# Probabilistic Optimization Model for Allocating Regulated Groundwater Supplies to Agricultural Water Management Districts in California

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## *Abstract*

A water balance allocation model was developed for a sample of Kern County (California) agricultural water districts optimizing surface and groundwater use, and approximating water transfers and groundwater recharge for districts within a shared regulated groundwater basin. Different hydrologic scenarios were considered which impact surface water available to the basin, water scarcity, and available groundwater. Most groundwater in California will eventually be subject to Sustainable Groundwater Management Act (SGMA) guidelines, meaning sustainable yield and (potentially) district-specific allocations being established per basin. To explore apportioning sustainable yield to districts, the model was configured to balance maximization of region-wide crop net revenues and groundwater storage conditions over varying conditions in a 5-year period. Both deterministic and probabilistic models are developed, assuming future known and unknown hydrologic conditions. In this example probabilistic model, economic output for the basin fares better in intermediate or median hydrologic year types versus deterministic values, but worse in dryer or wetter year values; average $1,208 million/year output across all scenario types (3.8% of statewide production, approximately $311 million better output than deterministic approach for the intermediate scenario). Following probabilistic model results appears to maximize output during higher-probability median conditions while suggesting aggressive storage as preparation for drought or very wet (lower-probability) years. It does not necessarily provide a hedge against all impacts during these year types, even suggesting dry-year storage at the expense of economic output, but the model appears to favor production during ‘more likely’ conditions. Furthermore, this Excel-based optimization model demonstrates use of an economic-based method for allocating groundwater under SGMA - with the relatively simplified approach likely adaptable to many agricultural regions.

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*"Things might not always go as you planned, but they'll always end up as they should."*
- Anonymous

## Table of Contents



## Lists of Tables and Figures

## Section 1: Background

Water in California is commonly managed by public agencies (or districts) acting with regional wholesalers in delivering supplies to a set user base within a jurisdictional area (Hanak *et al*. 2011). District supply portfolios typically consist of local groundwater and/or surface water sources. Surface supplies may include diversions from local rivers and streams following priority diversion rights or from inter-regional imports following contracts with controlling agencies (e.g., state managed delivery of California State Water Project (SWP) supplies). Surface waters are often limited by changes in the volume, nature, and timing of precipitation and snowpack runoff in supplying watersheds (Olson-Raymer, 2015). Accordingly, uncertain future hydrology (i.e., high precipitation 'wet' or low precipitation 'dry' conditions) partially dictates each district's surface water availability. Conversely, groundwater is mostly pumped by private well owners within each district's area to supplement surface water unavailable to meet demands, with historically little regulation on pumped quantities.

Water demands may vary greatly among districts with agricultural, urban, and environmental emphases. In California, average statewide water use is roughly 40% agriculture (e.g., crop irrigation), 10% urban, and 50% environmental (e.g., undiverted natural river flow, species protection flows) (PPIC, 2014). Percentages of water used by each sector vary dramatically across regions and between wet and dry years. Some water also returns to rivers and groundwater basins to be reused for other demands. For this project, only agricultural water management districts are examined due to relatively stable irrigation demands which are well established by crop type. Some parts of California's Central Valley consist solely of agricultural districts, accounting for roughly 80% of all human water use statewide, when considering only urban and applied irrigation demands (PPIC, 2014).

In 2014 California's Legislature passed the Sustainable Groundwater Management Act (SGMA) to mitigate groundwater overdraft (i.e., groundwater use beyond natural or artificial replenishment) and manage other groundwater problems. In most cases SGMA will require restrictions on groundwater pumping from basins with large quantities of historic overdraft designated as 'high' or 'critical' basins by the California Department of Water Resources (DWR) (DWR, 2015). Restrictions will be enacted by local agencies, and may entail basinwide pumping limits based on 'sustainable yield' calculations (i.e., a groundwater usage value for limited or no overdraft). Pumping limits for districts sharing a basin would be verified by the DWR, and based on some policy, such as proportion of overlying land or by optimization of some regional output value (e.g., agricultural economic production or excess of water supply availability).

Kern County, in California's southern Central Valley, overlies a 'critical' groundwater basin, so its groundwater use will be regulated under SGMA (DWR, 2015). Most of the county's districts manage water for agriculture, with an array of cropping patterns and crop demand data widely available from DWR and local district sources. Regional surface water mostly consists of SWP contract allocations and priority rights to the local Kern River; both are highly variable. If excess surface water is available, some districts can recharge the underlying groundwater to store groundwater for later use. Regional water infrastructure also allows transfers between districts, facilitating water movement based on economic or emergency demands. As such, districts frequently move water following negotiated dollar per volume quantity rates - to account for conveyance costs and economic production losses. The combination of (variable) surface water and groundwater supplies, defined recharge projects, ability to transfer water, and compiled crop demand data makes Kern County an ideal test case for use of optimization to maximize regional economic production in allocating groundwater use. Also noteworthy are impacts to county water resource operations from eventual SGMA guidelines (e.g., changes to district water use and/or delivery operations from basin-wide regulations).

Many parts of California have similar competing water demands with an array of supplies and management options. Kern County concerns under SGMA will likely be similar to other groundwater basins, in the Central Valley with most of California's water consumption (PPIC, 2017). The focus of this report is to assess allocation of groundwater under SGMA for agricultural water districts in a regulated and shared groundwater basin, similar in concept to the example shown for Kern County.

## Section 2: Model Selection

The flexible allocation of groundwater sustainable yield to water users can be based on optimization of regional output value (shown later), perhaps using water markets. Two types of optimization models traditionally fit the considerations described for Kern County; stochastic dynamic programming (SDP) and probabilistic linear programming (PLP). Both consider decision making with uncertain and probabilistic conditions, in this case groundwater allocations with uncertain surface water availability. Both methods have advantages and disadvantages, which are summarized below:

SDP traditionally applies to multi-stage decision making, with conditions that evolve or change over a planning horizon (Lund, 2014). Staged decisions, such as groundwater use, are formally contingent on a set of feasible input states, such as discrete surface water quantities available at a specified time. Optimal decisions are linked across stages using a recursive formula; an accumulated objective or desired output value, linking consequences of one decision to subsequent ones over the entire planning horizon. A prominent example of SDP applied to water allocation problems includes the optimization of stochastic inflows for a reservoir storage and release system - stages based on release volume decisions per time period and programmatic states based on reservoir storage (Stedinger *et al.* 1984; Trezos and Yeh, 1987; Stedinger *et al.* 2013). The key to these SDP-applicable problems are discernable decision stages and input states which are linked together over a decision process (i.e., one event takes place after the next, such as with inflow-storage-release reservoir considerations at subsequent time periods). The groundwater allocation problem, regarding apportionment of sustainable yield, does not necessarily follow a similar multi-decision process in this traditional sense. Allocation decisions are made prior to realization of surface water availability, and there are no operational follow-up decisions once hydrologic conditions are realized within a single year; for instance, water transfers and recharge are considered to occur simultaneously with district water usage once surface water becomes available. Multi-year analysis of groundwater apportionment may be closer to the multi-stage decision format used in SDP, however, the uncertainty in the ability to predict future hydrologic conditions (i.e., probability of annual probability of hydrologic conditions) means the size of decisions may grow beyond reasonable computing efforts if model decomposition is not used - which is beyond the scope of this report.

Multi-stage formulations of PLP models often allow for more decision-oriented analyses of uncertainties following initial decisions (Lund, 2014). The groundwater apportionment situation effectively describes a two-stage PLP problem; an allocation decision is made, surface water becomes available with a probabilistic pattern, and a follow-up decision/response is subsequently made (e.g., transfer quantities and fulfillment of demands). PLP models provide a more straight-forward path derived from an initial decision and subsequent stage decision, more sensitivity analysis information, and are less subject to discretization problems impacting problem dimensionality and propagating in the recursive formula. PLP has been applied to many water network and appropriation problems, following varied water balance formulations, including agricultural irrigated land supply and demand problems, and multi-reservoir systems (Naadimuthu and Lee, 1982; Draper, 2001; Rosenberg *et al.* 2007; Cui *et al.* 2015). Additionally, for more intensive analytical analysis of hydroeconomic data, multi-stage formulations have also been used with nonlinear problem sets (Zhu *et al.* 2015) - meaning PLP can act as a foundation-level model for more detailed analysis with different solution techniques. Based on the applicability of PLP to the problem, following well-defined approaches with similar water problems - albeit not done before with SGMA-related agricultural groundwater apportionment - this formulation was used for subsequent analyses.

*This report uses a PLP model configuration to develop a relatively simplified optimization model with standardized water supply and demand inputs, to investigate groundwater allocations within a sustainable yield and offer operational suggestions for shared-basin agricultural districts subject to SGMA.* The simplified input approach facilitates these tools being used by water managers, however, model expansion and/or more-detailed data analysis should be performed as follow-up. Use of the model without these details, as well as assumptions and shortcomings, are discussed later in this report.

## Section 3: Model Development

Five prominent agricultural water districts were selected within Kern County, based on data availability and impact to the regional economy (Poso Creek IRWM, 2014). These districts are shown in Figure 1 and detailed in Table 1. Supply and demand data were obtained from each district's respective 'Agricultural Water Management Plan (AWMP)' document[1] (DWR, 2014) for five individual years. District output (production) values are based on USDA California agricultural crop statistics (USDA, 2012); an estimate of economic output based on statewide data applied to district-specific annual cropping patterns - values could theoretically be based on any other agreed-upon economic output parameter (e.g., $/acre-ft valuation of water supplies to districts). District relative sizes (acres) and cropping demands vary greatly with their location in the groundwater basin and hydrologic year type.

[1] AWMPs prepared by districts and required by DWR, typically describe water supplies and irrigation demands, local conditions, facilities, rules and policies, and other management activities (DWR, 2014).

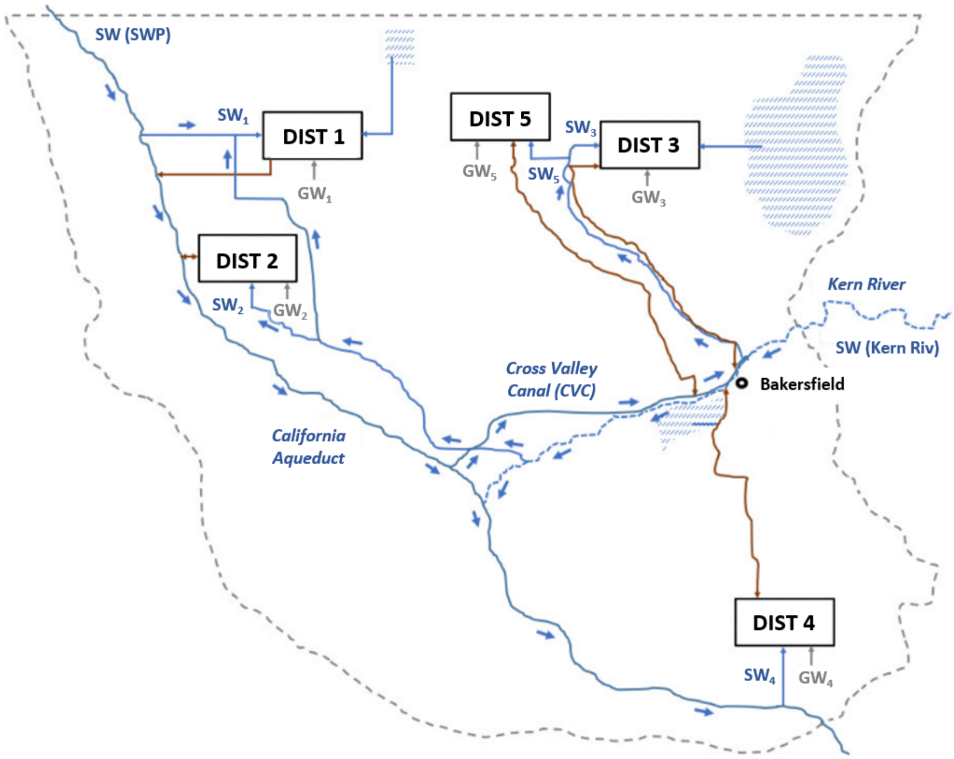


**Figure 1.** Kern County water district map
*(blue lines surface water infrastructure; red lines transfer infrastructure; districts DIST as shown).*

**Table 1.** District supply and demand profiles.

| [1] District | [2] Total Area (acres) | [3] Total Demand (AF), Yr 1[1] | [4] Total Demand (AF), Yr 2[1] | [5] Total Demand (AF), Yr 3[1] | [6] Total Demand (AF), Yr 4[1] | [7] Total Demand (AF), Yr 5[1] |
|---|---|---|---|---|---|---|
| D1 | 135,968 | 548,669 | 507,736 | 519,342 | 531,213 | 526,705 |
| D2 | 36,912 | 154,723 | 158,070 | 148,767 | 134,505 | 133,624 |
| D3 | 39,750 | 131,578 | 131,541 | 137,445 | 125,231 | 133,499 |
| D4 | 90,082 | 296,023 | 323,874 | 323,136 | 322,468 | 319,883 |
| D5 | 52,396 | 209,967 | 223,575 | 231,059 | 237,763 | 90,998 |
| **Avg** | 54,785 | 268,192 | 268,959 | 271,950 | 270,236 | 240,942 |
| **Tot** | 355,108 | 1,340,961 | 1,344,796 | 1,359,749 | 1,351,179 | 1,204,710 |

| [1] District | [8] Valuation ($/AF), Yr 1 | [9] Valuation ($/AF), Yr 2 | [10] Valuation ($/AF), Yr 3 | [11] Valuation ($/AF), Yr 4 | [12] Valuation ($/AF), Yr 5 | [13] Avg. Surface Water Allocation (AF/yr) |
|---|---|---|---|---|---|---|
| D1 | $824 | $503 | $1,780 | $1,763 | $1,231 | 83,600 |
| D2 | $935 | $699 | $1,888 | $1,656 | $1,268 | 194,034 |
| D3 | $928 | $752 | $1,827 | $1,664 | $1,250 | 66,201 |
| D4 | $934 | $834 | $1,790 | $1,685 | $1,347 | 49,108 |
| D5 | $948 | $909 | $1,759 | $1,728 | $1,397 | 32,171 |
| **Avg** | $914 | $739 | $1,809 | $1,699 | $1,299 | 85,022 |
| **Tot** | $4,569 | $3,696 | $9,043 | $8,497 | $6,494 | 425,114 |

[1] Total cropping demands per district per year given in AWMP docs (DWR, 2014); years varied as described in Appendix A. Economic value for crops given in USDA California Ag Statistics Report (2012); proportion of statewide acreage and outputs.

Surface water conveyance and groundwater pumping costs are given for each district in Table 2. Average surface water rates are $42/AF for SWP or managed supplies[2], $12/AF for Kern River, and $80/AF for other supplies[3] (e.g., local treatment of low-quality water) - rates are weighted by percentage of total surface water supply (Poso Creek IRWM, 2014). Groundwater pumping costs vary by crop irrigation method (i.e., extraction rate) and local depth to groundwater, meaning rates vary across the region and by prior year's pumping (DWR, 2003). Although not precise, rates were estimated from historical average groundwater usage and water level data from district cropping patterns in AWMP documents, and separate San Joaquin Valley crop-based groundwater extraction data (Medellin-Azuara *et al.* 2016), shown in Table 3.

**Table 2.** District surface water use costs.

| [1] District | [2] Avg. SWP Supply (AF/yr) | [3] Avg. CVP Supply (AF/yr)[1] | [4] Avg. Kern River Supply (AF/yr)[2] | [5] Other Surface Water (AF/yr) | [6] River Priority | [7] Avg. Surface Water Cost ($/AF/yr) | [8] Std Dev of Surface Water (AF/yr)[3] |
|---|---|---|---|---|---|---|---|
| D1 | 72,211 | 0 | 1,637 | 9,988 | 4 | $45.94 | 92,111 |
| D2 | 11,502 | 0 | 31,523 | 16,339 | 1 | $36.52 | 62,844 |
| D3 | 13,260 | 0 | 9,879 | 35,156 | 3 | $59.83 | 14,022 |
| D4 | 84,564 | 0 | 0 | 41,223 | -- | $54.45 | 26,088 |
| D5 | 0 | 0 | 97,832 | 0 | 2 | $12.00 | 149,787 |
| **Avg** | 36,307 | 0 | 28,174 | 20,541 | | $41.74 | 68,970 |
| **Std Dev** | 38,995 | 0 | 40,915 | 17,264 | | $18.82 | 54,686 |
| **Tot** | 181,537 | 0 | 140,871 | 102,706 | | | |

[1] Central Valley Project (CVP) surface water supplies; managed by Bureau of Reclamation under Friant-Kern, east-side of county. No districts contracted for CVP supply', but may receive CVP water when excess available or via transfer; not in years assessed.
[2] Lower Kern River surface water supplies, quantities based on seniority use or 'water rights allocations' shown in [6].
[3] Variation in total surface water supply of five-year set of values.

**Table 3.** District groundwater use costs.

| [1] District | [2] Avg. Groundwater Consumed (AF/yr)[1] | [3] Avg. Depth to GW (ft)[2] | [4] Calc Use Depth Increase (ft/AF)[3] | [5] Initial GW Depth (ft)[4] | [6] Initial GW Cost ($/AF)[4] | [7] GW Cost per Depth ($/ft)[5] |
|---|---|---|---|---|---|---|
| D1 | 325,221 | 274 | 0.00018 | 277 | $81.53 | $0.14 |
| D2 | 70,398 | 256 | 0.00056 | 255 | $74.63 | $0.11 |
| D3 | 66,291 | 346 | 0.00021 | 365 | $107.75 | $0.38 |
| D4 | 79,797 | 347 | 0.00035 | 332 | $101.99 | $0.31 |
| D5 | 188,219 | 326 | 0.00014 | 328 | $97.31 | $0.33 |
| **Avg** | 145,985 | 310 | 0.00029 | 311 | $92.64 | $0.25 |
| **Std Dev** | 112,199 | 42 | 0.00017 | 45 | $14.01 | $0.12 |
| **Tot** | 729,926 | | | | | |

[1] Yearly consumed groundwater estimates from AWMP Documents (DWR, 2014); generally supply-demand balance 'closure terms'.
[2] Average of five-year period for available data from California Statewide Groundwater Elevation Monitoring (CASGEM) Program.
[3] Estimated linear-regression fit of GW consumption and level change data; not hydrogeologically precise, but provided enough insight to GW depth impacts from usage for model ($R^2$ *values:* D1 = 0.883, D2 = 0.637, D3 = 0.042, D4 = 0.446, D5 = 0.490).
[4] First year of five-year period used as 'initial' values.
[5] Estimated linear-regression fit of GW level change data and crop-based consumption cost estimates (Medellin-Azuara et al. 2016), assuming consumption reflects annual cropping pattern ($R^2$ *values:* D1 = 0.632, D2 = 0.155, D3 = 0.884, D4 = 0.951, D5 = 0.967).

[2] Includes conveyance along California Aqueduct system from Bay-Delta region to Kern County.
[3] Examples include oil-field produced water supplies or deep-well (lower quality) groundwater pumping.

