amount available. These percentages can be applied to the SWP Table A or CVP contract amounts to obtain the annual time series of deliveries.

22D.3.1.1 Model Logic

First, for each year and each agency, demand and supply quantities are used to achieve a water balance in the average water supply condition. If supply is insufficient to meet demand in the average condition, the amount and costs of additional water supplies are calculated. If the year type is below normal or wetter, the model calculates the cost of supply based on a unit value per AF for these year types. Cost data were generally obtained from the 2005 UWMP or other provider-specific sources. The model includes separate calculations for an average condition and a dry condition.

If the year type is dry or critical, the model allows for shortfalls to be eliminated with dry/critical supply sources and with end-user shortage. The incremental amounts and costs of additional supplies and shortage needed to achieve water balance in the dry condition are estimated.

If supplies are less than demand in the dry or critical year type, and the marginal water supply for the provider is a water transfer, then end-use shortages up to 5 percent are applied first (this priority mimics LCPSIM). Then, providers can acquire dry-year supplies to eliminate shortfalls up to 50 percent. These supplies have unit costs specific to the dry and critical condition. Thereafter it is assumed that end-users must take additional shortage.

If the marginal water supply for the provider is not a water transfer, then the 5 percent end-use shortage is not required first. The provider can eliminate a shortfall of up to 50 percent of demand using the dry/critical supply, but end-user shortage is used to cope with any larger shortfalls.

The model calculates shortage costs based on a constant elasticity of demand (CED) loss function with a demand elasticity of -0.1. A description of this shortage cost function is provided by M.Cubed (2007). This shortage function generates very high costs at high shortage levels. The marginal value of water from the CED function can be capped. The current cap is set at $7,000 per acre-foot year (AFY) more than the provider's retail water price.

Two model runs are required to compare a baseline and a with-project alternative. Results from a baseline scenario are saved as values and compared to results from the with-project scenario. The cost of water supplies required to obtain water balance in the baseline, without-project alternative average condition do not influence the incremental cost of supplies in the with-project alternative. In the dry and critical

condition, however, marginal costs of shortage increase with shortage. Therefore, the marginal value of additional supplies decline as supply increases.

22D.3.1.2 Discussion of individual water users

A separate detailed accounting by agency is included for the Central Coast region served by the SWP. The main purpose of the Central Coast worksheet is to isolate water balance information for those areas served by the SWP. Most of the urban water providers in this group are too small to require an UWMP. Model information is from local and regional plans. Water balance information is provided in Table 22D-10.

For Kern County Water Agency (KCWA), demand data for areas served by the SWP are not available because much SWP water is recharged and surface water and ground water are used interchangeably. Up to 53,000 AF of treated surface water will be provided around 2025, but groundwater will be available to meet demands if surface water is short. Therefore, economic calculations for KCWA are based on alternative costs of conjunctive use supplies only.

The SWP supplies for Coachella Valley (CVWD) and Desert Water Agency are not provided from the SWP delivery system. Rather, they are provided from the Colorado River through the CRA as an exchange with MWDSC. The amounts provided from the CRA to the two agencies are roughly equivalent to the amount they would obtain if they were connected to the SWP.

Table 22D-10
2030 Water Balance Information for Central Coast SWP Service Area, from Local Sources, AF per Year
Urban Water Supply Economics Modeling

Agency	Typical Demand[a]	2030 Demand	Surface Water	Natural Ground Water	Other Ground Water	Recycled Water	Other
Santa Barbara County							
Cachuma Project Area			25,714				
Carpintera Valley WD	2,122						
City of Santa Barbara	12,960		6,063	1,304		1,200	
City of Goleta Water District		17,010		2,350		1,000	
Montecito WD		8,000					
Santa Ynez River WCD ID #1	2,405						
Other							
City of Santa Maria		24,780		12,795	14,300		8,909
City of Solvang	1,277						
La Cumbre Mutual Water Co.	1,258						
California Cities Water Co.	375						
City of Buelton	806						
City of Guadalupe	574						
Morehart Land Co	150						
Raytheon Infrared	38						
Vandenberg AFB	4,500						
TOTAL Santa Barbara	**26,465**	**49,790**	**31,777**	**16,449**	**14,300**	**2,200**	**8,909**
San Luis Obispo County*							
City of Morro Bay	1,400		whalerock	300			645
Ca Men's Colony	400		whalerock				
Co Operations Center	425		whalerock				
Cuesta College	200		whalerock				
City of Pismo Beach	2,673		896	700			
Oceano CSD	750		303	900			
San Miguelito MWC	275		lopez				
Avila Beach CSD	100		lopez				
Avila Valley MWC	20		lopez				
San Luis Coastal USD	7		lopez				
Co of SLO CSA No 16-1	100						
TOTAL San Luis Obispo	6,350		1,199	1,900			

*For most assume demand=Table A

Antelope Valley East Kern (AVEK) has agricultural and urban water use, but the two are fairly well separated. "AVEK does not have production groundwater wells and has no plans to include groundwater pumping as a water supply. In previous years AVEK has made efforts to utilize groundwater to offset imported water deficiencies. These efforts were rejected by several of the larger AVEK purveyors…" (AVEK, 2005). Since agriculture does not receive surface water there does not appear to be an opportunity to reduce agricultural use to supply water for urban use unless urban users will take groundwater. Therefore, following a drought conservations savings, AVEK is assumed to tap water transfers for its additional supplies.

The Mojave UWMP adopts the same assumptions as their 2004 Regional Water Management Plan (RWMP), called agricultural scenario 2. Under this scenario “significant decreases in agricultural consumptive use” because “agriculture will voluntarily transfer its free production allowance to non-agricultural uses in lieu of purchasing replacement water” (MWA, 2005). Under this scenario, 12,500 AF of agricultural use remain by 2030. The Mojave UWMP states that the shortfall in a dry year would be met with demand management and increased reliance on stored groundwater. Therefore, low-value crops are the first demand to be reduced in shortage. Then, groundwater pumping is used to eliminate the rest of the shortfall.

In CVWD, M&I water supplies are not separated from agriculture, but almost all M&I water use is from wells. Most of the SWP exchange water is delivered to agriculture. Canal water and recycled water are used for golf courses and other landscape irrigation. Total 2030 demand is 320,800 AF agriculture, 92,400 AF golf course and other non-potable municipal, and 231,088 domestic. The 231,088 of demand would be met with groundwater (CVWD, 2005).

CVWD does have a water shortage contingency plan, so all users would be cut back in a severe shortage. However, their analysis of Water Service Reliability shows that shortages of SWP exchange water would be met entirely with increased groundwater pumping (CVWD, 2005). However, since the basin is managed, shortages in exchange water would require additional replenishment purchases later. CVWD can place an assessment on groundwater pumping to finance water purchases for recharge. The district did purchase water from Palo Verde in the shortage caused by the initial signing of the QSA (CVWD, 2005). Therefore, to be consistent with the UWMP, the entire SWP exchange deficiency should be made up by additional purchases of water in the CRA market. CVWD does not appear to be willing to idle lower value crops even if idling would provide the water at lower cost.

The primary areas that obtain urban water from the CVP are the City of Redding, the City of West Sacramento, Tracy and San Benito County. The San Benito water use is primarily agricultural. Relatively small amounts are modeled for Shasta Lake and the San Joaquin Valley cities of Avenal, Coalinga and Huron. UWMPs were not available for these smaller water users. Demands were assumed equal to contract amounts.

22D.4 References

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