Appendix Q - Attachment 2

Attachment Q.2 California Water Economics Spreadsheet Tool (CWEST) Model Documentation

This appendix documents the California Water Economics Spreadsheet Tool (CWEST) model used to support the impact analysis in the EIS. The CWEST version used for the EIS is an update to the version used in Final Environmental Impact Statement of the Coordinated Long-Term Operation of the Central Valley Project and State Water Project (Reclamation 2015). The methodology, assumptions, and key changes are provided.

Q.2.1 CWEST Model Methodology

The CWEST Microsoft Excel® spreadsheet model provides economic benefit and cost estimates associated with differences in delivery of SWP and CVP (project) municipal water deliveries between two or more scenarios provided by Calsim 3. Calsim 3 provides an annual time series of water deliveries for a scenario for almost all project water users. The time series are, typically, based on historical hydrologic time series but adjusted to a common level of development. The level of development reflects facilities in place, operations, and demand levels for a given year, recent conditions, or a future condition.

CWEST compares two or more scenarios in terms of economic benefits or costs realized by municipal water users. (Costs are generally the same as negative benefits so that costs and benefits can be added together). Costs include delivery and conveyance costs, groundwater pumping costs, groundwater recharge and extraction costs, water transfer acquisition costs, water sales revenue losses and customer shortage costs in dry years. In addition, each water user has a long-term water supply option which provides the same amount of water supply and has the same cost every year. For each annual time series of a user’s project water deliveries the model optimization finds the least-cost total cost solution for acquiring water supplies to meet demand where conservation and end-user shortage can be arts of the solution. The main metric produced by CWEST is the difference in annual average costs between the two Calsim scenarios.

For the LTO, a 2040 level of development is used with 2023 price levels. For the 2040 CWEST, data on 2040 demands and supplies from the most recent (2020) Urban Water Management Plans (UWMPs) were used to determine the net demand for project (SWP/CVP) supplies. One important exception is that Calsim 3 includes demand data for a large share of the agencies north of the Delta. For 14 out of 42 agency groups, the Calsim 3 demand data is used instead of the UWMP data.[1]

Q.2.1.1 CWEST Development History

CWEST was developed for analyzing the effect of water project operations and policy on urban water users in California. It was applied for assessing quantitative economic impacts for the Coordinated Long-Term Operation of the Central Valley Project and State Water Project and documented in Appendix 19A of the EIS of that project (Reclamation 2015). An update of that version of the model was also used for the 2019 Re-consultation EIS (Reclamation, 2019). The model has undergone two rounds of important revisions since that time. The following model description and assumptions highlight the recent revisions and data.

Q.2.1.1.1 2021 Revisions

ERA Economics first used the model as part of economic studies of Sites reservoir for the federal feasibility study. The CWEST model provided by Jacobs Engineering, CWEST_06192015_v6.xls, (hereafter, referred to as CWEST V6) is not the same model that was used for the 2015 LTO EIS. Upon initial review of CWEST V6, it was determined that additional work was needed to resolve inaccuracies in the model, update some of the calculations and macro code, and make the model consistent with Calsim outputs. The model required substantial modifications to address issues in the data/solver and to modify the economic parameters/logic in several ways so that it could be applied to the Sites project. The Reclamation team and the ERA project team agreed that ERA would proceed with additional effort required to revise, update, document, and apply the model to the Sites project.

The CWEST V6 model was modified in the following ways:

1. Water year indices in CWEST were changed to be historical rather than climate-change modified.
2. All M&I contractors in CWEST were included, consistent with Calsim outputs, so that all changes in deliveries for all contractors were modeled.
3. An apparent error was corrected in the water rate revenue loss calculations for conservation costs, removing an incorrect reference to the remaining shortage in the rate revenue loss calculation in the region-specific calculations.
4. The model used the standard Excel® optimization routine Solver to find the minimum supply and shortage cost given all other supplies. Preliminary analysis showed that Solver did not find the minimum cost supply mix, therefore the model was not finding an optimal solution, yet no error messages were provided. Solver options and initial conditions were adjusted to resolve the problem.

[1] The agencies are Yuba City, City of Redding, Shasta Lake/Shasta County Water Agency/Centerville Community Services District/Mountain Gate Community Services District/Shasta Community Services District, West Sacramento, Stockton-East Water District, Tracy, Avenal, Coalinga, Huron, Folsom, San Juan Water District, El Dorado Irrigation District, Roseville, and Elk Grove/SCWA/SMUD/Rancho Cordova/SCWA Laguna.

5. Water transfer average unit costs were adjusted for consistency with the State's Water Storage Investment Program (WSIP; see California Water Commission, 2016), reflecting more current statewide estimates of the water transfer market.
6. The model as provided did not constrain the amount of water transfers to M&I users in any way. Total transfers in the No Action condition exceeded 1 million acre-feet (AF) in some years. This was deemed unrealistic because this amount is substantially greater than observed historical transfers, local areas have policies in place to limit transfers, and other limits exist on the ability to convey those quantities of water that are not reflected in the CWEST modeling. MWDSC 2020 UWMP was reviewed and applied to limit Central Valley transfers to 50,000 AF annually. Transfers to other agencies in the model were adjusted in a similar manner based on current information stated in UWMPs. The limitations do not include supplies from an entity's share of groundwater banks in the Central Valley.
7. CWEST V6 allowed beginning MWDSC local surface water storage to be at full capacity of 892,000 AF. This was reviewed and set at half the capacity, 446,000 AF, based on current data.
8. MWDSC's 2020 UWMP shows available capacities of surface storage facilities with some capacity reserved for emergencies. Reservoir capacity was adjusted accordingly to reflect current data in the UWMP.
9. MWDSC's 2020 UWMP shows available capacity of takes from groundwater banks to be limited to in a five-year drought, and limited in critically dry years (e.g., 1977). A constraint was added to limit annual withdrawals in any critical year, or during either of the five-year extended droughts in the hydrologic sequence provided by Calsim.
10. MWDSC alternative supply costs were updated to reflect current conditions.