District groundwater recharge is based on their infrastructure capability to support "*in-lieu*" recharge; the purposeful deep percolation of surface water resources for later groundwater pumping and extraction *in-lieu* of future surface water use. Most recharge infrastructure in Kern County consists of surface spreading and percolation in dedicated basins or ponds (Poso Creek IRWM, 2014). Total annual recharge capacity (volume) per district, shown in Table 4, assumes total recharge pond acres multiplied by typical percolation/empty rates and a reasonable efficiency factor (i.e., not all percolated water will be recoverable in underlying aquifer, either by losses to unrecoverable zones, evaporation, or external pumping). District conveyance to recharge facilities is not considered explicitly, but is considered part of the efficiency factor as reduction to total volume intended for recharge. Indirect or "active" recharge based on the delivery of surface water for irrigation - deep percolation resulting from irrigation, flooding of fallow fields, or resulting from unlined conveyance - is not considered in this effort. Neither is purposeful flooding of irrigated fields beyond crop demands for recharge purposes (O'Geen *et al.* 2015; Dahlke *et al.* 2017).

Similarly, districts can store surface water year-to-year in 'carryover storage' such as large and small-regulating reservoirs or lakes, canal systems, or by ponding natural areas. Table 4 includes 'in-district' and 'out-of-district' surface storage, with limits defined by each district's apportionment of carryover storage in these facilities or infrastructure-based capacities (i.e., yearly additions to storage cannot exceed maximum storage limits)[4]. District conveyance from 'out-of-district' facilities is considered as input surface water, with costs shown above, while 'in-district' conveyance is not considered explicitly.

**Table 4.** Groundwater recharge and carryover storage data.

| [1] District | [2] Recharge Area (acres) | [3] Max Recharge Fill (AF/yr)[1] | [4] Recharge Impact (ft/AF)[2] | [5] Recharge Efficiency (%)[3] | [6] In-District Storage (AF/yr) | [7] Out-District Storage (AF/yr) |
|---|---|---|---|---|---|---|
| D1 | 800 | 21,040 | 0.00018 | 0.90 | 0 | 12,725 |
| D2 | 1,160 | 23,200 | 0.00056 | 0.86 | 0 | 48,349 |
| D3 | 400 | 3,800 | 0.00021 | 0.90 | 834 | 3,136 |
| D4 | 0 | 0 | 0.00035 | 0 | 0 | 16,180 |
| D5 | 1,500 | 4,125 | 0.00014 | 0.90 | 80 | 41,000 |
| **Avg** | 772 | 10,433 | 0.00029 | 0.71 | 183 | 24,278 |
| **Std Dev** | 595 | 10,818 | 0.00017 | 0.40 | 366 | 19,398 |
| **Tot** | 3,860 | 52,165 | | | 914 | 121,390 |

[1] Values confirmed with district-specific AWMP documents (DWR, 2014). Recharge fill represents total theoretical max quantity of water (AF) districts can annually recharge in current facilities.

[2] Assumption of delivery offsetting corresponding groundwater pumping in future; essentially, delivery of one AF of water on the surface immediately displaces groundwater level and does not depend upon percolation and movement of water in the aquifer (Semitropic, 2013). *Specified by location or district per applicable AWMPs, same as pumping impact values shown in Table 3.*

[3] Efficiency factor assumed as percentage reduction in total recharge to account for pond evaporation, conveyance losses, and unrecoverable GW supplies (Semitropic, 2013); *5% loss per year of recharged volume assumed to unrecoverable percolation.*

Districts also can transfer water supplies to other districts within the region. For water exchanged within Kern County an average operating and transaction cost of $110/AF is assumed - rounded average of 2010 to 2014 data *not* reflecting negotiated per unit

[4] Includes reservoirs for specific surface water systems (e.g., Lake Isabella for Kern River supplies).

management or facilitation costs (notes from Poso Creek IRWM, 2014). Regional infrastructure consists mostly of lined and unlined canals, meaning potential for losses to evaporation and seepage. Losses are assumed a limiting factor in deciding to transfer water; proportional to distance between sending and receiving districts. Infrastructure distances between each district are shown in Table 5. A loss rate of 0.07% per mile of transferred water quantity is assumed lost to evaporation and seepage (USBR, 2010).

**Table 5.** Water transfer distances.

| Transfer District | | [1] From District - Location (mi) | | | | | [3] Max Transfer Volume (AF/yr)[1] |
|---|---|---|---|---|---|---|---|
| | | D1 | D2 | D3 | D4 | D5 | |
| [2] To District | D1 | 0 | 11 | 75 | 56 | 74 | 68,602 |
| | D2 | 11 | 0 | 55 | 29 | 54 | 56,447 |
| | D3 | 75 | 55 | 0 | 35 | 6 | 11,155 |
| | D4 | 56 | 29 | 35 | 0 | 34 | 43,713 |
| | D5 | 74 | 54 | 6 | 34 | 0 | 22,318 |

[1] Based on wet year transfer out data, assumed maximum transfer capability (DWR, 2014).

Deterministic and probabilistic model configurations are discussed below. Districts use available surface water and groundwater resources to fulfill crop demands. It is assumed they will use all annually available surface water before pumping groundwater based on lower per unit costs, or may choose to recharge groundwater or use carryover storage based on excess surface water availability (Semitropic WSD, 2013). A fixed percent of in-district demands must be fulfilled before allowing outbound water transfers or recharge. For this model, 33-percent of internal demands must first be fulfilled, representing the average regional portion of irrigation demands for higher-valued specialty crops typically never fallowed even in times of drought. Sustainable yield for the Kern County groundwater basin has not yet been established under SGMA (DWR, 2015). A value of 437,958 AF/year was assumed, an approximate reduction of historical groundwater usage by 40% for selected districts, a modest percentage of preliminary groundwater analysis performed by the DWR for coinciding 'Kern County Subbasin' (No. 5-22.14; DWR, 2003). As formulated, district groundwater pumping limits must then be within that annual value or average the value over the defined five-year period.

## *3.1 Scenario Development*

Quantities of SWP and Kern River water available to Kern County districts depend on annual hydrologic conditions, which are largely uncertain in forecast planning models (Poso Creek IRWM, 2014). Hydrologic year types are typically categorized (e.g., wet or dry), and historical surface water deliveries can help estimate the probability of each year type (DWR, 2014). During dry conditions imported SWP supplies are curtailed equally, as percentages of contract allocations, while Kern River supplies are given in-full or in-part to districts with diversion seniority before other districts receive any water[5]. As mentioned in model selection analysis, decisions such as sustainable yield apportionment must be made available to district

[5] Following Appropriative Water rights law in California for diversions from water sources (SWRCB, 2017); *see Table 2 for district seniority listing of rights to Kern River.*

planners prior to knowledge of year type, with surface water supplies not realized until precipitation patterns have already occurred. Table 6 describes potential surface water scenarios assessed in this model, based on historical data with general hydrologic 'year types' assumed - California Data Exchange Center (CDEC) precip data and SWP Delivery Capability Reports (DWR, 2015), shown in Appendix A.

**Table 6.** Surface water availability scenarios.

| [1] Scenario | [2] Year Type | [3] Prob. | [4] Supply Allocation (% of Total) | | | [5] Total Surface Water Allocation (AF) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SWP[1] | Kern Riv.[2] | Other | D1 | D2 | D3 | D4 | D5 |
| S1 | Drought | 0.10 | 25% | 25% | 60% | 13,605 | 15,417 | 19,075 | 28,709 | 8,731 |
| S2 | Dry Year | 0.25 | 50% | 50% | 80% | 75,743 | 37,742 | 44,102 | 113,424 | 18,909 |
| S3 | Intermed. | 0.40 | 75% | 75% | 100% | 116,491 | 114,327 | 76,745 | 170,940 | 95,909 |
| S4 | Wet Year | 0.20 | 100% | 100% | 100% | 155,001 | 129,715 | 96,380 | 223,530 | 127,396 |
| S5 | Full Alloc | 0.05 | 100% | 125% | 100% | 175,165 | 148,631 | 107,387 | 246,556 | 359,532 |

[1] SWP supplies curtailed equally down to supply allocation percentage.

[2] Kern River supplies curtailed in total with full or partial supplies given to priority in order; typical of water rights in California.

Possible scenario combinations were assessed over the five year period, as shown in the Figure 2 diagram. In scenarios consisting of a sequence of year types, district cropping patterns and volumetric valuations will presumably change with available surface water (e.g., drought followed by drought may decrease crop acreages, as opposed to wet conditions), as shown in Table 7. Changes are based on available data for year-type by district (DWR, 2014).

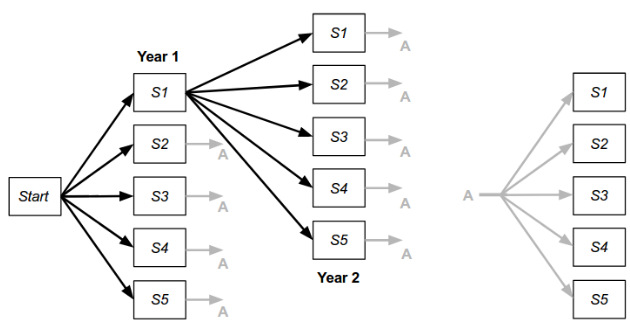


**Figure 2.** Scenario combination diagram.

**Table 7.** Scenario parameter changes with scenario year-type *(Adjustments to Table 1).*

| [1] Scenario | [2] Change in Crop Demand Valuation ($/AF)[1] | | | | | [3] Change in Surface Water Availability (AF) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | D1 | D2 | D3 | D4 | D5 | D1 | D2 | D3 | D4 | D5 |
| S1 | $23 | $32 | ($32) | ($7) | ($182) | -16,091 | -26,784 | -820 | -7,954 | -9,134 |
| S2 | $47 | $187 | $1 | $37 | ($45) | -5,057 | -12,059 | -42 | -1,788 | -3,324 |
| S3 | $56 | $293 | $3 | $49 | ($21) | -1,755 | -5,263 | 49 | 1,061 | -1,822 |
| S4 | $57 | $399 | $10 | $64 | ($3) | -456 | -660 | 248 | 2,840 | -525 |
| S5 | $87 | $674 | $32 | $96 | $28 | 9,886 | 19,032 | 806 | 11,277 | 14 |

*Note: Changes applied to annual values in 5-yr sequence (e.g., add $23 to valuation for District 1 (D1) if year type is Scenario 1). D and S parameters reference districts and scenarios, respectively (e.g., D1 = District 1 and S1 = Scenario 1).*

*[1] Valuation refers to the unit economic output per district (e.g., increase in output value with additional volume of supply), shown in columns [8] through [12] of Table 1 - the objective function basis. Shown are value adjustments based on scenario year-type.*

### *3.2 Deterministic Model*

First part of this model is based on a set of deterministic relationships with model output fully determined by parameters values and initial conditions. Parameter values are fixed for all scenario combinations for five-year period. This allows optimization of decision variables for a specific year type and five-year pattern, regardless of the uncertainty of that scenario combination occurring. *The objective is to maximize total regional economic output ($) based on district economic output values from Table 1*; based on each district's surface water and groundwater utilization, recharge (groundwater) and carryover (surface water) storage, and quantities transferred within the region. The model objective function is as follows, as depicted in Figure 3.

$$\text{Max } P = \sum_{y}\sum_{i} \Big[ \underbrace{Q_{sw,iy}(V_{i\,y-1} + \Delta V_{iy} - C_{sw,iy})}_{\text{Surface Water (Dist } i\text{, Year } y)} + \underbrace{Q_{GW,iy}(V_{i\,y-1} + \Delta V_{iy} - C_{GW,iy})}_{\text{Groundwater Use (Dist } i\text{, Year } y)} - \underbrace{(V_{i\,y-1} + \Delta V_{iy}) \sum_{k} [Q_{Tout,ik\,y}]}_{\text{Transfer Output (Dist } i \text{ to Dist } k\text{, Year } y)}$$

$$+ \underbrace{\sum_{j} [Q_{Tout,ji\,y} - (TD_{loss}\, Q_{Tout,ji\,y})TD_{ji}](V_{i\,y-1} + \Delta V_{iy} - C_t)}_{\text{Transfer Input (Dist } j \text{ to Dist } i\text{, Year } y)} - \underbrace{(Q_{Rout,iy} + \sum_{k} [Q_{Rout,ik\,y}])(V_{i\,y-1} + \Delta V_{iy})}_{\text{Recharge Output (Dist } i \text{ future self, Dist } i \text{ to future Dist } k\text{, in Year } y)}$$

$$+ \underbrace{(Q_{Rin,iy} + \sum_{j} [Q_{Rout,ji\,y}])(V_{i\,y-1} + \Delta V_{iy} - C_{GW,iy})}_{\text{Recharge Input (Dist } i \text{ past self, Dist } i \text{ from past Dist } j\text{, in Year } y)} - \underbrace{Q_{Cout,iy}(V_{i\,y-1} + \Delta V_{iy})}_{\text{Carryover Output (Dist } i \text{ future self, in Year } y)} + \underbrace{Q_{Cin,iy}(V_{i\,y-1} + \Delta V_{iy} - C_{sw,iy})}_{\text{Carryover Input (Dist } i \text{ past self, in Year } y)} \Big]$$

$$C_{GW,iy} = CD_{GW,i}\,[G_{lvl,i\,y-1} + (Q_{GW,iy} + \underbrace{(Q_{Rin,iy} + Q_{Rout,ji\,y})}_{\text{Recharge into Dist } i} - \underbrace{(Q_{Rout,iy} + Q_{Rout,ik\,y})}_{\text{Recharge out of Dist } i}(1 - R_{eff,i}))\, D_{GW,i}]$$

where:

- $P$ = regional economic output ($);
- $V_{i\,y-1}$ = unit district *i* valuation output from prior year *y-1* ($/AF) <- Table 1;
- $\Delta V_{iy}$ = change in district *y* valuation for current year *y* ($/AF) <- Table 6;
- $C_{sw,iy}$ = cost of surface water use for district *i* in year *y* ($/AF) <- Table 2, with Table 6 adjust;
- $C_{GW,iy}$ = cost of groundwater use for district *i* in year *y* ($/AF) <- *see equation above.*
- $CD_{GW,i}$ = groundwater cost per depth in district *i* in year *y* ($/ft) <- Table 3;
- $G_{lvl,i\,y-1}$ = average depth to groundwater in district *i* at end of prior year *y-1* (ft) <- initial Table 3;
- $R_{eff,i}$ = Recharge efficiency for district *i* <- Table 4;
- $D_{GW,i}$ = Calculated groundwater use depth increase for district *i* (ft/AF) <- Table 3;
- $TD_{loss}$ = percentage transfer losses (%) <- 0.07% loss rate;
- $TD_{ji}$ = total transfer distance from district *j* to *i* (mi) <- Table 5;
- $C_t$ = transfer cost ($/AF) <- $110/AF assumed region-wide.

Decision variables are as follows:

$Q_{sw,iy}$ = quantity of surface water utilized by district *i* in year *y* (AF);
$Q_{GW,iy}$ = quantity groundwater pumped for district *i* in year *y* (AF);
$Q_{Tout,ji\ y}$ = quantity of water transferred from district *j* to *i* in year *y* (AF), equals transfer input;
$Q_{Tout,ik\ y}$ = quantity of water transferred from district *i* to *k* in year *y* (AF), equals transfer output;
$Q_{Rin,iy}$ = quantity groundwater recharge into district *i* in year *y* (AF);
$Q_{Rout,ji\ y}$ = quantity groundwater recharge into district *i* in year *y* from past district *j* (AF);
$Q_{Rout,iy}$ = quantity groundwater recharge out from district *i* in year *y* (AF);
$Q_{Rout,ik\ y}$ = quantity groundwater recharge out from district *i* in year *y* to future district *k* (AF);
$Q_{Cin,iy}$ = quantity carryover storage into district *i* in year *y* (AF);
$Q_{Cout,iy}$ = quantity carryover storage out from district *i* in year *y* (AF);

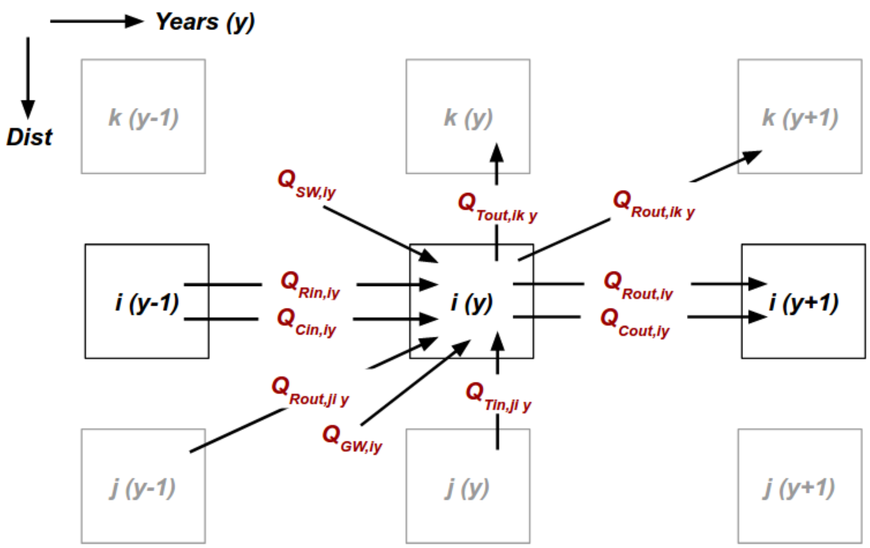


**Figure 3.** Model water balance diagram
(Dist *k* is other district receives water supplies from Dist *i*, while other Dist *j* sends water to *Dist i*).

The model is based on sum of water quantity for and between each district ($i$ = 1 to 5) for each year ($y$ = 1 to 5). Output is defined by $/AF valuations, representing production generated for each unit of water supply received. Water used by each district for irrigation demands or transfer/store out cannot exceed groundwater pumped, surface water imported, and transfer in. As such, the following model constraints are defined:

| | |
|---|---|
| 1. $Q_{SW,iy} \le Q_{SW,iy\text{-}max}$ | Surface water usage within max available [∀iy]; |
| 2. $Q_{SW,iy} \ge 0$ | Surface water non-negativity [∀iy]; |
| 3. $Q_{Cout,iy} \ge 0$ | Carryover storage out non-negativity [∀iy]; |
| 4. $Q_{Cin,iy} \ge 0$ | Carryover storage in non-negativity [∀iy]; |
| 5. $(S_{i\ y\text{-}1} + Q_{Cout,iy} - Q_{Cin,iy})(1 - S_{loss}) \ge 0$ | Year end carryover storage non-negativity [∀iy]; |
| 6. $(S_{i\ y\text{-}1} + Q_{Cout,iy} - Q_{Cin,iy})(1 - S_{loss}) \le S_{max,i}$ | Dist end carryover less than max storage [∀iy]; |
| 7. $\sum i\ [Q_{GW,iy}] \le Q_{SY,y}$ | Total GW use within sustainable yield [∀iy][6]. |

[6] Within single-year sustainable yield (SY) shown. Model runs for yearly SY criteria and total period SY (e.g., $\sum\sum Q_{GW,iy} \le Q_{SY}$ five-year SY constraint), allowing refill and empty of basin as explained below.

8. $Q_{GW,iy} \geq 0$ Groundwater use non-negativity [∀iy];
9. $(Q_{Rout,iy} + \sum k\ [Q_{Rout,ik\ y}]) \leq R_{max,i}$ Recharge out within max recharge capacity [∀iy];
10. $Q_{Rout,iy} \geq 0$ Recharge out to self non-negativity [∀iy];
11. $Q_{Rout,ik\ y} \geq 0$ Recharge out to others non-negativity [∀iky];
12. $Q_{Rin,iy} \geq 0$ Recharge in from self non-negativity [∀iy];
13. $Q_{Rout,ji\ y} \geq 0$ Recharge in from others non-negativity [∀ijy];
14. $R_{i\ y-1}+(Q_{Rout,iy}+ \sum k\ [Q_{Rout,ik\ y}])(1 - R_{eff,i}) - (Q_{Rin,iy}+ \sum j\ [Q_{Rout,ji\ y}])(1 - R_{loss}) \geq 0$ Recharge bal [∀iy];
15. $\sum k\ [Q_{Tout,ik\ y}] \leq T_{max,i}$ Transfer out within max recharge capacity [∀iy];
16. $Q_{Tin,ji\ y} \geq 0$ Transfer in from others non-negativity [∀iky];
17. $Q_{Tout,ik\ y} \geq 0$ Transfer out to others non-negativity [∀iky];

***Supply Utilization:*** $SU_{iy} = Q_{SW,iy} + Q_{GW,iy} + \sum k\ [Q_{Tout,ik\ y}] + \sum j\ [Q_{Tin,ji\ y}] - (Q_{Rout,iy} + \sum k\ [Q_{Rout,ik\ y}]) + (Q_{Rin,iy} + \sum j\ [Q_{Rout,ji\ y}]) - Q_{Cout,iy} + Q_{Cin,iy}$

*18.* $SU_{iy} \geq 0$ Supply utilization non-negativity [∀iy];
*19.* $D_{iy} \geq SU_{iy}$ No use of water supplies beyond demands [∀iy];
20. $T_P D_i \leq SU_{iy}+(Q_{Rout,iy}+ \sum k[Q_{Rout,ik\ y}]) - (Q_{Rin,iy}+ \sum j\ [Q_{Rout,ji\ y}])+ Q_{Cout,iy}- Q_{Cin,iy}$ % demand bal [∀iy];

Where:

$Q_{SW,iy-max}$ = surface water allocations, maximum available to district *i* (AF) <- Table 5;
$S_{loss}$ = carryover storage losses per year (%) <- assumed 5% of to-date stored volume;
$S_{i\ y-1}$ = end of prior year carryover storage for Dist *i*, principally $[Q_{Cout,iy} - Q_{Cin,iy}]$ per Year *y*[7] (AF);
$S_{max,i}$ = carryover storage maximum for Dist *i* (AF) <- Table 4 ‘in-district’ and ‘out-of-district’;
$R_{max,i}$ = recharge capacity for Dist *i* (AF) <- Table 4;
$R_{i\ y-1}$ = end of prior year recharge total towards Dist *i* per Year *y*[7] (AF);
$R_{eff,i}$ = recharge efficiency per Dist *i* (%) <- Table 4;
$R_{loss}$ = recharge storage losses per year (%) <- assumed 5% of to-date recharged volume[8];
$T_{max,i}$ = Maximum transfer volume annually for Dist *i* (AF) <- Table 5;
$D_{iy}$ = annual water demands for Dist *i* (AF) <- Table 1;
$T_P$ = minimum mandatory demand fulfillment (%) <- assumed 33% of $D_i$

The deterministic model was run for two conditions, to illustrate realistic basin sustainable yield ($Q_{SY}$) management options:

1. *Annual sustainable yield limitation*, regional pumping constrained to a SY limit each year that limits any overdraft - assume SY volume of 437,958 AF/yr;
2. *Periodic sustainable yield limitation,* regional pumping constrained to five-year period limit on quantity pumped from basin rather than annually - allows instances of ‘greater’ pumping to help offset limited surface water-year types, so long as ‘long-term’ constraints are met - assume five-year SY volume of 2,189,790 AF (annual SY x5).

[7] For first year (*y* = 1) carryover storage-related values $S_{i\ y-1}$ and $Q_{Cin,iy}$ ∀*i* set equal to zero (e.g., no available prior-stored water supplies). Similarly, recharge-related values $R_{i\ y-1}$ , $Q_{Rin,iy}$ and $Q_{Rout,ji\ y}$ ∀*j* also set equal to zero in first year.
[8] Assumed unrecoverable recharge volume to deep percolation or other groundwater movement.

### *3.3 Probabilistic Model*

A second model is based on a probabilistic equilibrium objective; same set of parameter values and initial conditions leading to an ensemble of different outputs. This means optimization of decision variables for a probabilistic distribution of year types over the five-year period, contributing to an optimized average output. The model objective function is shown below, similar to deterministic but including probabilities for water year type scenarios ($N$ = 1 to 5), replacing sequential year-to-year format with a scenario-to-scenario type format (non-temporal).

$$
\begin{aligned}
Max\ P = \sum_{N} P_N \Bigg[ \sum_{i} & \underbrace{[Q_{sw,iN}(V_{IN} - C_{sw,iN})}_{\substack{\text{Surface Water}\\ \text{(Dist } i\text{, Scenario } N)}} + \underbrace{Q_{GW,i}(V_{iN} - C_{GW,iN})}_{\substack{\text{Groundwater Use}\\ \text{(Dist } i\text{, Scenario } N)}} - \underbrace{\sum_{k}[Q_{Tout,ik\ N}\ V_{IN}]}_{\substack{\text{Transfer Output}\\ \text{(Dist } i \text{ to Dist } k\text{, Scenario } N)}} \\
& + \underbrace{\sum_{j}[Q_{Tout,ji\ N} - (TD_{loss}\ Q_{Tout,ji\ N})TD_{ji}](V_{iN} - C_t)}_{\text{Transfer Input (Dist } j \text{ to Dist } i\text{, Scenario } N)} + \sum_{M}\Big[ - \underbrace{(Q_{Rout,i\ NM} + \sum_{k}[Q_{Rout,ik\ NM}])\ V_{iN}}_{\substack{\text{Recharge Output (Dist } i \text{ to self or other}\\ \text{Dist } k\text{, from Scenario } N \text{ to } M)}} \\
& + \underbrace{(Q_{Rin,i\ MN} + \sum_{j}[Q_{Rout,ji\ MN}])(V_{iN} - C_{GW,iN})}_{\substack{\text{Recharge Input (Dist } i \text{ from self or other Dist } j\text{, from}\\ \text{Scenario } M \text{ to } N)}} - \underbrace{Q_{Cout,i\ NM}\ V_{iN} + Q_{Cin,i\ MN}(V_{iN} - C_{sw,iN})\Big]\Big]}_{\substack{\text{Carryover Output \& Input}\\ \text{(Dist } i \text{ to/from other Scenario } M)}} \Bigg]
\end{aligned}
$$

Where: $P_N$ = probability of scenario $N$ <- Table 4.
*(reference other objective function variables above, with Scenario N replacing Year y).*

The PLP model is built on a 'planning decision', with decision variable(s) made prior to any scenario occurrence - becoming constant regardless of scenario borne out - and 'operational decisions' which are a function of individual scenarios (i.e., management suggestions for the different hydrologic scenario conditions). Groundwater allocations of sustainable yield become the planning decision for operational decisions which include surface water usage and transfer quantities to maximize regional value output. Inter-scenario recharge and conveyance act as water supply buffers between possible probabilistic scenario patterns (e.g., S1 Drought followed by another S1 Drought or followed by S4 Wet Year). This concept is shown in Figure 4.

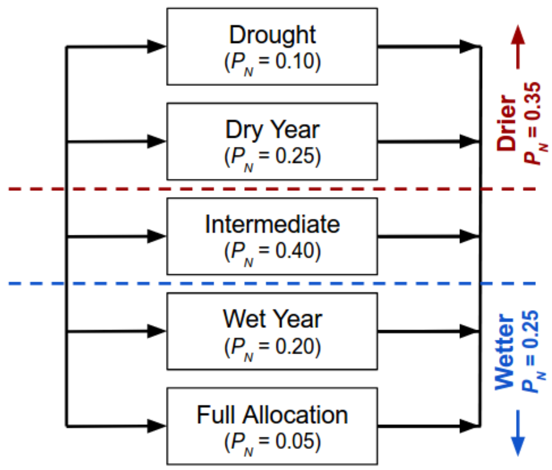


**Figure 4.** Probabilistic optimization model diagram
(shows interaction of parameters between scenario types).

Planning and operational decisions (decision variables) are as follows:

*Planning Decision:*

$\boldsymbol{Q_{GW,i}}$ = quantity groundwater allocation for Dist *i*, held regardless of Scenario *N* (AF);

*Operational Decisions:*

$\boldsymbol{Q_{SW,iN}}$ = quantity of surface water utilized by Dist *i* in Scenario *N* (AF);
$\boldsymbol{Q_{Tout,ji\ N}}$ = quantity of water transferred from Dist *j* to *i* in Scenario *N* (AF);
$\boldsymbol{Q_{Tout,ik\ N}}$ = quantity of water transferred from Dist *i* to *k* in Scenario *N* (AF);
$\boldsymbol{Q_{Rout,i\ NM}}$ = quantity groundwater recharge out to self, from Scenario *N* to *M* (AF);
$\boldsymbol{Q_{Rout,ik\ NM}}$ = quantity recharge out from Dist *i* to Dist *k*, from Scenario *N* to *M* (AF);
$\boldsymbol{Q_{Rin,i\ MN}}$ = quantity groundwater recharge in to self, from Scenario *M* to *N* (AF);
$\boldsymbol{Q_{Rin,ji\ MN}}$ = quantity recharge in from Dist *j* to Dist *i*, from Scenario *M* to *N* (AF);
$\boldsymbol{Q_{Cout,I\ NM}}$ = quantity carryover storage out to self, from Scenario *N* to *M* (AF);
$\boldsymbol{Q_{Cin,I\ MN}}$ = quantity carryover in from self, from Scenario *M* to *N* (AF);

The probabilistic model is still based on an average water quantity balance, however, it accounts for how those balances change and interact with each scenario condition. As such, all constraints shown before - besides number 7, replaced with variation shown below - must be assessed for each scenario-specific value instead of sequential years; same number of total constraints.

*Updated constraint:*

7. $\sum P_N\,[Q_{GW,i} - \sum M\,[Q_{Rout,i\ NM} + Q_{Rout,ik\ NM}] + Q_{SY,N}] \geq 0$   GW use within avg. sustainable yield [∀i].

For adaptations of these models with additional water supply scenarios or districts within a shared sub-basin, consideration should be given to the increase in constraints or decision variables and resulting increases to computational effort required - aforementioned decomposition methods may become necessary. Only the '*periodic sustainable yield limitation'* condition of groundwater use was considered with this probabilistic model; allowing pumping over sustainable yield in each individual scenario but constrained by an effective 'long-term' yield value - average annual sustainable yield values over the five scenarios.

## Section 4: Results/Findings

Both deterministic and probabilistic models were developed using Microsoft Excel and solved using an open-source optimization tool (OpenSolver for Excel, v 2.8.5; Simplex LP Solver). Groundwater pumping allocations, surface water utilization, recharge quantities, and transfer quantities were predicted for each district as model output. Results are detailed below, with corresponding Excel worksheets given in Appendix B.

### *4.1 Deterministic Model: Annual Sustainable Yield Limitation*

Tables 8A and 8B show select deterministic model outputs, assuming decision variables depend solely on varying hydrologic scenarios over a five-year period[9]. All annual conditions (scenarios) are assumed known. Results correctly indicate years with higher water availability produce greater regional economic output, with water demands fulfilled by available surface water thereby decreasing groundwater reliance. Of interest is the amount of water recharged during the driest year patterns compared with wettest[10] (i.e., recharge consistently near capacity, even in more water-scarce patterns). As more surface water is available, more water is available for groundwater storage and districts would likely increase recharge operations. However, even with less water availability the model suggests aggressive recharge, as shown in Figure 3. It is likely the model is using recharge value “loss” at lower unit/value output districts to support higher output districts - an indirect form of water transfer to ‘future self’ and others within the basin between different years. From a groundwater usage and basin sustainable yield credit standpoint this may be acceptable - certainly in a multi-year (long term) groundwater bank scenario, but may also cause other localized short-term undesired impacts (e.g., declining levels or water quality issues).

**Table 8A.** District Groundwater Use as Percent of Sustainable Yield (GW) for Various 5-year Patterns

| Parameter [District] | S1x5 (Drought) | S2x5 (Dry Year) | S3x5 (Intermed) | S4x5 (Wet Year) | S5x5 (Full Alloc) | Avg All Scenarios | Std Dev All Scenarios |
|---|---|---|---|---|---|---|---|
| *Scenario No* | *1* | *782* | *1563* | *2344* | *3125* | | |
| **$GW_1$ [D1]** | 43% | 14% | 10% | 12% | 31% | 29% | 10% |
| **$GW_2$ [D2]** | 0% | 0% | 0% | 16% | 25% | 11% | 9% |
| **$GW_3$ [D3]** | 16% | 24% | 19% | 14% | 11% | 18% | 4% |
| **$GW_4$ [D4]** | 41% | 51% | 43% | 33% | 33% | 38% | 4% |
| **$GW_5$ [D5]** | 0% | 11% | 28% | 25% | 0% | 4% | 7% |
| **SW (AF/yr)[3]** | 85,536 | 289,919 | 571,310 | 713,563 | 922,917 | 511,730 | 311,513 |
| **Recharge Avg (AF/yr)[2]** | 50,265 | 51,215 | 48,261 | 46,841 | 52,165 | 49,868 | 2,634 |
| **Out ($mil/yr)[4]** | $760 | $1,184 | $1,556 | $1,802 | $2,338 | $1,462 | $245 |

*See notes below Table 8B.*

[9] As illustrated in Figure 2; *total of 3125 deterministic model runs of different five-year scenario patterns.*
[10] Driest pattern: S1x5 (P = 0.00001); Wettest pattern: S5x5 (P = 0.0000003), see Table 5.

**Table 8B.** District Groundwater Use as Percent of Sustainable Yield (GW) for 5-year Patterns (Historic)

| Parameter [District] | S2x1, S1x2, S2x1, S5x1 | S5x1, S2x1, S1x3 | S4x1, S5x1, S2x1, S1x1, S2x1 | S2x2, S4x1, S3x1, S4x1 | S5x2, S4x1, S2x2 | S1x1, S4x1, S1x1, S5x2 |
|---|---|---|---|---|---|---|
| Years[1] | 2013-2017 | 2011-2015 | 2005-2009 | 2001-2009 | 1998-2002 | 1992-1996 |
| *Scenario No* | *635* | *2626* | *2402* | *839* | *3082* | *400* |
| **$GW_1$ [D1]** | 37% | 27% | 25% | 18% | 22% | 50% |
| **$GW_2$ [D2]** | 0% | 18% | 19% | 0% | 33% | 0% |
| **$GW_3$ [D3]** | 17% | 23% | 20% | 18% | 12% | 22% |
| **$GW_4$ [D4]** | 40% | 32% | 36% | 41% | 33% | 28% |
| **$GW_5$ [D5]** | 6% | 0% | 0% | 23% | 0% | 0% |
| **SW (AF/yr)[3]** | 345,540 | 303,888 | 449,106 | 508,377 | 651,565 | 546,452 |
| **Recharge Avg (AF/yr)[2]** | 51,215 | 51,215 | 51,215 | 51,215 | 45,415 | 48,685 |
| **Out ($mil/yr)[4]** | $1,131 | $1,130 | $1,377 | $1,464 | $1,787 | $1,391 |

*Note: Recall total GW pumped by region each year limited to Sustainable Yield value, allocated between districts (D1 to D5). Headers indicate 5-yr scenario patterns (e.g., 5-yrs all Scenario 1 is S1x5, or mixed scenarios in order as shown).*

[1] Historical water year type patterns (five-year), based on CDEC Hydrologic Classification Indices for San Joaquin Valley.

[2] Average annual recharge quantity in basin, mix to self or other districts (e.g., *Dist i (y)* to *Dist k (y+1)*); *maximum 52,165 AF/yr.*

[3] Average surface water quantity available to region per year.

[4] Regional economic output for scenarios, see Appendix B for district values (i.e., Objective Function output, see Section 3.2).

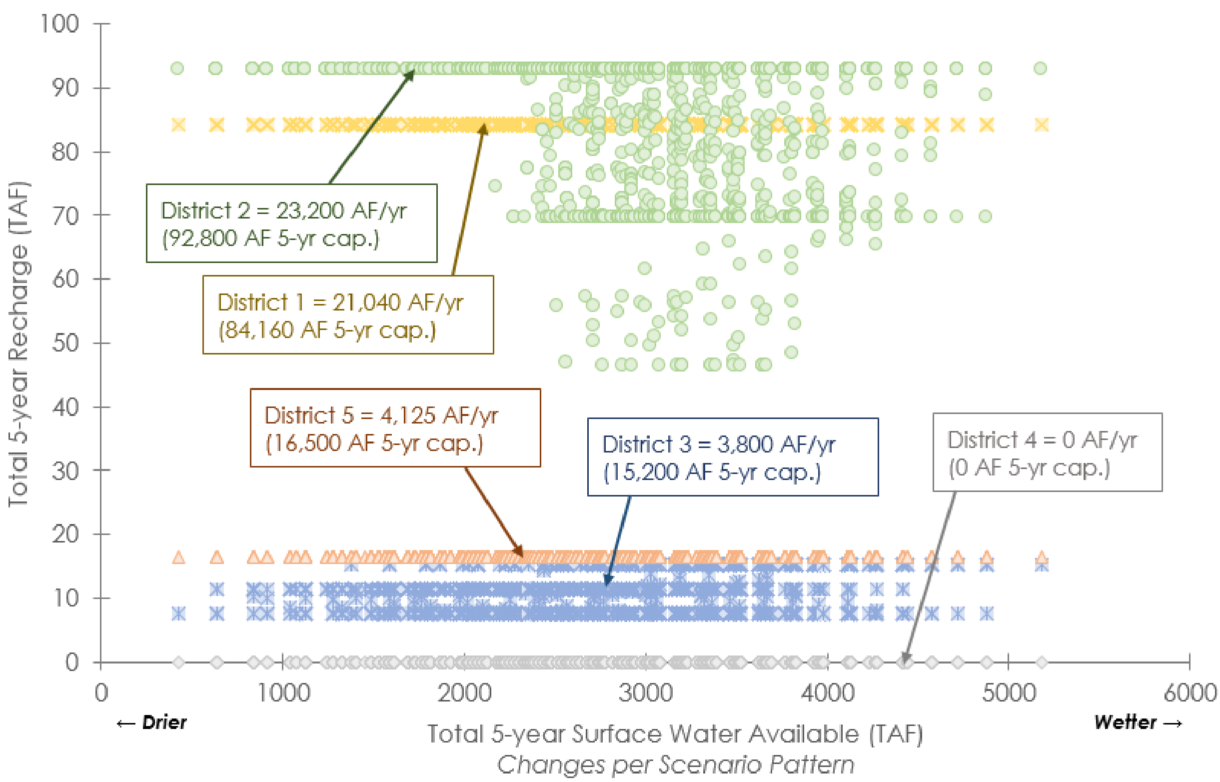


**Figure 5.** Total 5-year Recharge Out of each District over Scenario Patterns.
(*Note: Increasing surface water availability indicates 5-year patterns with more favorable year types, lowest availability for five 'Drought' S1 years and highest for five 'Full Allocation' S5 years.)*

In this analysis, differences between solely 'Drought' pattern conditions - conditions with less total 5-year surface water available - and 'Full Allocation' conditions was approximately

$1,500 million (around 22% of average 5-year output value), perhaps indicative of recent drought impacts to agriculture in California (Howitt *et al.* 2015). This may be confirmed by the similarly $1,200 million approximate difference between the 2013-2017 'dry' 5-year pattern (from Table 8B) and 'Full Allocation' conditions. Percentages of sustainable yield allocations also vary between scenarios presumably due to groundwater pumping costs influencing water use decisions in drier years (e.g., District 1 with 44% in drier scenarios, 32% in wetter ones, but around 10% in intermediate pattern). In drier years, Districts 2 and 5 receive very little allocation of sustainable yield, and presumably cannot fulfill met demands in those cases. The standard deviation of percentage sustainable yield allocation for all scenarios for each district value is less than 10%, suggesting values are somewhat stable over possible 5-year scenario patterns.