The 2021 changes to CWEST changed the nature of the model's response to new water supplies to be more consistent with current information. In particular, MWDSC costs increased due to reduced availability of inexpensive transfers in dry years. With more realistic water transfers, changes in supplies are largely optimized by changes in fixed-yield supplies: new groundwater development, recycling, conservation, desalination, and stormwater management.

Q.2.1.1.2 2023 Revisions

The current version of CWEST has been further revised for application to the 2023 LTO EIS. The major revisions are:

1. Calsim 3 now provides water deliveries for a 99-year hydrologic sequence, 1922 to 2020. CWEST has been modified to accept the longer time series.
2. The previous version of the model assumed a 2030 level of development. Data on water demand and non-project supplies were taken from 2010 Urban Water Management Plans (UWMPs). For the new CWEST, data on 2040 demand and non-project supplies were taken from 2020 UWMPs. Data are shown in Table Q.2-4. 2040 Supply and Demand Data (in AF) from 2020 UWMPs for Agencies Using UWMP Data in CWEST.
3. The model has been updated to use 2023 water price data as explained in section Q.3.2 and water transfer and water delivery cost data have been updated to 2023 costs using WSIP water transfer price estimates, Bulletin 132 and CVP rate sheets.

4. CWEST operates local water storage and recharge operations in MWDSC and for most Bay Area agencies. These operations have been updated for new projects.
5. Some amounts and costs of local fixed yield options have been changed based on 2020 UWMP information, real energy cost increases, and inflation.
6. All prices are updated for inflation to 2023 price levels. Water transfer prices have been updated to 2040 levels based on updates provided for the WSIP and are also expressed in 2023 dollars.
7. MWDSC maximum Sacramento Valley transfer is 50,000 AF as per their 2020 UWMP.
8. CWEST estimates how much of any Calsim delivery is unused. In the past, this water was valued at its delivery cost; that is, it was assumed that it was not used and did not incur any delivery cost. The model has been changed so that this water is valued at the avoided variable cost of groundwater pumping. That is, it is now assumed that this excess water can be used and that it can replace groundwater pumping.

More details about some of these changes are described in the following sections.

Q.2.1.2 Modeling Objectives

CWEST provides a transparent and flexible tool that is applicable to many studies. The EIS modeling objectives accomplished with CWEST include the evaluation of the following potential impacts:

- Effects on CVP and SWP M&I contractor costs and revenues
- Effects on end users from experiencing shortage costs
- Annual quantities of transferred water to CVP and SWP M&I contractors

Q.2.1.3 CWEST Methodology

CWEST is a representation of how CVP and SWP M&I contractors will meet current or future water demand levels at the lowest economic cost, subject to constraints. The model assumes that each CVP and SWP M&I contractor uses its contract delivery (modeled in Calsim version 2 or 3), local supplies, and imported water (if applicable) to meet annual demand. CWEST operates on an annual time step for the hydrologic period. In years where available project supplies are lower than demand, the CVP and SWP M&I contractor will use local stored supplies, purchase or transfer water on a market, or short its customers—all of which result in an economic cost. If these shortage costs happen often throughout the modeled hydrologic period, the least-cost solution for the CVP and SWP M&I contractor may include investment in additional fixed-yield supplies. This tradeoff between incurring shortage costs, using or acquiring short-term supplies, and investing in additional fixed-yield supply is the central economic optimization in CWEST.

CWEST uses water supply costs that represent the specific situation and supply conditions for each CVP and SWP M&I contractor. Transfer and groundwater pumping costs vary by contractor. All shortage costs are based on linear cost functions ($/AF costs) except for the end-user shortage costs. End user shortage cost is based on a constant elasticity demand function calculated from price, quantity, and short-run demand elasticity. The resulting cost function for retail water is non-linear; therefore, CWEST uses Excel Solver® to find the optimal mix of supplies and shortage, including the level of additional fixed-yield supply.

At least one fixed-yield supply is included for every agency to choose when optimizing. Types of projects include stormwater capture, conservation, recycling, groundwater development, or desalination. The Metropolitan Water District of Southern California (MWDSC) can choose from a number of fixed-yield project supply types, each with a increasing marginal cost function. The quantity of fixed-yield supply is a choice when optimizing and the cost for the new supply must be paid each year.

When annual supplies exceed demand, CWEST allows CVP and SWP M&I contractors to reduce groundwater pumping, put water into local or regional storage (if applicable), or turn back the water. Each CVP and SWP M&I contractor deals with excess water differently. Reduction in groundwater pumping results in a benefit based on the variable costs of groundwater pumping. In cases where the Calsim model provides more project water than a contractor's quantity demanded, CWest assumes that the contractor stores the water or uses it in lieu of groundwater pumping if possible. (see recent 2023 revisions described below). Fixed local supplies such as recycled water or desalination are not reduced in response to annual variation in project supply, even in years that it exceeds project water demand.

Q.2.1.4 CWEST Coverage

Individual CVP and SWP M&I contractors are grouped into geographic areas**.** Table Q.2-1 displays the CVP and SWP M&I contractors included in each area.