Figure 6 illustrates the average percentage of crop demand fulfillment with their range over all scenarios. As mentioned in Section 3, a 33% minimum fulfillment (for permanent crops) was established for each district in each year. Districts 1 and 2 have lower demand fulfillment percentages with better surface water availability, but carry lower crop valuations (see Table 1). The model clearly shifts and uses water in districts and years with greater valuations to increase regional output.

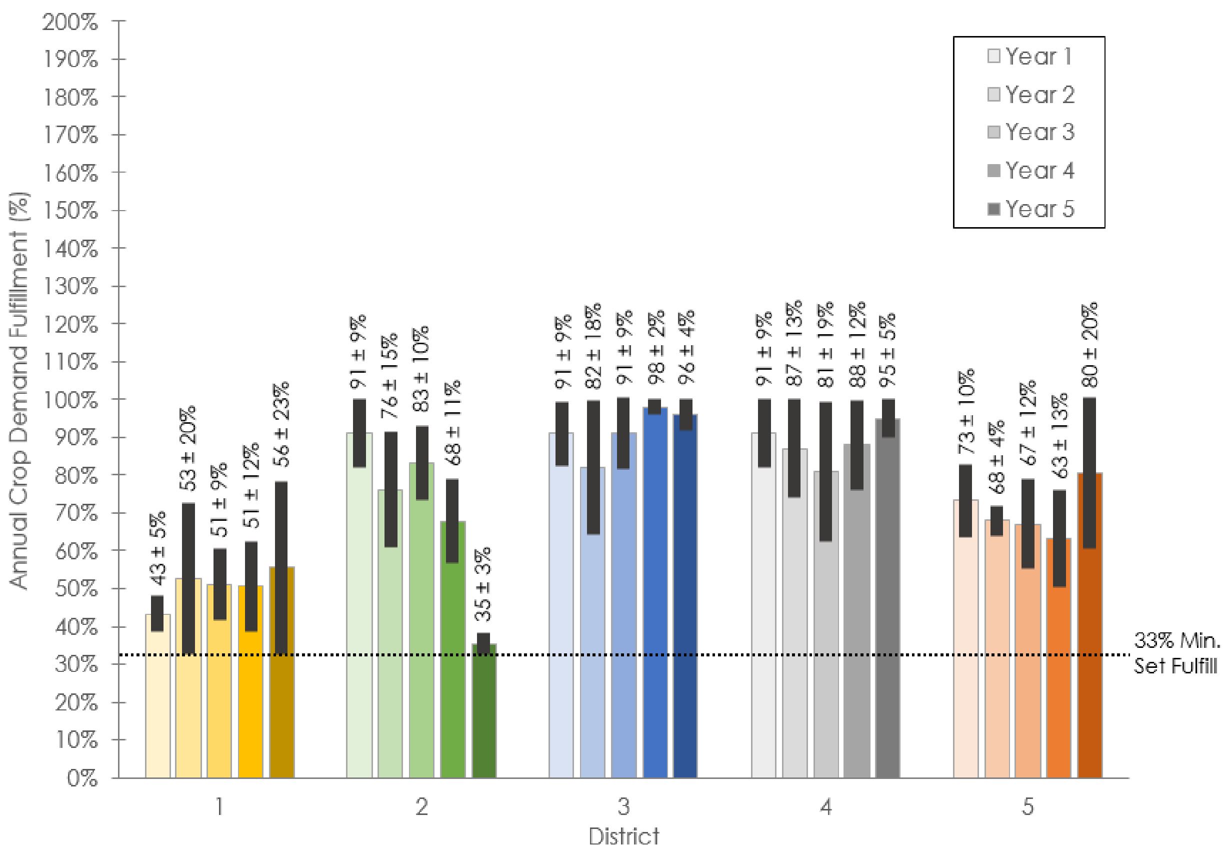


**Figure 6.** Crop Demand Fulfillment by District and Year.

Most district results use maximum recharge capacity over 5-year scenario patterns as seen in Figure 5. Only Districts 2 and 3 varied with total surface water availability, seemingly hitting recharge 'stages' or grouping at specific values approximately ¾ and ½ of 5-year recharge capacity. Investigation of model behavior did not clarify why these conditions occured, but instances seem driven by crop demands dramatically increasing for these districts, perhaps leaving less water available for recharge. Assuming the model was using recharge as an indirect water transfer to ‘future self’ and others, these points may be instances where ‘receiving’ districts either had adequate supply or lacked economic demand to warrant additional recharge. Regarding in-year water supply transfers, Figure 7 shows general outputs for specific district-to-district operations over the 5-year scenarios (e.g., which pairs of ‘sending’ and ‘receiving’ districts were occuring more frequently). Each graph is for a receiving district and illustrates trends from senders for different 5-year patterns, from less available water (drier) to more available (wetter). Most districts seemed to maintain consistent ‘partners’, but quantities varied greatly across year types.

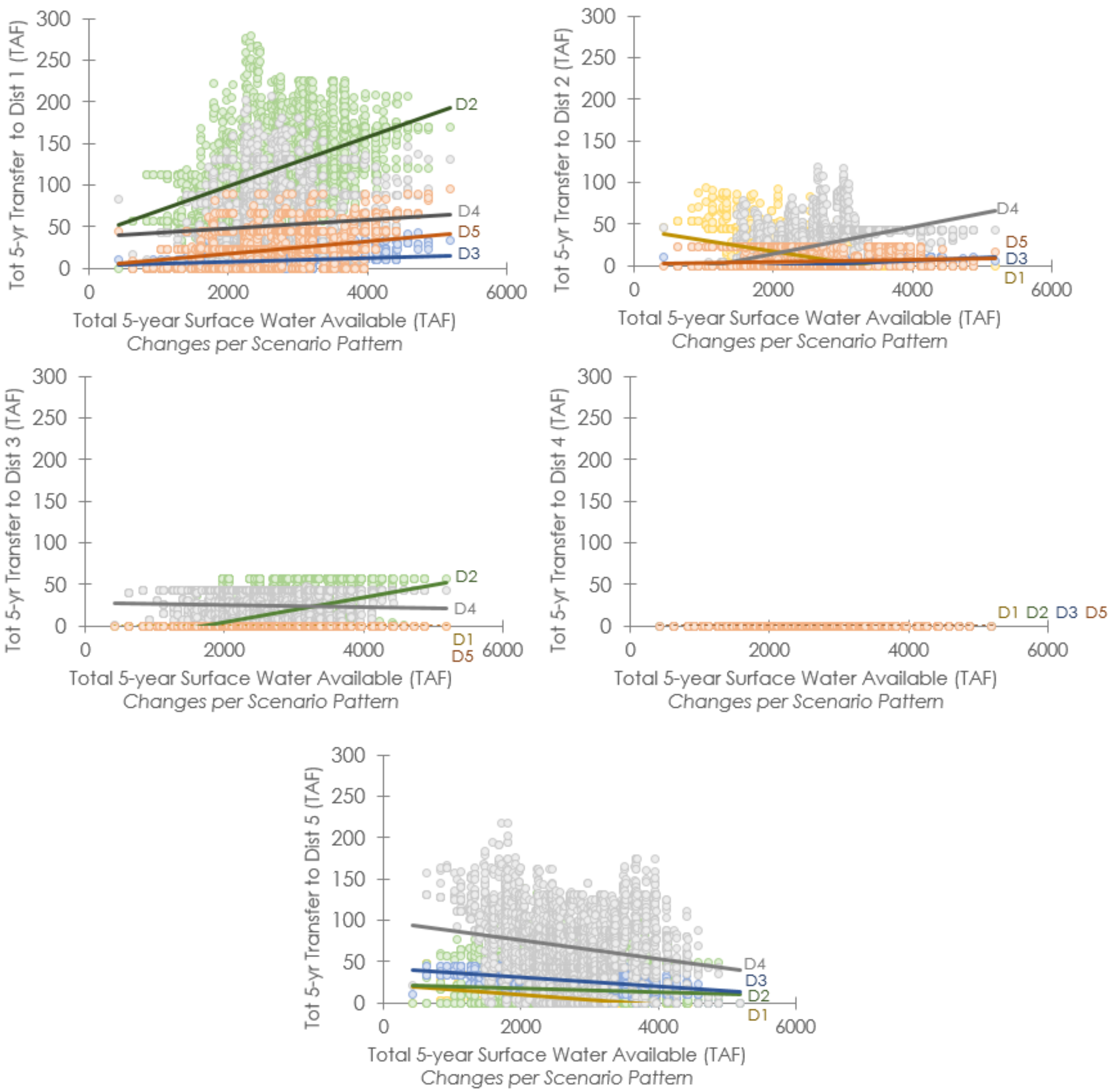


**Figure 7.** District-to-District Water Supply Transfers.

Figure 8 shows the regional output values for all scenarios. As expected, total 5-year output increases with more surface water availability with variation in slopes affected by crop valuations, surface water supply availability, sustainable yield allocation, etc. Line slopes provide a generalized unit value of surface water ($/AF) for each district, which may indicate a crop water unit value for additional surface water. Other parameters are similarly assessed in Table 9 as potential indicators of regional and district output, or opportunities to increase output from available water sources.

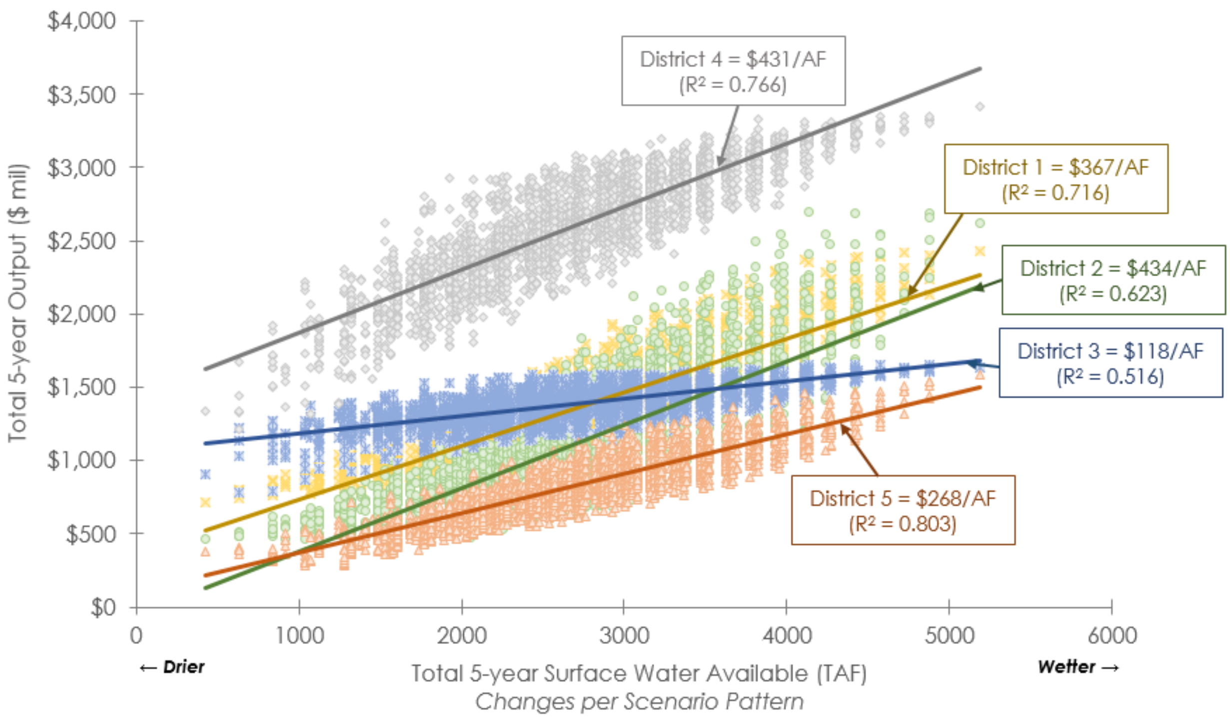


**Figure 8.** Regional Output Values over Scenario.

**Table 9.** Parameter Assessment of District Output Value.

| **Parameter**[1] | **District 1** | | **District 2** | | **District 3** | | **District 4** | | **District 5** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Unit Value ($/AF) | R^2 | Unit Value ($/AF) | R^2 | Unit Value ($/AF) | R^2 | Unit Value ($/AF) | R^2 | Unit Value ($/AF) | R^2 |
| Surface Water | $367 | 0.716 | $434 | 0.623 | $118 | 0.516 | $431 | 0.766 | $268 | 0.803 |
| Groundwater (Sustain Yield) | $290 | 0.169 | $512 | 0.688 | $265 | 0.031 | $337 | 0.031 | $172 | 0.090 |
| Recharge[3] | $877 | 0.170 | $976 | 0.136 | $1,159 | 0.049 | --[2] | --[2] | $1,111 | 0.605 |
| Transfer In | $480 | 0.139 | $706 | 0.222 | $725 | 0.016 | --[2] | --[2] | $661 | 0.293 |
| Carryover Storage | $1,190 | 0.550 | $1,249 | 0.801 | $304 | 0.097 | $972 | 0.160 | $540 | 0.268 |

*Note: Values indicate average increase in 5-year district output per unit increase in parameter (i.e., output per acre foot of additional water), perhaps which sources contributed more towards district crop output and are 'economically worth more' to each district. Doesn't include unit cost which may reduce district benefits (e.g., District 1 (D1) carryover $1,190/AF minus option unit cost).*

[1] Values are 5-year total quantity; sum of quantity to other districts and future 'self', if applicable.

[2] No or constant recharge and transfer water into district during all scenarios, unable to assess slope and R^2 values.

[3] Recharge in either from past self or other other sending districts, requires past recharge storage into future time steps.

### *4.2 Fixed-Scenario Deterministic Models: Periodic Sustainable Yield Limitation*

Tables 10A and 10B show fixed-scenario deterministic model outputs with periodic sustainable yield limitations (e.g., averaged over 5-year period as opposed to being annually fixed, as above). These are model-determined percentages of sustainable yield allocated to each district. All annual conditions (scenarios) are still assumed known, and pumping allocations are assigned for a presumed scenario based on 5-year sequencing.

**Table 10A.** District Groundwater Use as Percent of Sustainable Yield (GW) for Various 5-year Patterns

| Parameter [District] | S1x5 (Drought) | S2x5 (Dry Year) | S3x5 (Intermed) | S4x5 (Wet Year) | S5x5 (Full Alloc) | Avg All Scenarios | Std Dev All Scenarios |
|---|---|---|---|---|---|---|---|
| *Scenario No* | *1* | *782* | *1563* | *2344* | *3125* | | |
| **$GW_1$ [D1]** | 25% | 9% | 0% | 0% | 0% | 14% | 12% |
| **$GW_2$ [D2]** | 0% | 0% | 0% | 0% | 2% | 11% | 5% |
| **$GW_3$ [D3]** | 7% | 7% | 19% | 15% | 27% | 22% | 8% |
| **$GW_4$ [D4]** | 57% | 66% | 47% | 38% | 71% | 46% | 17% |
| **$GW_5$ [D5]** | 11% | 18% | 34% | 47% | 0% | 7% | 18% |
| **SW (AF/yr)[3]** | 85,536 | 289,919 | 571,310 | 713,563 | 922,917 | 511,730 | 311,513 |
| **Recharge Avg (AF/yr)[2]** | 50,265 | 50,265 | 44,465 | 44,465 | 51,215 | 47,140 | 2,893 |
| **Out ($mil/yr)[4]** | $795 | $1,207 | $1,594 | $1,850 | $2,408 | $1,553 | $247 |
| **vs Annual SY** | +4.6% | +1.9% | +2.4% | +2.7% | +3.0% | +6.3% | +0.8% |

*See notes below Table 10B.*

**Table 10B.** District Groundwater Use as Percent of Sustainable Yield (GW)for 5-year Patterns (Historic)

| Parameter [District] | S2x1, S1x2, S2x1, S5x1 | S5x1, S2x1, S1x3 | S4x1, S5x1, S2x1, S1x1, S2x1 | S2x2, S4x1, S3x1, S4x1 | S5x2, S4x1, S2x2 | S1x1, S4x1, S1x1, S5x2 |
|---|---|---|---|---|---|---|
| Years[1] | 2013-2017 | 2011-2015 | 2005-2009 | 2001-2009 | 1998-2002 | 1992-1996 |
| *Scenario No* | *635* | *2626* | *2402* | *839* | *3082* | *400* |
| **$GW_1$ [D1]** | 8% | 0% | 0% | 8% | 0% | 0% |
| **$GW_2$ [D2]** | 0% | 0% | 0% | 0% | 12% | 0% |
| **$GW_3$ [D3]** | 24% | 26% | 22% | 18% | 24% | 31% |
| **$GW_4$ [D4]** | 52% | 32% | 36% | 50% | 64% | 56% |
| **$GW_5$ [D5]** | 16% | 42% | 42% | 24% | 0% | 13% |
| **SW (AF/yr)[3]** | 345,540 | 303,888 | 449,106 | 508,377 | 651,565 | 546,452 |
| **Recharge Avg (AF/yr)[2]** | 50,265 | 50,265 | 50,265 | 44,465 | 50,265 | 50,265 |
| **Out ($mil/yr)[4]** | $1,195 | $1,218 | $1,526 | $1,516 | $1,904 | $1,490 |
| **vs Annual SY** | +5.7% | +7.8% | +10.9% | +3.5% | +6.5% | +7.1% |

*Note: Recall total GW pumped by region in 5-year period limited to Sustainable Yield value over period (i.e., SY x 5).*
*Headers indicate 5-yr scenario patterns (e.g., 5-yrs all Scenario 1 is S1x5, or mixed scenarios in order as shown).*

[1] Historical water year type patterns (five-year), based on CDEC Hydrologic Classification Indices for San Joaquin Valley.