Table Q.2-1. CVP and SWP M&I Contractors Included in the EIS

Central Valley Region—Sacramento Valley	Central Valley Region—San Joaquin Valley	San Francisco Bay Area Region	Central Coast Region	Southern California Region
Bella Vista WD	Other Friant-Kern M&I contractors	Alameda County FC&WCD, Zone 7	San Luis Obispo Co. FC&WCD	Antelope Valley-East Kern WA
El Dorado Irrigation District	Avenal, City of	Alameda County Water District	Santa Barbara Co. FC&WCD	Castaic Lake Water Agency
Folsom, City of	Coalinga, City of	Contra Costa Water District	N/A	Coachella Valley Water District
Redding, City of	Fresno, City of	East Bay Municipal Utility District	N/A	Crestline-Lake Arrowhead WA
Roseville, City of	Huron, City of	Napa County FC&WCD	N/A	Desert Water Agency
Other Sacramento County users	Kern County Water Agency	San Benito County WD, Zone 6	N/A	MWDSC
San Juan Water District	Lindsay, City of	Santa Clara Valley Water District	N/A	Mojave Water Agency
Other Shasta Area Communities	Orange Cove, City of	Solano County Water Agency	N/A	Palmdale WD & Littlerock Creek ID
West Sacramento, City of	Stockton East Water District	N/A	N/A	San Bernardino Valley MWD

Central Valley Region—Sacramento Valley	Central Valley Region—San Joaquin Valley	San Francisco Bay Area Region	Central Coast Region	Southern California Region
Yuba City, City of	Tracy, City of	N/A	N/A	San Gabriel Valley MWD
N/A	N/A	N/A	N/A	San Gorgonio Pass Water Agency
N/A	N/A	N/A	N/A	Ventura County WPD

CSD = Community Services District; FC = Flood Control; ID = Irrigation District; MWD = Municipal Water District;
WCD = Water Conservation District; WA = Water Agency; WD = Water District;
MWDSC = Metropolitan Water District of Southern California

Some CVP contractors with a predominantly irrigation water contract also serve some municipal users but are not included in the list above.

Q.2.2 CWEST Assumptions

Each of the EIS alternatives were evaluated under the same set of local supply, demand, and cost assumptions for 2040 conditions. The only model input that varied across alternatives is the Calsim 3 CVP and SWP M&I contractor delivery data.

Q.2.2.1 2040 Demand and Non-Project Supplies

CWEST calculates costs based on a share of demand and supply in each agency. The share of demand met by fixed local supplies, or demand that cannot be served by the projects, is excluded where possible. Data were obtained from DWR's Urban Water Management Plan database (2023) and from Calsim. For most agencies, their 2040 demand estimate is reduced by the amount of supply provided by non-project sources so that the remaining demand is that share that could be met by project deliveries.

The agencies included in CWEST and their CVP or SWP contract amounts are shown in Table Q.2-2 below.

Table Q.2-2. SWP and CVP M&I Users Included in Calsim 3 and CWEST, and their Contract Amounts in Calsim 3 [a]

Contractor	Type	Contract Volume (TAF)
Yuba City	SWP M&I Service	9.60
Antelope Valley-East Kern WA	SWP M&I Service	144.84
Palmdale WD	SWP M&I Service	21.30
Littlerock Creek ID	SWP M&I Service	2.30
Mojave WA	SWP M&I Service	89.80
San Gorgonio Pass WA	SWP M&I Service	17.30

Contractor	Type	Contract Volume (TAF)
Desert WA	SWP M&I Service	55.75
Coachella Valley WD	SWP M&I Service	138.35
San Bernardino Valley MWD	SWP M&I Service	102.60
Crestline-Lake Arrowhead WA	SWP M&I Service	5.80
San Luis Obispo Co FC&WCD	SWP M&I Service	25.00
Santa Barbara Co FC&WCD	SWP M&I Service	45.49
Kern County WA	SWP M&I Service	134.60
Napa County FC&WCD	SWP M&I Service	29.03
Solano County WA	SWP M&I Service	47.76
City of Vacaville	SWP M&I Service	18.00
City of Redding	CVP Settlement	26.00
Bella Vista WD	CVP M&I Service	11.00
Shasta M&I contractors	CVP M&I Service	9.00
Stockton East WD	CVP M&I Service	75.00
Avenal, Coalinga, and Huron- M&I (Reach 7)	CVP M&I Service	16.50
City of Folsom	CVP M&I Service	18.29
San Juan WD	CVP M&I Service	41.00
El Dorado ID	CVP M&I Service	7.55
City of Roseville	CVP M&I Service	32.00
Sacramento County WA	CVP M&I Service	20.00
Sacramento County WA (Laguna)	CVP M&I Service	12.00
Elk Grove WSC	CVP M&I Service	7.00
Rancho Cordova	CVP M&I Service	14.00
SMUD	CVP M&I Service	17.00
City of Fresno	Friant-Kern Class 1	60.00
City of Lindsay	Friant-Kern Class 1	2.50
City of Orange Cove	Friant-Kern Class 1	1.40
Contra Costa WD	CVP M&I Service	140.00
City of Tracy	CVP M&I Service	30.00
Zone 7 WA	SWP M&I Service	80.62
Alameda County WD	SWP M&I Service	29.51
East Bay MUD	CVP M&I Service	Varies
Santa Clara Valley WD	SWP M&I Service	100.00
San Felipe M&I	CVP M&I Service	127.65
Metropolitan Water District of Southern CA	SWP M&I Service	1911.50
Ventura County FCD	SWP M&I Service	20.00
Santa Clarita Valley WA	SWP M&I Service	82.50

Contractor	Type	Contract Volume (TAF)
San Gabriel Valley MWD	SWP M&I Service	28.80

[a] Contract amounts not used directly by CWEST. Deliveries may be enabled by exchange.

Calsim 3 includes demand data for 14 urban agencies, most of them north-of-Delta. The demands are expressed as net demand for project supplies. These data are used in CWEST because CWEST demands should be consistent with Calsim demands. The agencies involved, their Calsim 3 demand amounts and their 2040 dry year demand used in CWEST are provided in Table Q.2-3 below. Dry year 2040 total demand is required for demand function and shortage cost calculations for these agencies. These data are from the UWMPs.

Table Q.2-3. Project Water Demands and Dry Year Total Demand for Agencies with CWEST Using Calsim 3 Demands, in AF

Contractor	2040 demand served	2040 dry year demand
Yuba City, City of	9,000	18,722
Redding, City of	26,000	25,668
City of Shasta Lake, Shasta County WA, Centerville CSD, Mountain Gate CSD, and Shasta CSD	8,999	2,785
Bella Vista	10,053	20,072
Stockton-East Water District	58,999	81,378
Tracy, City of	30,000	32,603
Avenal, City of	3,500	3,500
Coalinga, City of	10,001	6,017
Huron, City of	3,000	3,000
Folsom, City of	34,000	25,145
San Juan Water District	41,000	54,820
El Dorado Irrigation District	8,999	44,740
Roseville, City of	32,000	62,547
Elk Grove, SCWA, SMUD, Rancho Cordova, SCWA Laguna	53,998	84,183

CWEST uses separate demand and non-project supply estimates for a normal condition, and for a dry condition. For those agencies in Table Q.2-3, Calsim 3 and CWEST do not differentiate dry-year and normal-year demands.

Table Q.2-4 (attached) shows the other agencies and their demands and supplies in CWEST using UWMP data. The dry condition used in the 2020 UWMPs is a five-year drought. The dry condition assumptions are used for three five-year droughts (1929 to 1934, 1987 to 1992 and 2012 to 2016), as well as any other critical year as provided by the Sacramento River Index (for

CWEST Sacramento Valley and Bay Area regions) and by the San Joaquin River index for other regions.

CWEST models some local water storage operations in MWDSC and the Bay Area. These supplies are not included in Table Q.2-4 and are discussed separately below.

From the Table Q.2-4 data, some agencies do not have a defined need for project water in 2040. These agencies are United Water Agency in Ventura County, Desert Water Agency, Coachella Water District, San Luis Obispo County, City of Santa Barbara, Yuba City, Kern County Water Agency, and City of Fresno. For these agencies, project water deliveries are valued using the larger of project water delivery cost or the avoided cost of groundwater pumping.

Q.2.2.2 2023 Retail Prices

Water prices are used for water revenue losses and customer shortage costs. The model can choose shortage as a least-cost way to cope with inadequate supplies. The costs of shortage are the water net revenue loss for the provider and the customer shortage cost. The shortage quantity times price is the revenue loss. Net revenue is net of CVP or SWP charges and delivery (conveyance) cost. The customer benefits from the reduced water cost, but this loss is offset by the reduced benefit caused by the lost use of the water. For the customer, the net loss is the lost "consumer surplus," CWEST estimates constant elasticity demand functions for each agency based on dry-year demand quantity, the retail price, and an assumed short-run elasticity of demand of -0.1. The consumer surplus loss is estimated as a linear approximation of the area below the demand function but above the price.

Table Q.2-4. 2040 Supply and Demand Data (in AF) from 2020 UWMPs for Agencies Using UWMP Data in CWEST

Location	2040 Normal Demand	2040 Normal Non-Project Supplies	Net Normal Demand	2040 Dry Demand	2040 Dry Non-Project Supplies	Net Dry Demand	Notes: Unless specified, referenced table numbers are from the DWR Water Use Efficiency Data Portal (https://wuedata.water.ca.gov/)
MWD of Southern California	3,936,000	2,836,000	1,100,000	3,974,000	2,713,000	1,261,000	Normal from page 2-14. Dry from 2-13.
United WCD (5 TAF SWP)	7,265	7,265	0	7,265	7,265	0	Casitas and Ventura cannot receive SWP now. Normal demand from 4-3. Normal non-project supplies from 6-9. Dry demand and non-project supplies from 7-4.
Castaic Lake WA (Santa Clarita)	100,448	60,245	40,203	95,782	60,887	34,895	Normal demand and supply from 4-3 and 6-9. Supply is all supply minus SWP supply. Dry demand from DWR Table 7-4, supplies from p. 7-16 of UWMP.
San Gabriel Valley MWD	15,345	0	15,345	19,638	0	19,638	Normal demand from 4-3. Supplies are all from SWP per data tables. Dry demand from 7-4. Supplies are all from SWP per data tables.
Antelope Valley-East Kern WA	55,210	6,050	49,160	55,210	15,078	40,132	Normal demand from 4-3, supply from 6-9. Dry demand from 7-4, dry supply projections table 7-3 page 7-7. Assuming same as 2025 for now.
Palmdale WD & Littlerock Creek ID	24,780	24,295	485	24,780	21,195	3,585	Normal demand from 4-3, normal supply from 6-9 (less SWP). Dry demand from 7-4, dry supply from 7-4 (less SWP). Multiple dry year SWP from page 4-12. Some demand (1300 AFY) includes 'sales to other agencies,' most of which is to AVEK, only a few AF to LCID.
Mojave Water Agency	140,200	112,603	27,597	140,200	112,603	27,597	Normal demand from 4-3. Reported managed basin supplies in this dataset inconsistent with UWMP - corrected. On page 3-21. Dry demand from 7-4.
San Gorgonio Pass WA	38,100	31,166	6,934	38,100	34,636	3,464	Normal demand from 4-3. Normal supplies from 6-9, less SWP water. SWP Table A listed in Table 3-17 on page 3-31. Dry demand from 7-4 and dry supplies from 7-4, less SWP water. SWP Table A listed in Table 3-17 on page 3-31.
Desert WA	43,907	43,907	0	43,907	43,907	0	Only source listed is groundwater.
Coachella Valley WD	158,982	158,982	0	158,981	158,981	0	Only source listed is groundwater.
San Bernardino Valley MWD	65,452	0	65,452	52,972	0	52,972	Normal demand from 4-3. Supply in database shows everything as either SWP or sites, so setting as 0 here. Numbers match Part 4 / Appendix A of the UWMP. Dry demand from 7-4.
Crestline-Lake Arrowhead WA	375,399	270,681	104,718	300,683	190,490	110,193	Normal demand from 4-3. Combination of Crestline Village and Lake Arrowhead CSD. Supply data for Lake Arrowhead from 6-9 (less CLAWA, i.e., SWP). Supply data for Crestline updated from UWMP submittal table 6-9 to include groundwater supply (the rest is CLAWA water i.e., SWP, and not included). Dry demand for Lake Arrowhead from 7-4. Percent of groundwater in dry years is in DWR submittal Table 7-1. For Lake Arrowhead, 50 AF is SWP supply in each dry year per table 8.5 in the UWMP.
Contra Costa Water District	171,300	56,700	114,600	171,300	55,309	115,991	Normal demand from 4-3. Normal supply from 6-9, all supplies less CVP. Dry demand from 7-4. For dry supply, UWMP page 6-24, table 6-9W