[2] Average annual recharge quantity in basin, mix to self or other districts (e.g., *Dist i (y)* to *Dist k (y+1)*); *maximum 52,165 AF/yr.*

[3] Average surface water quantity available to region per year.

[4] Regional economic output for scenarios, see Appendix B for district values (i.e., Objective Function output, see Section 3.2).

Output trends follow the annually restricted deterministic model, with differences in district output values which average $91 mil or 6.3% more with loosening pumping restrictions over the 5-year period. The amount of allocated sustainable yield is similar in both models when averaged over all scenarios. Similarly, most patterns end up recharging nearly full amounts with water transferred via recharge to and from other districts. Recharge from each district has identical patterns between the annual and period fixed runs (see Figure 5).

Average groundwater use patterns by district and year are shown in Figure 9. The annual restricted model effectively fixes constant district allocations of sustainable yield for each year. As expected, the looser multi-year sustainable yield restrictions allows more varied pumping with most having less pumping in early years and greater pumping in later years; specifically in last year of the 5-year period. Notable exceptions include districts 4 and 5, with some greater average groundwater consumption in years 1 and 2. These districts both have generally less drastic changes in surface water availability over time (see Table 6), with district 5 having much smaller crop water demands.

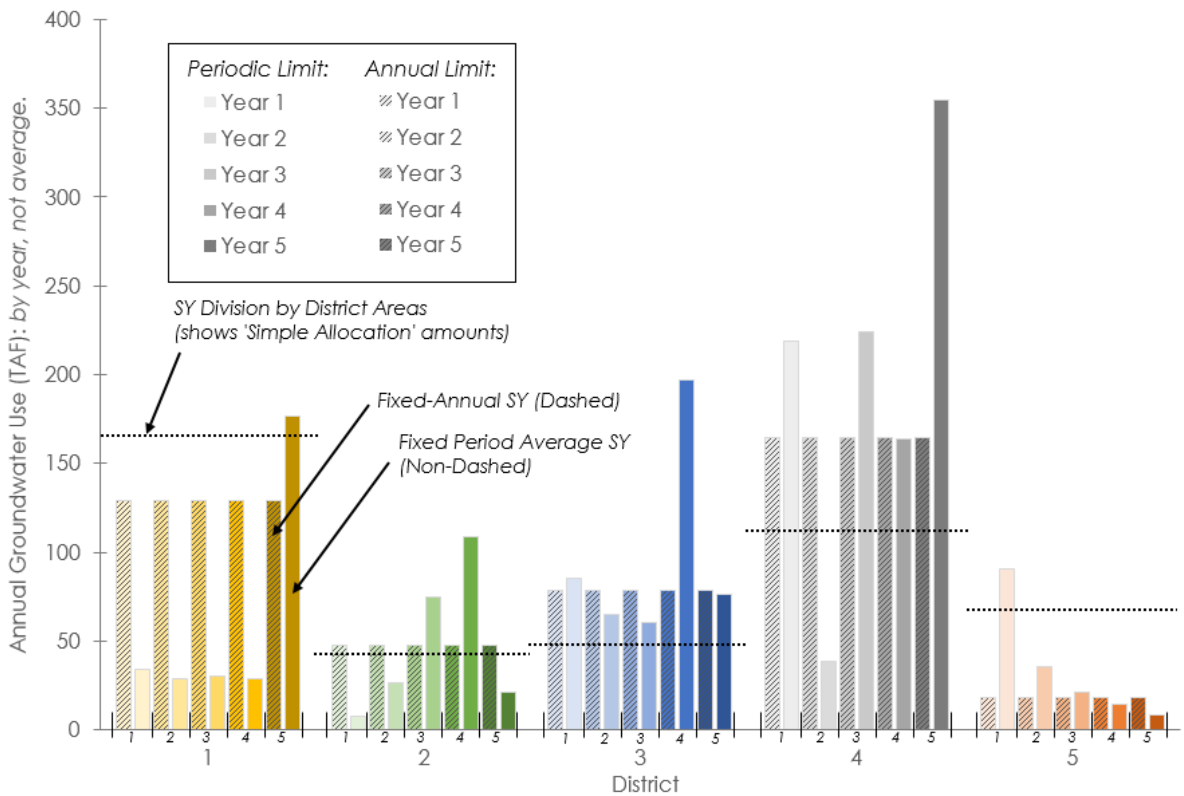


**Figure 9.** District Groundwater Consumption per Year under Varying Models.

From an operations standpoint, the long-term nature of SGMA may not facilitate a strategy shown in the graph, like reducing pumping early on to save for later time steps, since an 'ending time step' will not likely be as well defined practically. Districts may be unable to pass on short-term groundwater consumption if the long-term benefits and availability are unclear. However, districts could operate in 5-year 'cycles' where a similar periodic strategy is maintained and adapted based on short-term conditions (e.g., drought condition adaptations). The operations of districts under SGMA, especially in Kern County, have not yet been established and will be contested through regional or basin negotiations. Most districts fare better using either the annual or multi-year strategy than the simple allocation of sustainable yield by service area (graphed dashed lines).

Figure 10 illustrates the updated average percentage of crop demand fulfillment with ranges of values over all scenarios. Some individual districts/years fared better than the annual restricted scenario, however, demand fulfillment results were generally similar between models. Increases in late-period fulfillment and lesser range values, in particular years 4 and 5, likely account for the approximate 6% average increase in regional output values shown earlier[11] (i.e., supply-demand timing constraints). For instance, Districts 4 and 5 which have greater increase in crop water valuation over time (Table 6) show higher demand fulfillment in the averaged-restricted model.

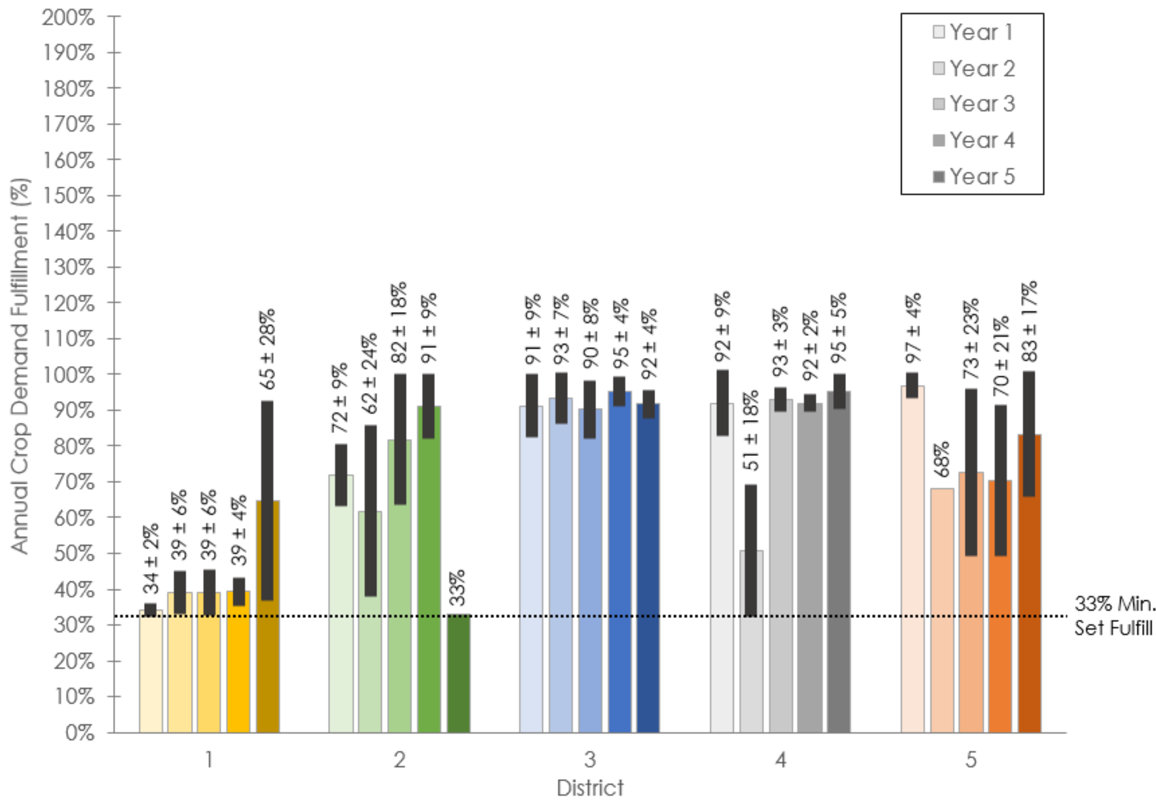


**Figure 10.** Crop Demand Fulfillment by District and Year.

There are increased numbers of transfers between districts; mostly from district 2 in drier years and from districts 3 through 5 in wetter years. Greater pumping costs for districts 3 through 5, reflecting greater groundwater depths for the eastern basin, are likely influencing transfers to these areas. Better surface water allocations to east-side districts in wetter years makes transferring supplies towards the basin west-side more economical. This model seems to reflect a more realistic approach to current water allocation practices, especially in early-period years. It illustrates groundwater consumption varying between years and conditions, with quantities transferred and recharged between districts in a conjunctive-use[12] situation (DWR, 2014; Poso Creek IRWM, 2014).

[11] Percent increase in output vs. year 1: *Annual Model* - Yr 2 +116%, Yr 3 +116%, Yr 4 +141%, Yr 5 +161%, *Periodic Model* - Yr 2 +85%, Yr 3 +116%, Yr 4 +144%, Yr 5 +187%. *Note Yr 2/5 differences.*

[12] "Conjunctive-use" refers to active management of surface and groundwater resources. Typically, surface water is used in wet years and groundwater in dry years; recharged in wet years for future use.

### *4.3 Probabilistic Model*

Table 11 shows probabilistic model output assuming scenario conditions in no particular sequence (i.e., not a 5-year pattern of scenarios but rather a continuous subsequent scenario type setup). All future water year types remain unknown but influence the regional output based on probability of occurrence. This model reflects the aforementioned apportionment of groundwater based on optimization of regional output value. However, individual scenario types are permitted groundwater usage over individual sustainable yield values so long as total scenario limits are maintained based on probability of occurrence (i.e., similar to period restricted deterministic model, where scenario-types replace year sequencing).

**Table 11.** District Groundwater Use as Percent of Sustainable Yield (GW) for Scenario Types

| Parameter [District] | Drought | Dry Year | Intermed | Wet Year | Full Alloc | Avg All Scenarios | Std Dev All Scenarios |
|---|---|---|---|---|---|---|---|
| **$GW_1$ [D1]** | 48% | 22% | 50% | 11% | 0% | 32% | 22% |
| **$GW_2$ [D2]** | 8% | 1% | 11% | 0% | 0% | 5% | 5% |
| **$GW_3$ [D3]** | 7% | 14% | 7% | 19% | 0% | 12% | 7% |
| **$GW_4$ [D4]** | 20% | 29% | 15% | 39% | 0% | 26% | 15% |
| **$GW_5$ [D5]** | 17% | 34% | 17% | 31% | 0% | 25% | 13% |
| **Scenario SY (AF)[4]** | 336,922 | 688,130 | 933,287 | 231,444 | 0 | 437,958 | 332,446 |
| **% SY Criteria[1]** | 77% | 157% | 213% | 53% | 0% | 100% | 76% |
| **SW (AF)[3]** | 85,537 | 289,919 | 574,412 | 732,021 | 955,244 | 527,427 | 345,966 |
| **Recharge Avg (AF)[2]** | 52,165 | 52,165 | 52,165 | 52,165 | 52,165 | 52,165 | 0 |
| **Out ($mil)** | $465 | $1,267 | $1,731 | $1,289 | $1,289 | $1,208 | $459 |

[1] Percentage of defined sustainable yield (SY) value per year, equals 437,958 AF/yr. *Note average of all scenario types.*
[2] Average annual recharge quantity in basin, mix to self or other districts (e.g., *Dist i (y)* to *Dist k (y+1)*); *maximum 52,165 AF/yr.*
[3] Average surface water quantity available to region per scenario.
[4] Each scenario can pump more than annual SY limits, so long as average as defined in Section 3.3.

Probabilistic output trends follow the deterministic model with surface water use and transfer patterns under different scenarios, however, recharge is fully utilized regardless of year type. This clearly indicates the importance of recharge and carryover storage to prepare for uncertain future conditions as shown in Figure 11; the model foregoes immediate crop valuation output in each scenario and instead pursues recharge with available water. Average and most scenario regional output values fall between deterministic ‘dry year’ and ‘intermediate’ outputs (see Table 8A). Although this model does not realize the economic output of wetter or drier (deterministic) scenarios, it effectively hedges water supplies by making the most of intermediate and high-probability conditions - accounting for a collective 40%+ probability of occurrence (see Figure 4). It also performs better than most optimized values in fixed cases.

The expected value of perfect information (EVPI), and value of stochastic solution (VSS) can both be assessed with this probabilistic model. EVPI represents willingness-to-pay to gain certain information (i.e., theoretically pay for insight into future hydrologic conditions); calculated as difference between average scenario deterministic output and the probabilistic output, as follows:

*Expected Value of Perfect Information (EVPI):*

| | | |
|---|---|---|
| Avg. | $1,462 mil | *=avg(Deterministic Values, Table 8A)* |
| Probabilistic | $1,208 mil | *=avg(Probabilistic Scenarios, Table 11)* |
| **EVPI** | **$254 mil** | |

VSS represents objective function value for using the probabilistic model as opposed to fixed-scenario deterministic models (i.e., assuming a hydrologic scenario without prior knowledge); calculated as difference between average fixed-scenario deterministic output and the probabilistic output, as follows:

*Value of Stochastic Solution (VSS):*

| Scenario | Drought S1x5 | Dry Year S2x5 | Intermed S3x5 | Wet Year S4x5 | Full Alloc S5x5 | Avg. |
|---|---|---|---|---|---|---|
| Avg[1] | $616 mil | $1,087 mil | $1,420 mil | $1,225 mil | $1,557 mil | $1,181 mil |
| Probabilistic | $465 mil | $1,267 mil | $1,731 mil | $1,289 mil | $1,289 mil | $1,208 mil |
| **VSS** | **($151 mil)** | **$180 mil** | **$311 mil** | **$64 mil** | **($468 mil)** | **$27 mil** |

[1] Probabilistic scenario percentages (Table 10) applied to corresponding deterministic pattern, run as fixed in model.

Both EVPI and VSS indicate value gained on average for using probabilistic planning model as opposed to deterministic ones - useful in assessing whether it's advantageous to allocate groundwater using a probabilistic approach.

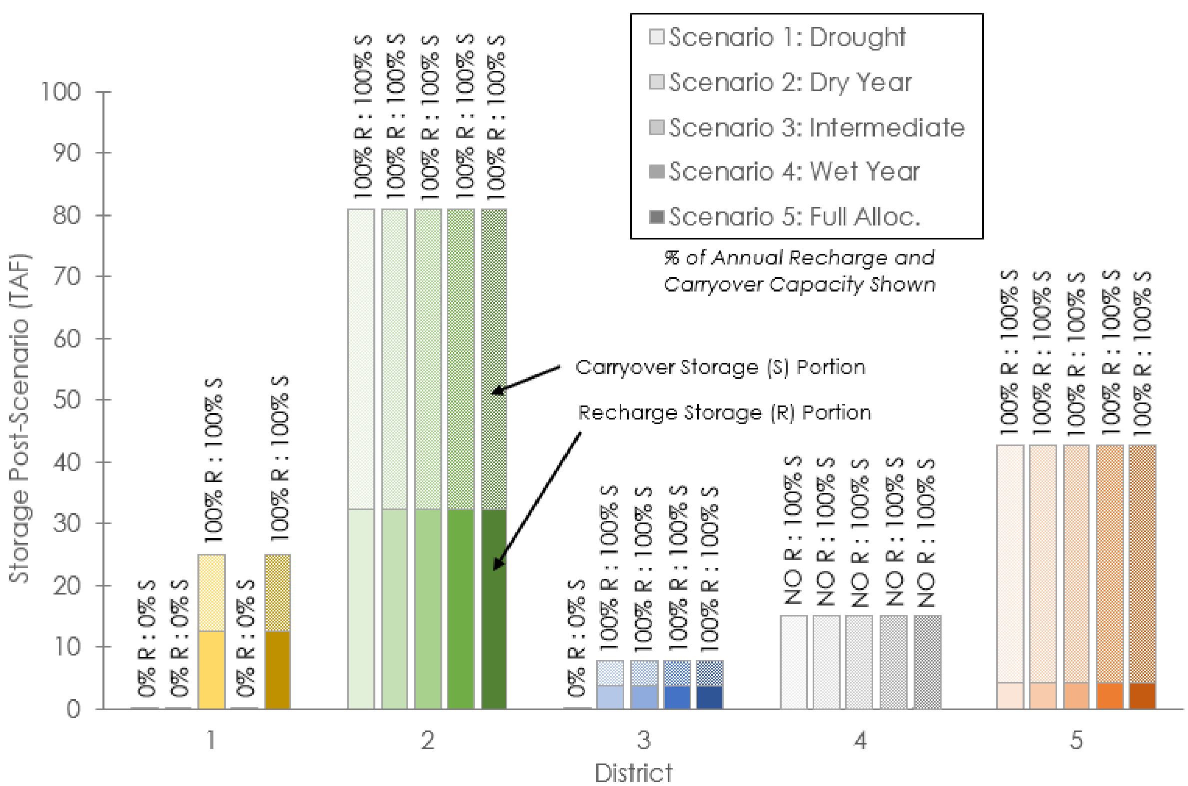


**Figure 11.** Recharge and Carryover Storage for Scenarios.

As part of the greater economic output for the region using these figures ($1,462 million plus), EVPI and VSS are 17.3% and 1.8%, respectively. The probabilistic model seems to endorse rather aggressive storage and transfer operational decisions in maximizing output on high-probability scenarios, as opposed to saving against 'drought' or maximizing 'full allocation' conditions. This seems opposed to some extreme condition hedging operations and cost-saving measures on low-probability tail conditions. In other words, the model appears to carry out similar operational logic regardless of impact to extreme scenario conditional output.

Recharge and carryover values shown above also provide some operational guidelines for maximizing regional output, regardless of scenario occurance in a specific pattern. Note average GW use values per district are closest to the 'wet year' deterministic value, although there are some key differences which illustrates the complexity in SGMA allocation guidelines for the basin within sustainable yield. Assessments will likely differ based on hydrologic conditions (probabilities) and consumption data for different regions of California, but is worth knowing potential benefits offered by the probabilistic model.

## Section 5: Policy and Management Implications

Regulated groundwater management in California under SGMA can be a sensitive topic, especially where large agricultural users depend on groundwater and surface water is limited (Feinerman and Knapp, 1983; Blomquist, 2016; PPIC, 2017). Optimization of a region-wide output value, such as economic crop production considering recharge capabilities, can allow for allocating groundwater in a more economical manner as opposed to simple proportion of overlying land or similar method that does not ensure water going to the most "beneficial" use[13]. Models can suggest management practices (recharge and transfers) that help hedge against uncertain future conditions.