Location	2040 Normal Demand	2040 Normal Non-Project Supplies	Net Normal Demand	2040 Dry Demand	2040 Dry Non-Project Supplies	Net Dry Demand	Notes: Unless specified, referenced table numbers are from the DWR Water Use Efficiency Data Portal (https://wuedata.water.ca.gov/)
							shows the expected percent and amount of CVP water in dry years 1, 2, 3. Later shown that dry years 4 and 5 are same as 3.
Alameda County WD	60,200	47,400	12,800	56,720	50,040	6,680	Normal demand from 4-3. Normal supply from 6-9 (less SWP). Dry demand from 7-4. Dry supplies from submittal table 7-1 and page 3-5 in UWMP.
Alameda County FCWCD, Zone 7	55,300	29,700	25,600	55,300	47,520	7,780	Normal demand from 4-3. Normal supply from 6-9, all supplies less SWP and Sites. Dry demand from 7-4. Dry supply data from 7-1. Incudes desalination water and Cawelo storage. Does not include Semitropic.
Lindsay, Orange Cove, other FK	--	--	--	--	--	--	No UWMPs so demand is set to contract and other supplies are 0
San Luis Obispo County FCWCD	8,730	8,730	0	8,389	8,389	0	Normal demand from 4-3, normal supply from 6-9. Page 1-5 - "Zone 3 does not have a contract to receive water from the Sacramento-San Joaquin Delta through the State Water Project. Dry demand and supply from 7-4.
Santa Barbara, City of	14,719	20,768	0	14,130	19,175	0	Normal demand from 4-3, normal supply from 6-9. Dry demand and supply from 7-4 - for dry year SWP water, used midpoint of value range reported on page 5.
Kern County Water Agency	65,600	79,645	0	65,600	89,497	0	Normal demand from 4-3, normal supply from 6-9. Supply includes banked water recover, not SWP supply. Dry demand from 7-4. Dry supplies from 7-4, less SWP allocation (M&I allocation = 77,000 AF). Five-year consecutive drought SWP allocation percentages from page 55.
Napa, City of	16,425	17,475	0	16,425	9,987	6,438	Normal demand from table 4-3. Normal supply from 6-9, less SWP supplies. Dry demand from 7-4. Dry supply from 7-4, less SWP water. SWP Table A water in multiple dry years on page 7-7 of UWMP.
Fresno, City of	246,096	292,000	0	214,283	248,082	0	Normal demand from 4-3. Normal supply from 6-9, less USBR CVP. Dry demand from 7-4. Dry supply from UWMP - 5-year drought supply estimates in table 7-3 on page 7-6.
East Bay Municipal Utilities District	239,870	239,870	0	193,297	137,495	55,801	Taken all from UWMP: CVP contract information from pg. 13. Supply and demand information available on Table W-3. Assuming Mokelumne River for surface water, demand based on 15% rationing (demand in 5-yr drought not explicitly listed).
Solano County WA	1,082	658	424	1,082	658	424	No UWMP for Solano County WA posted, so using the one for Suisun - Solano Water Authority. Projected demands from Table 4.2 on page 36. Projected supplies from page 65 table 6.9. Based on Table 7.4 on page 79, supply and demand are the same during drought.
Santa Clara Valley Water District	333,400	454,000	0	335,000	316,200	18,800	Normal demand from 4-3, normal supplies from 6-9. Table 6-5 on page 40 separates 'imported water' from SWP/CVP for normal year, subtracted from both normal supply and dry supply. Dry demand and supplies from 7-4. Table 6-5 on page 40 separates 'imported water' from SWP/CVP for normal year, subtracted from both normal supply and dry supply.

Location	2040 Normal Demand	2040 Normal Non-Project Supplies	Net Normal Demand	2040 Dry Demand	2040 Dry Non-Project Supplies	Net Dry Demand	**Notes:** **Unless specified, referenced table numbers are from the DWR Water Use Efficiency Data Portal** (https://wuedata.water.ca.gov/)
San Benito County Water District, Zone 6	6,765	0	6,765	9,771	0	9,771	Normal demand from 4-3. This dataset shows all CVP water - UWMP also shows some groundwater and higher demand, but estimated net demand for CVP is similar. Dry demand from 7-4. This dataset shows all CVP water - UWMP also shows some groundwater and higher demand, but estimated net demand for CVP is similar.

MWDSC fixed yield options include conservation. For MWDSC, dry-year demand is reduced by this conservation quantity. Conservation cost includes an implementation cost as well as the revenue loss caused by conservation. Customers benefit from conservation by reduced water cost but it is assumed that this benefit is offset by customer conservation costs.

Previous versions of CWEST used the 2006 Black & Veatch California Water Rate Survey. ERA Economics undertook a review of current water rates using several sources. More recent data summaries were reviewed (California State Water Board, 2020; Raftelis Financial Consultants, Inc. 2015; Black & Veatch Management Consulting, LLC 2019) but none of these were complete or dated to 2023. Therefore, ERA compiled information provided on the websites of each agency. Most agencies have a variety of different rates for different meter sizes and price tiers are often used. For each agency, a representative water price, normally the retail price paid by most residential customers, was used. This price should be most accurate for water shortage cost calculations because residential customers are most often targeted for emergency savings. In many cases, a CWEST agency provides wholesale supplies to more than one retail agency. In these cases, price data from one retail agency, normally the largest, is used in CWEST. As prices were collected in 2023 so no price updating was required. However, recent history suggests that retail water prices will increase faster than inflation to 2040. Based on data from MWDSC, a real rate of increase of 1.364 percent per year is assumed. Retail price assumptions are shown in Table Q.2-4.

Q.2.2.3 Groundwater Pumping Costs

CWEST includes reduced groundwater pumping as a way to utilize project water, and any unused water deliveries from Calsim are valued at the larger of groundwater variable pumping cost or project water delivery cost. Table Q.2-4 shows groundwater pumping costs. These were developed from estimates for each region and are updated to 2040 dollars assuming a real cost increase of 1.7 percent per year. This rate of increase is based on real energy cost increases forecast by the California Energy Commission (2013).

Q.2.2.4 Project Water Delivery Cost

All project water incurs a delivery cost. CWEST includes only the variable component of water delivery charges. Water delivery costs are from Bulletin 132-10 Table B-24 and from CVP M&I rate sheets. The SWP variable delivery cost is the variable OMP&R plus the off-aqueduct component. For CVP water the Cost of Service rate is used. Costs are updated to 2040 dollars assuming a 1.7 percent real increase annually and are expressed in 2023 dollars. Project water delivery costs are shown in Table Q.2-4.

Q.2.2.5 Local Storage Operations

CWEST operates certain surface and groundwater storage operations in MWDSC, the Bay Area and Stockton East. The Bay Area includes local groundwater storage and Semitropic Water Bank storage for Santa Clara Valley Water District, Zone 7, and Alameda County Water District. Storage operation costs for MWDSC are based on information provided in its Water Surplus and Drought Management Plan (MWDSC, 1999). Semitropic Water Storage District’s published put and take costs for banking operations are used in CWEST in addition to the delivery cost to each banking partner (SWSD 2014). Local groundwater storage operation costs used by San Francisco Bay Area Region CVP and SWP M&I contractors and Stockton-East Water District are based on their groundwater costs.

The following changes are included for the 2040 model:

- In the Bay Area, maximum take from Semitropic has been changed to be based on the Semitropic SWP allocation. Maximum take for these upstream agencies in any year is limited by the amount of SWP water Semitropic is allocated.
- In MWDSC, weighted average put and take amounts and costs have been modified to exclude Mojave, which is no longer operational, and to include the Hi-Desert Groundwater Bank project. The use of this weighted average costs and the conjunctive use operations is a simplification; individual banks are not modeled. "Hi Desert Bank" Storage is 280,000 AF, maximum put or take is 70,000 AF. Capital cost will be sunk. O&M costs are uncertain. A $100/AF take fee plus $100/AF actual O&M is assumed with no put fee. (Metropolitan 2023).
- Storage operation put and take costs are updated to 2040 levels for a real energy cost increase of 1.7 percent annually, plus inflation to 2023.
- Assumptions about storage capacities and costs are shown in Table Q.2-5 and Table Q.2-6.

Table Q.2-5. MWDSC Groundwater and Surface Storage Features (in TAF) Included in CWEST

	Beginning storage	**Storage Capacity**	**Put Capacity**	**Take Capacity**	**Put Cost, $/AF 1**	**Take Cost, $/AF 1**
GROUNDWATER STORAGE WITH PUT/TAKE COSTS						
Semitropic	175	350	45.2	50	$74	$159
Arvin Edison	175	350	111.1	75	$116	$162
Kern Delta	125	250	56.2	50	$47	$113
Mojave Storage Program	0	0	0	0	$0	$0
Hi Desert Bank	140	280	70.0	70	$0	$200
Conjunctive Use programs	106	212	62.0	70	$0	$100
Total, CWEST Assumption	**721**	**1,442**	**344.5**	**265**	**$55**	**$176**
Costs in 2040 averaged over banks and updated to 2023 dollars					$128	$412
Maximum take from all banks during drought, 2020 UWMP, annual limit in a critical year or 5-year drought				257	0	0
SURFACE STORAGE AND STORAGE WITH NO PUT/TAKE COSTS						
Castaic Lake	77	154	154	154	0	0
Lake Perris	32.5	65	65	65	0	0
Diamond Valley	271	542	400	400	0	0

	Beginning storage	Storage Capacity	Put Capacity	Take Capacity	Put Cost, $/AF 1	Take Cost, $/AF 1
Lake Mathews	50	100	100	100	0	0
Lake Skinner	5	10	10	10	0	0
Cyclic Storage	120	240	240	240	0	0
Total	**555.5**	**1,111**	**969**	**969**	**0**	**0**
CWEST assumption, no Perris or Castaic included	446	892	750	750	0	0

[a] Unit costs shown for individual banks are before updating to 2040 costs and 2023 prices. Average put and take costs used in CWEST are $128 and $412 per AF, respectively.

Table Q.2-6. Other Local Storage (in TAF) and Cost Operated in CWest

Storage Owner	Location	Storage Capacity	Ave. Natural Recharge	Put Capacity	Take Capacity	Recharge Cost $/AF	Take Cost $/AF
SCVWD	Local Basins	530	60.0	146.5	200.0	$17	$34
	Semitropic	350	0	44.5	45.6	$59	$231
	Total	**880**	**60.0**	**191.0**	**245.6**	**0**	**0**
Zone 7	Main Basin	126	13.4	20.0	26.2	$17	$34
	Cawelo	120	0	5.0	10.0	$59	$231
	Semitropic	78	0	8.3	11.7	$59	$231
	Total	**246**	**13.4**	**25.0**	**36.2**	**0**	**0**
EBMUD	Local Terminal	151.67	0	100.0	100.0	$59	$231
ACWD	Semitropic	150	0	19.1	19.5	$59	$231
Stockton East	Local	100	0	70.0	0	$86	0

Q.2.2.6 Local Fixed Yield Options

The model selects a level of feasible fixed yield option that minimizes total water and shortage cost. These options supply the same amount of water every year and incur a fixed cost every year. The model uses a single fixed yield and fixed unit cost option for most water agencies.