Estimates of parameters such as surface water availability or crop water demands can be straightforward, but will always include some error from measurement inaccuracy, modeling uncertainty, and hydrologic variability. Other parameters are more difficult to predict or accurately describe (e.g., Recharge Efficiency or Recharge Impact parameters in Table 4, or conveyance losses to evaporation/seepage). As with other tools that rely on regional water balances, there are often large uncertainties and intricate internal variabilities that may be overlooked when used for planning (Marques *et al.* 2005; Zhu *et al.* 2015; PPIC, 2017; Arnold *et al.* 2017). The probabilistic linear programming (PLP) model presented in this report is subject to these issues, as discussed in following subsection. The following are some important policy and management implications  from considerations of model uncertainty and variability in input data:

- Given California's natural hydrologic variability, and inherent uncertainty of these models, water and groundwater plans need to be prepared for simple water balances (or dependent allocation models) to be substantially wrong. Plans must support adjustments and adaptations into the future - such as constantly updated supply scenario probabilities, using EVPI and VSS to review model utility. *This is especially relevant for the long-term or scenario-based aspects of SGMA-required planning.*

[13] Districts tasked with managing groundwater resources will need to agree on sub-basin "beneficial uses"; this will likely be a challenging but important aspect for implementing SGMA (Blomquist, 2016).

- Water plans and operations also need to prepare for substantial variability in sources of water available across years (e.g., continuous adjustments to input water supplies and costs shown in Table 2). Source and sustainability planning should account for uncertainty estimates and try to reduce them over time to improve model accuracy.
- To reduce and better understand water uncertainties and variability, and improve collaboration among districts and other managing interests, more solid regional water accounting and measurement will likely be needed (PPIC, 2016).

Districts and other groundwater management agencies could work together to address these concerns, and should explore different scenarios and input conditions using the deterministic and probabilistic tools presented here. Being adaptive to changing conditions under SGMA long-term will be key, but similarly important will be defining basin beneficial uses and sustainable yields, and subsequently determining how best to allocate groundwater resources between dependent and often conflicting users.

## *5.1 Model Use Concerns and Shortcomings*

With this relatively simplistic approach to district operations, there are some notable concerns and shortcomings with PLP model formulation presented in this report. Some of these are issues and concerns are addressed below:

- While the model is configured only for agricultural users, and most basins also include others (e.g., urban or environmental), many of the input parameters (Tables 2-5) may be applicable to other uses. Output crop valuation can be adapted, or a portion of the sustainable yield value can be subtracted for others users prior to being input.
- This analysis of groundwater recharge depicts some in-basin management options, allowing 'recharge transferring' between future self or other districts. Those with more recharge capability may be able to supply more recharge to serve other districts[14]. District and regional managers can assess regional capabilities of recharge under SGMA, likely using more detailed hydrogeologic models. The model presented here illustrates that recharging with intent to allow other district's use may be management option worth considering.
- Values in Tables 2-5 may need to be adjusted to reflect in-district constraints (e.g., define surface water supplies capable of receiving instead of contract amount, or recharge capability with district conveyance system). More focus should be placed on model tendencies to recharge and store water for future uncertain conditions; provides justification for more aggressive storage within realistic limits.
- Deterministic methods illustrate allocation of groundwater resources between multiple districts within a basin, based on common valuation output. The model introduces a method for considering different hydrologic conditions and potential impacts. While probabilistic scenarios did not have relatively large improvement over deterministic for Kern County sample in low-probability conditions, it still indicated output improvement in intermediate years (maximize higher-probability conditions). This may change for different basins with varying recharge and transfer capabilities, and supplies.

[14] Greater computational resources may be needed, or more detailed model (Zhu *et al.* 2015) may be better suited to analyze.

The input/output structure of the deterministic and probabilistic tools cannot depict all aspects of groundwater management under SGMA. In most cases, more intensive analytical analysis of hydroeconomic data that incorporate other water management strategies and operational constraints should be be used (Zhu *et al.* 2015). The PLP model is only intended to act as initial conditions for discussions of basin groundwater allocations and sustainable yield assessment.

## Section 6: Conclusions

A water balance optimization model of several Kern County agricultural water districts was developed, examining surface water and groundwater use, allowing recharge and water transfers within a common basin. Surface water supplies are highly variable and depend on hydrologic year type, with large uncertainty in available supply. Five-year combinations of different water availability scenario patterns were considered, directly impacting the surface water available and increasing dependence on groundwater. Local groundwater will eventually be subject to SGMA guidelines, meaning a basin sustainable yield and district-specific allocations established before hydrologic conditions are realized. For allocating sustainable yield, the model has been configured to maximize regional economic output.

Deterministic model runs, assuming known future hydrologic conditions, yielded large differences in groundwater allocation between scenario pattern types (e.g., district 2 with 0% in drier scenarios, closer to 25% in wetter ones). Economic output was between $760 million/year and $2,338 million/year for drier and wetter scenarios, respectively - between 2.4% and 7.4% of total statewide agricultural production (USDA, 2012). Results show surface water availability heavily influences economic performance, as expected, and highlights the importance of groundwater recharge and storage options. Deterministic models under fixed groundwater allocations (i.e., limiting groundwater to optimal values for 'intermediate' scenario and assessing the other scenario decision variables) indicate more emphasis on water transfers and carryover storage, similar to realistic conditions. However, groundwater recharge was nearly maximized in all year types, indicating the model used recharge an "indirect transfer" for accounting and hedging against future conditions. Regional economic output is lower with lack of future hydrologic knowledge. The probabilistic run, based on year-type rather than a pattern of determined hydrologic conditions, yields regional values better in intermediate hydrologic year teams versus deterministic outputs, but worse in drier and wetter year values; average $1,208 billion/year output across all scenario types (3.8% of statewide production, approx. $27 million more than deterministic average). Probabilistic analysis tends to maximize higher-probability median conditions at the expense of profit during lower-probability extreme drought or very wet conditions. It does not necessarily provide a hedge against all impacts during these year types, even suggesting dry-year storage at the expense of economic output. Rather, the model appears to favor production during 'more likely' conditions. EVPI and VSS parameters, which indicate (theoretical) willingness-to-pay to gain information and value gained from the probabilistic model compared to deterministic ones, respectively, are $254 and $27 million, only 17.3% and 1.8% improvements of total regional output.

The model, based on deterministic and probabilistic methods, provides approximate methods for allocating groundwater (apportioned from basin sustainable yield) to districts under fixed and uncertain future hydrologic conditions. Unlike fixed allocation values based on overlying land, the model optimizes regional economic output allowing economic drivers to encourage multi-year surface water usage, recharge, and in-regional water transfers. Caution should be taken in accepting results, and more work should be done to incorporate more districts sharing the Kern County basin, and to incorporate more realistic benefits of groundwater recharge for future use (i.e., longer periods, perhaps as *n*-way stochastic model).

## Section 7: Model Expansion Considerations/Future Studies

The developed model is only a simple representation of water demands, accounting only for crop demands on an economic output basis with some rather aggressive operational suggestions. Other factors, such as urban or environmental uses are omitted from the model and must be added for detailed SGMA-related work. While this model provides some insight into agricultural water use, recharge, carryover storage, and transfer practices within a shared basin under probabilistic conditions, there are some ways in which it can be improved. Some of those issues and opportunities are discussed below, as an expansion of the topics from Section 5:

- Multi-year analyses have implications for hydrologic conditions and land use planning as shown here. For instance, occurrence of dry/wet years may indicate a greater likelihood of similar year types following (e.g., based on a Lag-1 Markov Distribution). Similarly, cropping patterns and irrigation practices may change in future time steps, affecting economic value outputs of each district in ways not explored with this model. The probabilities of these events occurring may be difficult to quantify, since practices somewhat rely on a feedback loop, but any possible connection with the probability of a certain hydrologic year occurring should be considered. Should explore possible correlations in year-by-year water supply deliveries (e.g., SWP contract percentages) or regional precipitation and runoff conditions, possibly including updates to scenario probabilities based on ‘prior-year’ conditions or expansion beyond 5-year periods.
- More-intensive agricultural economic production models, such as the Statewide Agricultural Production Model (SWAP), could be integrated into this optimization framework for more-precise determination of total regional economic output. SWAP accounts for cropping types and related-irrigation decisions that transcend hydrologic year-types and can incorporate more-realistic cropping practices (Marques *et al.* 2005).
- Parameters correlated with district output values were briefly explored in Table 8, illustrating increases in values with increased supply from specific sources. More work could be done to explore these relations in a cost-benefit type analysis; may provide insight into water supply options for each district equivalent to a ‘willingness-to-pay’ marker for certain supplies by source.
- Deterministic 5-year patterns which match historical hydrologic data were explored in Tables 8B and 10B to illustrate some level of confidence in model outputs (i.e., drought-type patterns lead to less regional output as expected). More work could be

done to investigate historical trends against 5-year scenario patterns, and use data to better calibrate hydrologic scenario probabilities (Appendix A) or configure model inputs.

- Expanding the model will bring additional computing effort and may require shifting the model to more-efficient software (e.g., Python code and optimization package). Other optimization tools besides OpenSolver may provide more stable options for developing an *n*-stage PLP or increasing the number of analyzed years in the deterministic model (beyond five-years).

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## Appendix A: Data Compilation and Notes

This appendix addresses model data sources, used to populate Tables 1 through 7 (input tables), and rough approximation of the surface water hydrologic scenario probabilities.

### *A1 Data Sources*

Following direct sources were used to obtain data for Kern County and to generate results given in this report, with Figure A1 providing a source overview diagram and Table A1 with specific sources. Identifiers (e.g., S1, S2, …) are used to illustrate origin references for data, while sub-identifiers relate to column numbers from applicable tables in the report body.

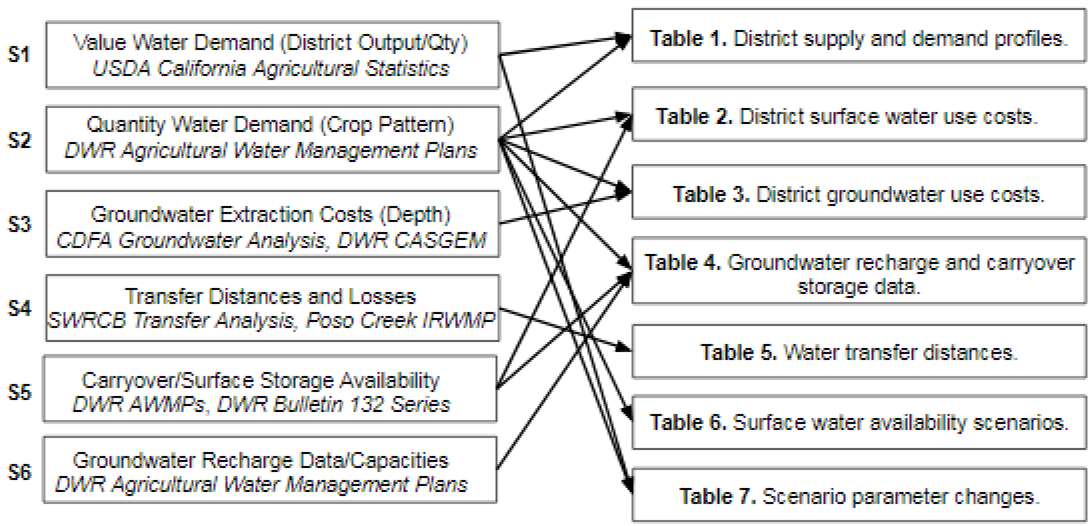


**Figure A1.** Generalized data sourcing diagram.

**Table A1.** Report source references.

| Report Table # | Column Number(s) | Source (Above) | Description(s)[1] |
|---|---|---|---|
| 1 | [2] | S2 | Water Supplier History and Size, typically Table 2 in applicable AWMP. |
| 1 | [3] to [7] | S2 | Cropping pattern profiles by district/year, typically Table 21 in applicable AWMP. |
| 1 | [8] to [12] | S1 | Crop Value Output Breakdown, USDA California Agricultural Statistics (2013) Commodity Rank, Acreage, Production, Value: 2012 Table, pg. 7-9 |
| 1 | [13] | S2 | Surface Water Supplies breakdown, typically Table 40 in applicable AWMP. |
| 2 | [2] to [5] | S2 | |
| 2 | [7] | S5 | Estimate of water conveyance costs to KCWA[2] contractors; DWR Bulletin 132-16, Appendix B. *Confirmed KCWA annual Water Supply Reports (any year).* |
| 3 | [2] | S2 | Water Budget Summary, Closure Term: estimates for groundwater consumption in given year(s), typically Table 48 in applicable AWMP. |
| 3 | [3], [5] | S3 | Recent estimates for Kern County area from DWR CASGEM data. Averages for available data based on relative location to each district; for 5-22.14 Kern County Subbasin: Groundwater Basin Contour Maps (2010 Depth to Water). |

[1] District listed: D1 = Semitropic Water Storage District, D2 = Buena Vista Water Storage District, D3 = Cawelo Water District, D4 = Wheeler Ridge-Maricopa Water Storage District, and D5 = North Kern Water Storage District.
[2] Kern County Water Agency, primary contractor of SWP water supplies from DWR for district listed in Kern County.

**Table A1.** Report source references (continued).

| Report Table # | Column Number(s) | Source (Above) | Description(s)[1] |
|---|---|---|---|
| 3 | [4] | S2 | Rough approximation of change in GW availability per quantity usage by year; calculated using AWMP groundwater consumption estimate (closure term) and change in relative district groundwater levels from CASGEM data[3]. |
| 3 | [6], [7] | S3 | Costs calculated from CDFA well pumping estimates, see Medellin-Azuara *et al.* 2016: Appendix A for details of analysis and available data. For Tulare area, but applied to Northern Kern County since relatively close proximity. |
| 4 | [2], [3], [5] | S6 | Applicable recharge facilities typically described in Section 2C of AWMP. Defined in more detail in Section 3E of AWMP; recharge capacities and annual quantities. |
| 4 | [4] | S2 | Usage of numbers from Table 3, Column [4] data shown above. Assumed offset for recharge quantity *into* groundwater instead of *out of* via extraction. |
| 4 | [6], [7] | S5 | Applicable in-district storage facilities typically described in Section 2C of AWMP. For SWP, shown in DWR Bulletin 132-16 Table 9-7 for KCWA[2] and confirmed in KCWA annual Water Supply Reports. |
| 5 | [1] to [3] | S4 | Described in Regional Description (Section 3) of Poso Creek IRWMP, some details in Section 3F of applicable AWMP. *Transfer losses based on estimate from SWRCB Transfer Analysis, see SWRCB 2017.* |
| 6 | [4], [5] | S2 | Estimates of water supplies, based on historical data from Surface Water Supplies breakdown, typically Table 40 in applicable AWMP. |
| 7 | [3] | S2 | |
| 7 | [2] | S1 | Estimates of change in district valuations, based on water supplies and associated cropping pattern changes; USDA Crop Value Output Breakdown and district cropping value profiles (AWMP Table 21). |

*Note: Most AWMPs referenced in report provided information for multiple years types (e.g., three years for "dry", "intermediate", and "wet"). Multiple versions and updates of AWMPs available from DWR typically provided five-years of unique data per district.*

[1] District listed: D1 = Semitropic Water Storage District, D2 = Buena Vista Water Storage District, D3 = Cawelo Water District, D4 = Wheeler Ridge-Maricopa Water Storage District, and D5 = North Kern Water Storage District.

[2] Kern County Water Agency, primary contractor of SWP water supplies from DWR for district listed in Kern County.

[3] Per footnote to Table 3: Estimated linear-regression fit of GW consumption and level change data; not hydrogeologically precise, but provided enough insight to GW depth impacts from usage for model.

## *A2 Scenario Probability Development*

Scenarios developed in Section 3.1 were loosely based on probability of occurrence of specific annual hydrologic conditions, to mimic uncertainty in forecast planning models. As stated, hydrologic year types are typically categorized (e.g., wet or dry), and historical surface water deliveries used to determine the probability of each year type (DWR, 2014). The California Data Exchange Center (CDEC) provides water year monthly precipitation data for stations across California - from California Cooperative Snow Surveys - with assumption of precipitation directly impacts associated river flows. As a simple approximation, total annual precipitation for 174 consistent stations across California were averaged into a single yearly value for each water year 1997 to 2016 (20-year period) to 'represent' data for various hydrologic year types. Figure A2 illustrates data organized from lowest average annual precipitation to greatest.

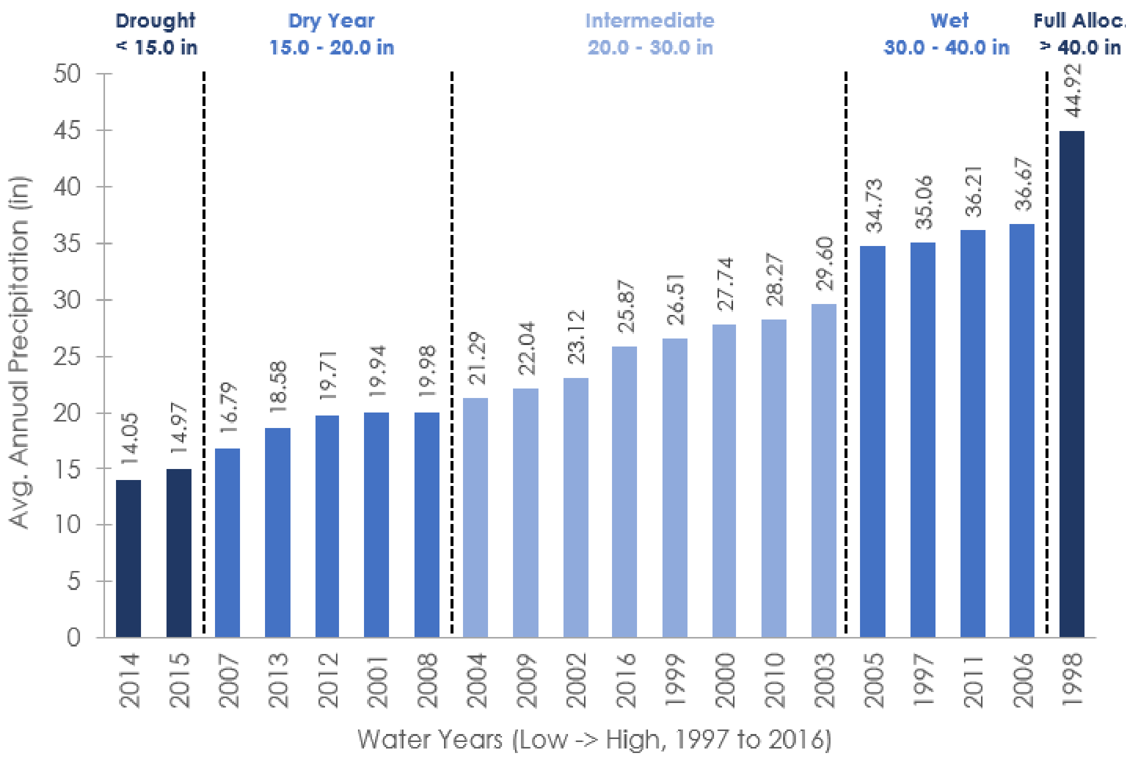


**Figure A2.** Statewide annual average gage precipitation for 20-year period.

Natural break-points in data provided some reasonable indication of differences in year types; used as generalized 'conditional ranges' for the analysis presented in this report (i.e., data appeared to group fairly nice, as shown in split between 2003 and 2005 data). Probability of occurrence was taken as the number of each condition years over the 20-year period for five categories, as indicated in Table A1. The naming convention and exact ranges of these categories is open to interpretation, as there are significant differences in hydrologic conditions between sub-regions across the state (e.g., dry conditions in Southern California will likely not reflect hydrologic conditions in Northern California). More analysis should be performed when assessing appropriate hydrologic conditions and scenarios for SGMA-related use of the models and tools presented in this report; presented are only simplified approximations.