For Zone 7 and ACWD, step functions for fixed yield options are included based on information provided in their planning documents.

For MWDSC, an increasing average cost function was developed based primarily on MWDSC documents with some information provided by LADWP and local stormwater management documents. It is reasonable to assume that implementation since 2010 has emphasized lower-cost options. Therefore, the size or number of options remaining should decrease and the average cost should increase. However, MWDSC’s 2020 UWMP includes estimates for additional potential for desalination, recycling and groundwater recovery that are more than the amounts allowed by the previous version of CWEST. Apparently, more options have been developed since 2010. On balance, there is no rationale to change the amounts of MWDSC fixed yield options available. For stormwater, much has been implemented in the last 10 years. CWEST assume that only 30 TAF of the original 2010 potential of 75 TAF remains.

It is presumed that more of the lesser-cost options have been implemented in the last 10 years. Therefore, minimum real costs are increased. The minimum conservation cost is increased from $192 to $500 per AF. For desalination, one recent source shows that desalination costs at Carlsbad have increased to $2,725 per AF.

Other fixed yield costs are increased by 20 percent for 2040 conditions. All costs are also increased to 2023 price levels using the GNP Implicit Price Deflator except that the initial desalination cost was already provided in 2023 dollars. Fixed yield option costs are shown with price data in Table Q.2-4.

Q.2.2.7 Temporary Supplies

Water agencies also have temporary supplies available. Generally, these are water transfers. Water transfer prices are based on analysis conducted for the Water Supply Investment Program. 2040 prices reflect the influence of SGMA. Prices are updated to 2023 dollars. Prices and maximum availability assumed for each agency are shown in Table Q.2-4.

Q.2.2.7.1 Shortage Costs

Shortages in critical years are handled in an approach that represents common behavior of CVP and SWP M&I contractors. CWEST requires that a 5% end-use drought conservation shortage be implemented before any annual supply is purchased in critical year. Then, a provider can eliminate a shortfall using dry/critical year annual supply.

Shortage costs are lost water net revenue plus end-user shortage costs. Revenue losses are based on the water prices displayed in Table Q.2-7. The model calculates shortage costs based on a constant elasticity of demand (CED) demand function. This form of shortage loss function is standard practice in California water economics studies and has documented descriptions (U.S. Department of the Interior, Bureau of Reclamation, 1997; M.Cubed 2007). The 2040 dry condition demand levels in Table Q.2-4 and the price in Table Q.2-4 define one point on the demand function, and the slope is defined by the price elasticity.

The short-run demand price elasticity assumed for all providers is -0.1. This elasticity represents a demand elasticity appropriate for drought conditions. A variety of studies have found short-run price elasticities in the range of -0.1 to -0.3 (Thomas and Syme 1988, Chesnutt et al. 1997). Urban price elasticity in California is generally believed to be even more inelastic than national averages because of demand hardening, meaning that many actions that people could use to reduce water use in response to shortage will already have been implemented by 2040.

This shortage cost function generates very high costs at high shortage levels, so CWEST can limit the marginal value of water from the CED function. The current cap is set at $7,000 per acre-foot year (AFY) more than the provider's retail water price.

Table Q.2-7. CWEST Assumptions for Retail Prices, Annualized Cost of Fixed Yield Supplies, Groundwater Pumping Cost, and Cost and Maximum Availability of Temporary Supplies

Location	2040 Retail Water Price, $/AF	$/AF Cost for Fixed Yield Project Supply 2023 $	Groundwater Pumping Cost, $/AF	Project Water Delivery Cost, $/AF	Temporary Supply				Transfer Limit, Quantity, TAF
					Below Normal or Better Cost	Below Normal or Better Type	Dry or Critical Cost	Dry or Critical Type	
SOUTH COAST									
MWDSC	$4,473	See Text	$137	$145	$553	Transfer	$1,494	Transfer	50
Ventura County WPD	$3,658	$1,510	$137	$267	$676	Project	$1,000	N/A	0
Castaic Lake WA	$1,300	$1,510	$137	$267	$676	Transfer	$1,617	Transfer	10
San Gabriel Valley MWD	$2,490	$1,510	$137	$161	$569	Cyclic Storage	$1,510	N/A	10
Antelope Valley-East Kern W.A.	$1,316	$812	$257	$173	$830	Pump GW	$1,269	Transfer	20
Palmdale Water District & Little Rock Creek	$1,316	$885	$257	$246	$903	Pump GW	$1,342	Transfer	5
Mojave Water Agency	$2,613	$1,427	$257	$287	$945	Pump GW	$1,384	Transfer	5
San Gorgonio Pass Water Agency	$687	$1,140	$257	$457	$1,114	Pump GW	$1,553	Transfer	5
Desert W.A.	$1,250	$833	$257	$168	$552	CRA water	$552	CRA Transfer	5
Coachella Valley W.D.	$1,969	$462	$257	$210	$552	CRA water	$552	CRA Transfer	5
San Bernardino Valley MWD	$1,108	$876	$257	$193	$850	Transfer	$1,289	Transfer	5
Crestline-Lake Arrowhead W.A.	$1,108	$1,292	$257	$198	$856	Transfer	$1,295	Transfer	5
BAY AREA									
CCWD	$3,532	$2,265	$86	$42	$451	Transfer	$1,392	Transfer	20
Zone 7 Water Agency	$2,394	Variable	$86	$52	$460	Transfer	$1,401	Transfer	10
ACWD	$2,621	Variable	$86	$36	$444	Transfer	$1,385	Transfer	10
EBMUD	$3,466	$2,265	$50	$143	$551	Transfer	$1,492	Transfer	20
Santa Clara Valley WD	$4,766	$3,253	$86	$31	$439	Transfer	$1,380	Transfer	20
San Benito County WD, Zone 6	$3,477	$864	$86	$48	$456	Transfer	$1,397	Transfer	10
Napa County F.C.&W.C.D.	$2,506	$555	$161	$32	$367	Transfer	$909	Transfer	5
Solano County W.A.	$1,667	$1,028	$152	$23	$680	Transfer	$900	Transfer	5
SACRAMENTO VALLEY									
City of Yuba City	$1,113	$735	$129	$0	$129	Pump GW	$877	Transfer	5
City of Redding	$872	$735	$129	$56	$129	GW	$933	Transfer	5
Shasta Area[1.]	$1,530	$1,008	$129	$116	$667	Transfer	$993	Transfer	5
Bella Vista	$1,333	$670	$86	$46	$86	Groundwater	$923	Transfer	5
City of Roseville	$795	$759	$86	$46	$381	Transfer	$923	Transfer	5
Sacramento Agencies [2.]	$702	$670	$86	$48	$86	GW	$925	Transfer	5

Location	2040 Retail Water Price, $/AF	$/AF Cost for Fixed Yield Project Supply 2023 $	Groundwater Pumping Cost, $/AF	Project Water Delivery Cost, $/AF	Temporary Supply				Transfer Limit, Quantity, TAF
City of Folsom	$828	$552	$86	$45	$86	Transfer	$922	Transfer	5
San Juan W.D.	$505	$552	$86	$45	$380	Transfer	$922	Transfer	5
El Dorado ID	$1,092	$670	$86	$45	$86	GW	$922	Transfer	5
1. City of Shasta Lake and Shasta CWA Centerville CSD, Mountain Gate CSD, Shasta CSD									
2. Elk Grove, Sacramento County Water Agency, Sacramento Municipal Utility District, Rancho Cordova, SCWA Laguna									
SAN JOAQUIN VALLEY AND CENTRAL COAST									
San Luis Obispo County FCWCD	$9,092	$717	$442	$232	$890	Transfer	$1,287	Transfer	5
County of Santa Barbara FCWCD and CCWA	$3,274	$1,432	$442	$206	$800	Conj. Use	$1,287	GW desal	5
Kern County Water Agency ID #4 and North of the River Municipal Water District	$1,264	$562	$274	$21	$274	GW	$372	Conj. Use	5
Stockton East WD	$1,623	$510	$137	$45	$338	Delta Supply	$1,142	Transfer	5
City of Tracy	$1,102	$1090	$137	$64	$722	Transfer	$1,161	Transfer	5
City of Avenal, Coaling or Huron	$1142-$1212	$1061-$1168	$137	$45-$116	$703-$768	Transfer	$1141-$1212	Transfer	5
City of Fresno Lindsay, Orange Cove, other Friant Kern	$916-$954	$748	$137	$42-$44	$137	GW	$1137-$1140	Transfer	5

Q.2.3 CWEST Results

CWEST generates results for each CVP and SWP M&I contractor, which are aggregated into regions or a statewide total and used in the regional economic impact analysis (see Appendix Q, Regional Economics Technical Appendix for summaries of the CWest model output by alternative used in the regional economic analysis). Result tables descriptions and interpretations are included below in Table Q.2-8.

Table Q.2-8. Interpretation of Reported Results

Reported Results	Interpretation
Average Annual CVP and SWP Deliveries (TAF)	The annual average change in project (CVP or SWP) deliveries compared to the No Action Alternative in thousand acre-feet. Deliveries do not include settlement water or water rights delivered by project facilities that are unaffected by the alternatives.
% change in deliveries from NAA	The percent change in project deliveries as compared to the No Action Alternative.
% change in deliveries in dry years	The percent change in dry year project deliveries as compared to the No Action Alternative. Dry years are critical years, plus all years during the extended droughts; generally, 1929 to 1935, 1987 to 1993, and 2012 to 2016. The San Joaquin river index is used for all regions except the Sacramento Valley where the Sacramento River index is used.
Delivery Cost ($1,000)	Additional project water delivery cost for project water in thousands of 2023 dollars.
New Fixed Yield Supply (TAF)	The change in fixed yield project supply as compared to the No Action Alternative in thousand acre-feet.
Annualized New Supply Costs ($1,000)	The change in annualized costs of new fixed yield supplies in thousands of 2023 dollars as compared to the No Action Alternative. Fixed yield supplies are those assumed to provide the same quantity in all years such as recycling, desalination, conservation, stormwater capture and additional groundwater development or recovery.
Surface/GW Storage Costs ($1,000)	The average annual change in surface and groundwater management costs for agencies that have modeled groundwater operations in CWEST, in thousands of 2023 dollars.
Lost Water Sales Revenues ($1,000)	Reduced annual revenues from water sales by wholesale and retail purveyors as compared to the No Action Alternative in thousands of 2023 dollars.

Reported Results	Interpretation
Transfer Costs ($1,000)	Increase in short-term water transfer costs in thousands of 2023 dollars including delivery costs.
Shortage Costs ($1,000)	The increase in water customer shortage costs in thousands of 2023 dollars is an economic cost to customers who would be willing to pay to avoid the shortages.
GW Pumping Cost ($1,000)	Increase in groundwater pumping costs in thousands of 2023 dollars.
Excess Water Savings ($1,000)	The value of additional project water supply that is not able to be used to meet demand. This water is valued at the maximum of delivery cost or groundwater pumping cost per AF. To be comparable to costs, an increase in excess water savings is shown as a negative.
Average Annual Cost ($1,000)	The total of all economic costs, including shortage costs, in thousands of 2023 dollars as compared to the No Action Alternative. A benefit is shown as a negative.
Annual Cost Impact ($1,000)	Calculated as Average Annual Cost less Shortage Costs, this is the actual change in costs that must be paid for by water providers. If water providers pass costs onto customers this measure indicates the reduction in disposable income available to water customers, in thousands of 2023 dollars.

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