**Table A1.** Generalized hydrologic scenarios.

| Scenario | Occurrence(s) | Percentage |
|---|---|---|
| Drought | 2 | 10% |
| Dry Year | 5 | 25% |
| Intermediate | 8 | 40% |
| Wet | 4 | 20% |
| Full Allocation | 1 | 5% |

Analysis of surface water variability with scenario was loosely based on multi-year water source data from specific district AWMPs (e.g., variation in Kern River and 'other' supplies generally following percentages of 'total possible available' shown in Table 6). Because of a lack of available data, however, values shown are simple representations of potential conditions.

As SWP supplies were primarily the only project-based surface water supplies considered in this effort[1], statewide percentages of contractual allocations were gathered for the 20-year period shown in Figure A3. Recall during dry conditions SWP supplies are generally curtailed equally, as percentages of contract allocations between DWR (managing agency) and supply contractors. SWP allocation percentages were used as a basis for adjusting surface water allocations under the different surface water availability scenarios shown in Table 5.

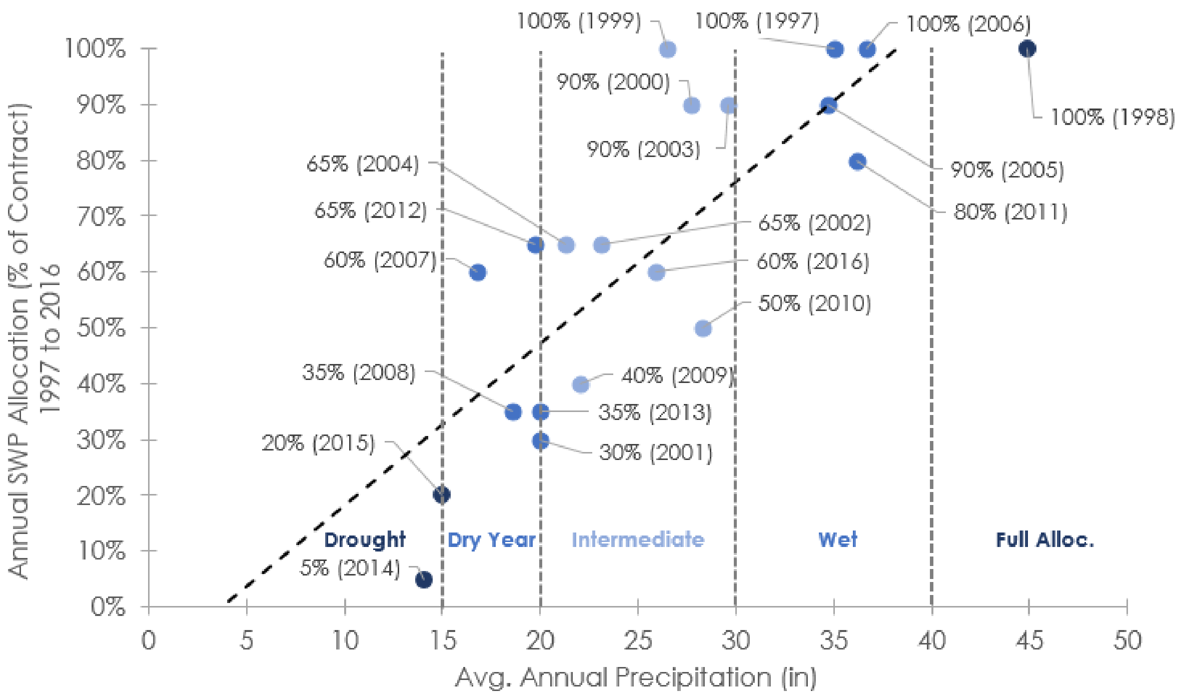


**Figure A3.** Statewide annual average gage precipitation for 20-year period.

The $R^2$ value of 0.67 on the trendline indicates modest correlation between statewide average annual gage precipitation and SWP allocation percentage. Values are presumably not exactly correlated because of SWP sourcing primarily from Northern California watersheds - differences in sub-region hydrologic conditions - and other factors, such as reservoir or carryover project storage, or environmental conveyance restrictions. For the purposes of this report and model, and because of differences in SWP data and use specific to Kern County, 'representative' percentage values were used in each scenario as shown in Tables 6 and A2.

**Table A2.** Generalized SWP Allocation scenarios.

| Scenario | Occurrence(s) | Avg. SWP% | Used SWP%[1] |
|---|---|---|---|
| Drought | 2 | 13% | 25% |
| Dry Year | 5 | 45% | 50% |
| Intermediate | 8 | 70% | 75% |
| Wet | 4 | 93% | 100% |
| Full Allocation | 1 | 100% | 100% |

[1] Values used in Table 6, Column 4; data from DWR SWPAO Water Deliveries.

[1] CVP supplies were considered (Table 2), however, none of the selected districts are CVP contractors.

## Appendix B: Excel Model Tool (Basin Resource Allocation)

This appendix provides a brief overview of the Excel model used in the report and details some model run results for the Annual Sustainable Yield Limitation, Periodic Sustainable Yield Limitation, and Probabilistic Model variants.

### *B1 Excel Tool Overview*

Both deterministic and probabilistic models were developed using Microsoft Excel and solved using an open-source optimization tool (OpenSolver for Excel, v 2.8.5; Simplex LP Solver). This software environment provided graphical opportunities to review decision variable inputs, easily adjust constraints and set values (e.g., sustainable yields or minimum crop fulfillments), and to review output data. As discussed in Section 7, there may be opportunities to transition the model to more-efficient software which may handle additional years or scenario types (e.g., Python code and other optimization package).

Input data containing Tables 1 through 7 were formatted on an 'INPUT_FORM' sheet, with scenario probabilities and corresponding crop demand, valuation, and surface water availability for all possible 5-year scenario patterns. Values are pulled into 'DETMod' sheet using INDEX/MATCH functions referencing a specific scenario number; values are formatted and shown in order: 1) Objective Function and district/year components, 2) Decision Variables, and 3) Constraints. All variables shown in Section 3.2 are explicitly listed in individual cells which are referenced by the OpenSolver tool[1]. Users change the Scenario number cell - used to adjust constraints such as surface water availability and district valuations - and set variables such as sustainable yield and minimum crop demand fulfillment, then run the optimization software. Output decision variables are transferred to the 'RESULTS' tab where side-by-side comparison is made between runs. A graphical depiction of these sheets is shown in Figures B1 and B2.

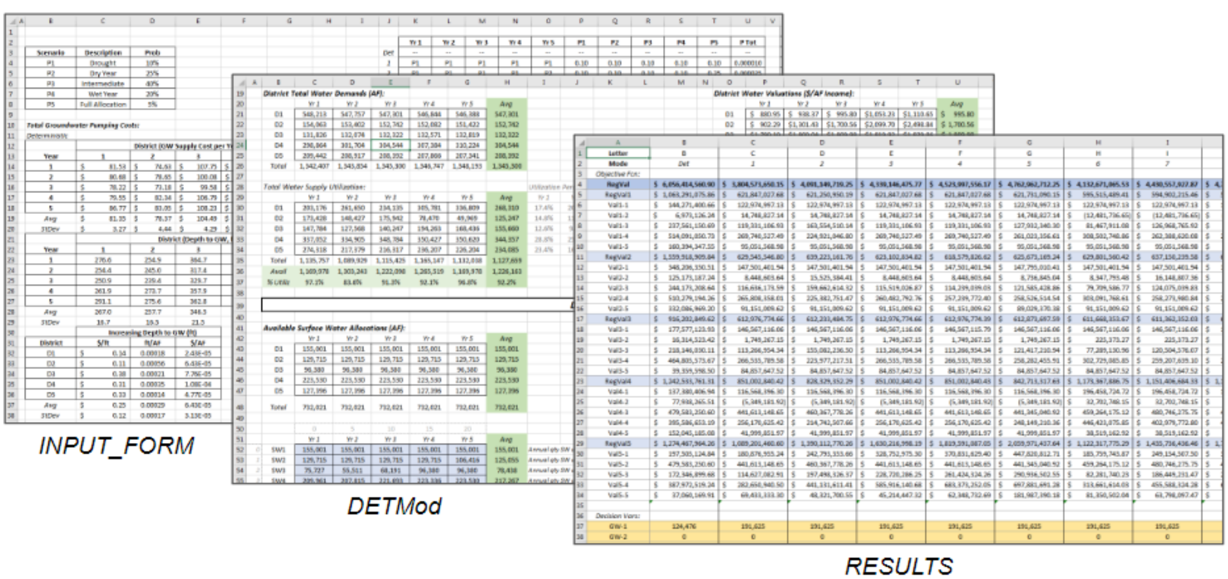


**Figure B1.** Excel tool data sheets.

[1] Visit 'Using OpenSolver' website at <https://opensolver.org/using-opensolver/> for more information.

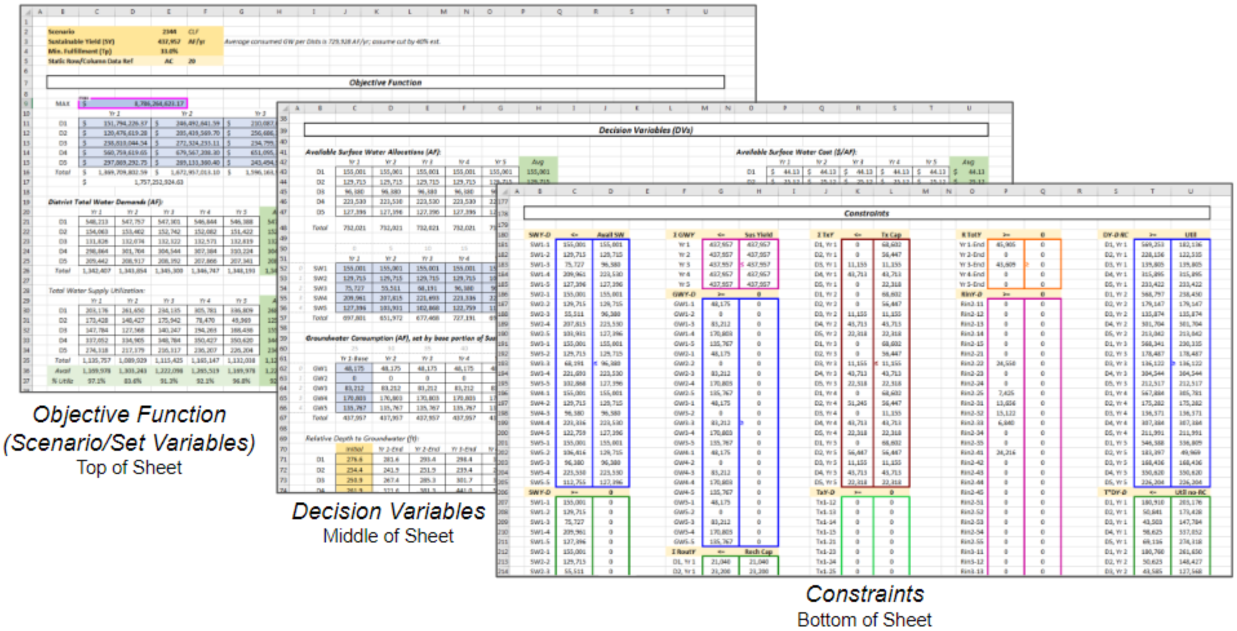


**Figure B2.** Excel tool DETMod sheet (top, middle, and bottom sets).
*Note: Same general setup for Probabilistic Model, scenarios instead of years listed (PROBMod sheet).*

To use these optimization tools, constraints were setup to effectively reference specific cell values (decision variables) using simple Excel mathematical formulas (e.g., simple cell addition or multiplication). OpenSolver evaluated these functions during model calculation steps; process takes approximately 3 to 5 minutes depending on computer resources. VBA code was used to run each scenario, by clearing the decision variables from the previous run and executing OpenSolver with the new scenario number referenced. Graphs and figures in the report were extracted from data on the RESULTS tab.

## *B2 Selected Model Results*

A total of 3,125 deterministic model runs of different five-year scenario patterns[2] were assessed, as illustrated conceptually in Figure 2. Tables 8A and 8B provided result overviews of five ‘constant scenario type’ conditions and six ‘historical pattern’ estimates for Annual SY limits, respectively. Tables 10A and 10B were effectively the same for the Periodic SY limit version. All model runs detailed in those tables are expanded here, to provide full output context (e.g., specific usage, transfer, recharge values). Other five-year pattern runs from both configurations are available upon request, but were excluded from this appendix due to size considerations.

Results for the single probabilistic model run, based on scenario (hydrologic condition) types instead of possible year-type patterns over five-years, are also shown here. These data expand from the information shown in Table 11.

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[2] For both the Annual and Periodic Sustainable Yield Limitation configurations. *Average* data included but not assessed as individual run (i.e., is simple average of all scenario data).

**Table B1.** *Deterministic Annual SY* Model Results (Scenario 1, S1x5 'Drought')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 2,851.4 |
| *Total 5yr Val (Objective Function)* | $3,800 |

| **Val[1]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** | **GW Supl** | **%SY** |
|---|---|---|---|---|---|---|---|
| D1 | $123 | $148 | $147 | $117 | $181 | 191.6 | 43% |
| D2 | $15 | $8 | $2 | ($5) | $442 | 0 | 0% |
| D3 | $119 | $117 | $113 | $442 | $115 | 68.6 | 16% |
| D4 | $270 | $266 | $267 | $256 | $283 | 177.8 | 41% |
| D5 | $95 | $91 | $85 | $42 | $69 | 0 | 0% |
| RegVal | $622 | $630 | $614 | $852 | $1,090 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| **Dist Out [To][2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 26.8: 0: 0: 2.7 | 18: 0: 0: 0 | 9.1: 0: 0: 0 | 0.3: 0: 0: 45.1 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 30.9 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 0 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 0: 0: 0: 43.7 | 0: 0: 0: 43.4 | 0: 0: 0: 40.4 | 0: 0: 40.3: 3.4 | 0: 0: 0: 25.8 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 22.3: 0: 0 |
| *RegTot* | *84.3* | *72.5* | *60.6* | *89.1* | *90.1* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| **Dist Out[2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 0 |
| D3 | 3.8: 0: 0: 0: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 37.7 | 54.6 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 3.5 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| **EOY[3]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 0 | 0 | 0 | 0 | 0 |
| D3 | 0 | 0 | 4 | 0 | 0 |
| D4 | 0 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B2.** *Deterministic Annual SY* Model Results (Scenario 782, S2x5 'Dry Year')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 3,981.5 |
| *Total 5yr Val (Objective Function)* | $5,919 |

| **Val[1]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** | **GW Supl** | **%SY** |
|---|---|---|---|---|---|---|---|
| D1 | $164 | $180 | $172 | $174 | $196 | 61.4 | 14% |
| D2 | ($11) | $31 | $14 | $72 | $500 | 0 | 0% |
| D3 | $226 | $236 | $235 | $500 | $230 | 104.9 | 24% |
| D4 | $508 | $513 | $52 | $525 | $549 | 225.6 | 51% |
| D5 | $73 | $79 | $63 | $59 | $105 | 46 | 11% |
| RegVal | $960 | $1,039 | $1,010 | $1,330 | $1,580 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| **Dist Out [To][2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 27.5: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 2.6: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 7.9: 0: 0: 3.3 | 2.2: 0: 0: 8.9 | 0: 0: 0: 1.1 | 0: 0: 0: 0 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 34.4: 9.3: 0: 0 | 38.4: 5.4: 0: 0 | 38.9: 1.4: 0: 0 | 34.6: 0: 9.1: 0 | 6.7: 0: 0: 27.2 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 22.3: 0: 0 |
| *RegTot* | *54.9* | *54.9* | *41.4* | *46.3* | *151.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| **Dist Out[2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 21: 0: 0 | 0: 8.5: 0: 0: 12.5 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 3.8 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 1.1: 0: 0: 0: 3 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *52.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 33.6 | 49.9 | 0 | 0 |
| EOY 2[3] | 19.8 | 19.5 | 37.3 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 3.2 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 3.5 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| **EOY[3]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 48.3 | 0 | 0 |
| D3 | 0 | 0 | 4 | 0 | 0 |
| D4 | 0 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B3.** *Deterministic Annual SY* Model Results (Scenario 1563, S3x5 'Intermediate')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,346.9 |
| *Total 5yr Val (Objective Function)* | $7,782 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $147 | $199 | $155 | $163 | $374 | 45.8 | 10% |
| D2 | $58 | $165 | $199 | $227 | $504 | 0 | 0% |
| D3 | $238 | $271 | $254 | $504 | $251 | 82 | 19% |
| D4 | $543 | $587 | $584 | $584 | $595 | 188.8 | 43% |
| D5 | $264 | $240 | $225 | $222 | $229 | 121.3 | 28% |
| RegVal | $1,250 | $1,462 | $1,417% | $1,700 | $1,953 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 9.7: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 11.2 | 11.2: 0: 0: 0 | 8.4: 1.4: 0: 0 | 0: 0: 0: 0 | 11.2: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 18.2: 17.2: 0: 0 | 26.5: 17.2: 0: 0 | 0: 43.7: 0: 0 | 0: 0: 43.7: 0 | 43.7: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 8.6: 0: 0: 0 | 6.7: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *46.5* | *54.9* | *62.2* | *60.1* | *111.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 16.1: 0: 4.9 | 0: 0: 21: 0: 0 | 0: 13.1: 0: 8: 0 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 15.2: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *40.3* | *0* |
| EOY 1[3] | 18.9 | 19.2 | 36.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 16.3 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 48.3 | 0 | 0 |
| D3 | 4 | 3.8 | 3.6 | 0 | 0 |
| D4 | 11 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B4.** *Deterministic Annual SY* Model Results (Scenario 2344, S4x5 'Wet Year')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 6,103.6 |
| *Total 5yr Val (Objective Function)* | $9,012 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $157 | $363 | $386 | $282 | $481 | 54 | 12% |
| D2 | $181 | $195 | $253 | $321 | $524 | 69 | 16% |
| D3 | $240 | $274 | $256 | $524 | $259 | 62.6 | 14% |
| D4 | $549 | $607 | $627 | $622 | $640 | 142.5 | 33% |
| D5 | $284 | $254 | $245 | $245 | $247 | 109.9 | 25% |
| RegVal | $1,411 | $1,693 | $1,767 | $1,994 | $2,151 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 35.5: 20.9: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 11.2 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 0 | 11.2: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 0: 43.7: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 0: 0: 43.7: 0 | 43.7: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 21.5: 0: 0: 0 | 22.3: 0: 0: 0 |
| *RegTot* | *54.9* | *133.6* | *133.6* | *121.6* | *133.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 21: 0: 0 | 0: 0: 21: 0: 0 | 0: 11.3: 0: 0: 9.7 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 9.5: 0: 0 | 0: 0: 20.8: 0: 2.4 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *34.7* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 19.6 | 36.6 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 26.9 | 0 | 0 |
| D3 | 4 | 3.8 | 3.6 | 0 | 0 |
| D4 | 9.2 | 0.8 | 0 | 0 | 0 |
| D5 | 6.6 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B5.** *Deterministic Annual SY* Model Results (Scenario 3125, S5x5 'Full Allocation')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 7,736.4 |
| *Total 5yr Val (Objective Function)* | $11,691 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $250 | $513 | $567 | $358 | $745 | 141.1 | 31% |
| D2 | $310 | $426 | $536 | $740 | $612 | 107.4 | 25% |
| D3 | $245 | $260 | $251 | $612 | $267 | 46.8 | 11% |
| D4 | $587 | $662 | $681 | $713 | $773 | 142.6 | 33% |
| D5 | $341 | $187 | $309 | $288 | $458 | 0 | 0% |
| RegVal | $1,733 | $2,048 | $2,344 | $2,711 | $2,855 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 0: 56.4: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 5.9: 0: 0 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 0 | 11.2: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 0: 43.7: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 0: 0: 43.7: 0 | 43.7: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 5.9: 16.4: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 |
| *RegTot* | *71.9* | *133.6* | *133.6* | *122.5* | *133.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 21: 0: 0 | 0: 0: 20.4: 0: 0.6 | 0: 5.2: 0: 0: 15.8 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 3.8 | 3.8: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 4.1: 0: 0: 0: 0 | 4.1: 0: 0: 0: 0 | 4.1: 0: 0: 0: 0 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *52.2* | *52.2* | *0* |
| EOY 1[3] | 18.9 | 6.9 | 24.5 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 18.8 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 3.2 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 3.5 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 12.7 | 12.7 | 12.7 | 12.1 | 0 |
| D2 | 48.3 | 45.9 | 6 | 0 | 0 |
| D3 | 4 | 1.2 | 1.1 | 0 | 0 |
| D4 | 16.2 | 15.4 | 14.4 | 13.4 | 0 |
| D5 | 41.1 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B6.** *Deterministic Annual SY* Model Results (Average, All Scenarios)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,238.9 |
| *Total 5yr Val (Objective Function)* | $7,312 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $178 | $269 | $268 | $274 | $370 | 129.2 | 29% |
| D2 | $108 | $142 | $170 | $214 | $487 | 47.7 | 11% |
| D3 | $212 | $239 | $215 | $487 | $234 | 78.3 | 18% |
| D4 | $484 | $508 | $529 | $510 | $580 | 164.4 | 38% |
| D5 | $172 | $178 | $163 | $138 | $184 | 18.3 | 4% |
| RegVal | $1,154 | $1,336 | $1,345 | $1,623 | $1,855 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 3.3: 0: 0: 2.5 | 1.3: 0: 0: 0.1 | 1.1: 0: 0: 0 | 0.5: 0: 0: 3.3 | 1.9: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 1.7: 0: 0: 2.7 | 26.2: 0: 0: 1.1 | 20.4: 0: 0: 0.6 | 24.3: 15.4: 0: 3.3 | 47: 0: 0: 9.2 |
| D3 [D1: D2: D4: D5] | 0.6: 1.9: 0: 7.2 | 3.7: 0: 0: 7.1 | 2.9: 0: 0: 7 | 0.6: 0: 0: 0.6 | 2.2: 0: 0: 5.3 |
| D4 [D1: D2: D3: D5] | 1.9: 19.5: 0: 7.5 | 16.1: 3.7: 0: 18.9 | 13.1: 3: 0: 17.9 | 9.4: 0.5: 24.4: 9.4 | 10.9: 0: 0: 14.2 |
| D5 [D1: D2: D3: D4] | 2: 2.8: 0: 0 | 6.2: 0: 0: 0 | 5.6: 0: 0: 0 | 5.9: 0: 0: 0 | 3.8: 3: 0: 0 |
| *RegTot* | *53.6* | *84.4* | *71.7* | *97.6* | *97.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 4.8: 0: 16.2 | 0.3: 0: 15.7: 0.1: 4.9 | 0.1: 5.4: 0.1: 0.5: 15 | 0: 0: 0: 0: 0 |
| D2 | 0: 0.1: 0: 0: 23.1 | 0: 0: 0: 1.1: 22.1 | 0: 0.3: 10.2: 0.4: 10.5 | 0.6: 0.3: 12.9: 0.1: 6.1 | 0: 0: 0: 0: 0 |
| D3 | 0.5: 0: 0: 0: 3.2 | 0.1: 3.2: 0: 0: 0.5 | 0.1: 0: 0: 0: 2.4 | 0.8: 0: 0: 0: 0.1 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 2.5: 0: 0: 0: 1.6 | 2.1: 0: 0: 0: 2 | 0.4: 0: 0.1: 0: 3.7 | 0: 0.1: 4: 0.1: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.1* | *52.2* | *49.1* | *46.0* | *0* |
| EOY 1[3] | 18.9 | 23.3 | 39.9 | 0 | 0 |
| EOY 2[3] | 19.8 | 9.3 | 21.8 | 6.9 | 0 |
| EOY 3[3] | 3.4 | 1.6 | 3.7 | 0.8 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 1.6 | 4 | 1.8 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 4.4 | 4.9 | 4.2 | 2.7 | 0 |
| D2 | 41.9 | 44.8 | 35.5 | 0 | 0 |
| D3 | 2.3 | 1.2 | 2.5 | 0.1 | 0 |
| D4 | 9.6 | 3.2 | 1.4 | 0.5 | 0 |
| D5 | 8.3 | 1.3 | 0.3 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B7.** *Deterministic Annual SY* Model Results (Scenario 635, '2013-2017' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 4,227.9 |
| *Total 5yr Val (Objective Function)* | $5,656 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $158 | $141 | $127 | $191 | $449 | 160.5 | 37% |
| D2 | $15 | $45 | ($26) | $44 | $496 | 0 | 0% |
| D3 | $175 | $126 | $119 | $496 | $305 | 74.9 | 17% |
| D4 | $505 | $265 | $299 | $422 | $757 | 178.1 | 40% |
| D5 | $72 | $77 | $68 | $42 | $288 | 24.4 | 6% |
| RegVal | $925 | $654 | $587 | $1,195 | $2,295 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 9.3: 0: 0: 13.7 | 0: 0: 0: 0 | 5.3: 0: 0: 0 | 0: 0: 0: 5.4 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 12.3 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 0: 0: 0: 0 | 0: 22.8: 0: 20.9 | 0: 8.7: 0: 17.9 | 0: 0: 43.7: 0 | 9.6: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 18.2: 0: 0: 0 |
| *RegTot* | *34.2* | *54.9* | *43* | *61.5* | *84.2* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 0 |
| D3 | 3.8: 0: 0: 0: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 3.8 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *52.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 19.5 | 37.3 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 3.2 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 3.5 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 0 | 0 | 48.3 | 0 | 0 |
| D3 | 0 | 0 | 4 | 0 | 0 |
| D4 | 0 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B8.** *Deterministic Annual SY* Model Results (Scenario 2626, '2011-2015' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 4,121.4 |
| *Total 5yr Val (Objective Function)* | $5,652 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $236 | $157 | $161 | $158 | $176 | 117.7 | 27% |
| D2 | $288 | $203 | $26 | $14 | $469 | 76.7 | 18% |
| D3 | $241 | $230 | $167 | $469 | $173 | 100.9 | 23% |
| D4 | $584 | $424 | $224 | $221 | $265 | 142.6 | 32% |
| D5 | $341 | $153 | $101 | $89 | $82 | 0 | 0% |
| RegVal | $1,690 | $1,167 | $679 | $951 | $1,165 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 46: 0: 0: 1.6 | 40.7: 0: 0: 15.7 | 35.4: 0: 0: 21 |
| D3 [D1: D2: D4: D5] | 0: 11.2: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 0 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 0: 43.7: 0: 0 | 0: 0: 0: 38.1 | 0: 0: 0: 43.7 | 0: 0: 6: 37.7 | 0: 0: 0: 18.2 |
| D5 [D1: D2: D3: D4] | 0: 22.3: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *77.2* | *49.3* | *102.5* | *100.2* | *85.8* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 21: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 3.8: 0: 0: 0: 0 | 0: 0: 0: 0: 3.8 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 4.1: 0: 0: 0: 0 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *52.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 24.7 | 42.3 | 0 | 0 |
| EOY 3[3] | 3.4 | 6.5 | 9.4 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 7.1 | 10.2 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 0 | 0 | 0 | 0 |
| D3 | 4 | 0 | 4 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 41.1 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B9.** *Deterministic Annual SY* Model Results (Scenario 2402, '2005-2009' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,011.1 |
| *Total 5yr Val (Objective Function)* | $6,886 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $203 | $410 | $158 | $191 | $212 | 108.6 | 25% |
| D2 | $195 | $268 | $255 | $34 | $438 | 85.3 | 19% |
| D3 | $238 | $230 | $199 | $438 | $221 | 86.8 | 20% |
| D4 | $558 | $645 | $462 | $255 | $510 | 157.2 | 36% |
| D5 | $169 | $289 | $105 | $104 | $99 | 0 | 0% |
| RegVal | $1,363 | $1,842 | $1,179 | $1,022 | $1,480 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 33.9: 0: 0: 0 | 0: 0: 0: 0 | 55: 0: 0: 1.4 | 11.4: 0: 0: 45 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 11.2 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 0: 43.7: 0: 0 | 43.7: 0: 0: 0 | 0: 0: 0: 38 | 0: 0: 0: 43.7 | 0: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *54.9* | *111.1* | *49.1* | *111.3* | *56.4* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 21: 0: 0 | 0: 0: 0: 21: 0 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 3.8 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *52.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 29.3 | 45.9 | 0 | 0 |
| EOY 2[3] | 19.8 | 37.7 | 54.6 | 0 | 0 |
| EOY 3[3] | 3.4 | 6.5 | 9.4 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 7.1 | 10.2 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 0 | 0 | 0 |
| D3 | 4 | 3.8 | 4 | 0 | 0 |
| D4 | 16.2 | 15.4 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B10.** *Deterministic Annual SY* Model Results (Scenario 839, '2001-2009' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,112.8 |
| *Total 5yr Val (Objective Function)* | $7,322 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $137 | $168 | $271 | $186 | $347 | 77.9 | 18% |
| D2 | ($11) | $65 | $171 | $198 | $540 | 0 | 0% |
| D3 | $199 | $198 | $232 | $540 | $278 | 76.6 | 18% |
| D4 | $488 | $435 | $614 | $569 | $688 | 181.6 | 41% |
| D5 | $102 | $140 | $218 | $207 | $342 | 101.8 | 23% |
| RegVal | $915 | $1,006 | $1,506 | $1,700 | $2,195 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 10.7: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 11.2 | 11.2: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 3.4: 9.3: 0: 0 | 24.1: 19.6: 0: 0 | 20.3: 23.4: 0: 0 | 0: 0: 41.8: 1.9 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *35.1* | *54.9* | *77.2* | *54.4* | *111.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 21: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 8.1: 0: 15.1 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 3.8 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 0: 0: 4.1 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *52.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 18.8 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 3.2 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 3.5 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 48.3 | 0 | 0 |
| D3 | 0 | 0 | 0 | 0 | 0 |
| D4 | 0 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B11.** *Deterministic Annual SY* Model Results (Scenario 3082, '1998-2002' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 6,107.6 |
| *Total 5yr Val (Objective Function)* | $8,937 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $276 | $458 | $365 | $187 | $219 | 97 | 22% |
| D2 | $298 | $418 | $430 | $438 | $481 | 146.2 | 33% |
| D3 | $244 | $236 | $237 | $481 | $165 | 52.1 | 12% |
| D4 | $587 | $647 | $665 | $442 | $510 | 142.6 | 33% |
| D5 | $341 | $297 | $270 | $110 | $137 | 0 | 0% |
| RegVal | $1,746 | $2,056 | $1,967 | $1,658 | $1,512 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 7.3: 49.2: 0: 0 | 11.3: 0: 0: 45.1 |
| D3 [D1: D2: D4: D5] | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 2.9 |
| D4 [D1: D2: D3: D5] | 16.6: 27.1: 0: 0 | 43.7: 0: 0: 0 | 0: 0: 0: 23.8 | 5.7: 0: 0: 38 | 0: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *77.2* | *133.6* | *91.4* | *111.3* | *59.4* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 21: 0: 0 | 0: 0: 21: 0: 0 | 0: 0.1: 0: 0: 20.9 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 3.8 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 4.1: 0: 0: 0: 0 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *52.2* | *25.2* | *0* |
| EOY 1[3] | 18.9 | 18.3 | 35.4 | 0 | 0 |
| EOY 2[3] | 19.8 | 37.7 | 54.6 | 0 | 0 |
| EOY 3[3] | 3.4 | 6.5 | 9.4 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 7.1 | 10.2 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 12.7 | 12.1 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 46.8 | 0 | 0 |
| D3 | 4 | 3.8 | 4 | 0 | 0 |
| D4 | 16.2 | 15.4 | 14.6 | 0 | 0 |
| D5 | 41.1 | 39 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B12.** *Deterministic Annual SY* Model Results (Scenario 400, '1992-1996' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,398.8 |
| *Total 5yr Val (Objective Function)* | $6,957 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $122 | $436 | $155 | $536 | $664 | 218.3 | 50% |
| D2 | ($12) | $118 | $1 | $198 | $432 | 0 | 0% |
| D3 | $165 | $333 | $168 | $432 | $277 | 96.3 | 22% |
| D4 | $226 | $539 | $223 | $596 | $626 | 123.3 | 28% |
| D5 | $71 | $103 | $94 | $173 | $285 | 0 | 0% |
| RegVal | $572 | $1,529 | $641 | $1,935 | $2,284 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 26.8: 0: 0: 29.4 | 0: 0: 0: 0 | 17.7: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 15.1: 0: 0: 0 | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 11.2 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 0 | 11.2: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 0: 0: 0: 17 | 43.7: 0: 0: 0 | 0: 0: 0: 43.2 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 |
| *RegTot* | *84.3* | *92.3* | *72.1* | *122.5* | *133.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 16.9 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 0: 3.8 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 0: 0: 4.1 | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *42.0* | *0* |
| EOY 1[3] | 18.9 | 0 | 18 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 12.7 | 12.1 | 0 |
| D2 | 48.3 | 45.9 | 48.3 | 0 | 0 |
| D3 | 0 | 0 | 0 | 0 | 0 |
| D4 | 0 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B13.** *Deterministic Periodic SY* Model Results (Scenario 1, S1x5 'Drought')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 2,851.4 |
| *Total 5yr Val (Objective Function)* | $3,977 |

| **Val[1]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** | **GW Supl** | **%SY** |
|---|---|---|---|---|---|---|---|
| D1 | $145 | $135 | $121 | $124 | $131 | 109.5 | 25% |
| D2 | $38 | $45 | $5 | ($5) | $502 | 0 | 0% |
| D3 | $64 | $62 | $67 | $502 | $63 | 30.7 | 7% |
| D4 | $487 | $496 | $349 | $132 | $126 | 249.6 | 57% |
| D5 | $60 | $76 | $85 | $79 | $88 | 48.2 | 11% |
| RegVal | $794 | $814 | $627 | $832 | $910 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| **Dist Out [To][2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 5.8: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 17.9: 0: 0: 12.9 |
| D3 [D1: D2: D4: D5] | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 16.9: 26.8: 0: 0 | 0: 18: 0: 25.7 | 0: 3.4: 0: 40.4 | 6.1: 0.3: 0: 37.3 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 22.3: 0: 0 |
| *RegTot* | *54.9* | *54.9* | *60.6* | *54.9* | *108.1* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| **Dist Out[2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 0: 0: 0: 0: 21 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 3.8: 0: 0: 0: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| **EOY[3]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 0 | 0 | 0 | 0 | 0 |
| D3 | 0 | 0 | 0 | 0 | 0 |
| D4 | 0 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B14.** *Deterministic Periodic SY* Model Results (Scenario 782, S2x5 'Dry Year')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 3,981.5 |
| *Total 5yr Val (Objective Function)* | $6,034 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $170 | $189 | $176 | $163 | $192 | 39.4 | 9% |
| D2 | ($11) | $52 | $13 | $71 | $548 | 0 | 0% |
| D3 | $97 | $222 | $228 | $548 | $219 | 30.7 | 7% |
| D4 | $541 | $187 | $593 | $516 | $915 | 289 | 66% |
| D5 | $69 | $65 | $70 | $95 | $106 | 78.8 | 18% |
| RegVal | $866 | $715 | $1,080 | $1,393 | $1,980 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 34.4: 9.3: 0: 0 | 38.4: 5.4: 0: 0 | 43.7: 0: 0: 0 | 8.9: 0: 0: 34.8 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 10: 0: 0 |
| *RegTot* | *77.2* | *77.2* | *54.9* | *111.3* | *121.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 0: 0: 0: 0: 21 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 3.8: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 48.3 | 0 | 0 |
| D3 | 0 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B15.** *Deterministic Periodic SY* Model Results (Scenario 1563, S3x5 'Intermediate')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,346.9 |
| *Total 5yr Val (Objective Function)* | $7,973 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $174 | $197 | $172 | $193 | $538 | 0 | 0% |
| D2 | $22 | $157 | $187 | $225 | $554 | 0 | 0% |
| D3 | $238 | $225 | $232 | $554 | $231 | 83.2 | 19% |
| D4 | $552 | $249 | $625 | $558 | $937 | 205.8 | 47% |
| D5 | $263 | $233 | $259 | $191 | $207 | 148.9 | 34% |
| RegVal | $1,249 | $1,061 | $1,475 | $1,721 | $2,467 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 9.1: 0: 0: 0 | 8.5: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 6.4: 0: 0: 37.3 | 5.8: 0: 0: 37.9 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *64* | *63.4* | *111.3* | *111.3* | *111.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 21: 0: 0: 0: 0 | 21: 0: 0: 0: 0 | 0: 0: 0: 21: 0 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *25.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 21.5 | 0 | 0 | 0 |
| D3 | 4 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B16.** *Deterministic Periodic SY* Model Results (Scenario 2344, S4x5 'Wet Year')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 6,103.6 |
| *Total 5yr Val (Objective Function)* | $9,251 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $141 | $300 | $311 | $344 | $789 | 0 | 0% |
| D2 | $96 | $198 | $254 | $321 | $568 | 0 | 0% |
| D3 | $240 | $228 | $237 | $568 | $240 | 65.7 | 15% |
| D4 | $561 | $353 | $655 | $595 | $906 | 166.4 | 38% |
| D5 | $316 | $249 | $244 | $243 | $294 | 205.8 | 47% |
| RegVal | $1,354 | $1,328 | $1,701 | $2,071 | $2,797 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 14.8: 29: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *54.9* | *111.3* | *111.3* | *111.3* | *111.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 21: 0: 0: 0: 0 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *25.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 12.7 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 0 | 0 | 0 | 0 |
| D3 | 4 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 41.1 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B17.** *Deterministic Periodic SY* Model Results (Scenario 3125, S5x5 'Full Allocation')

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 7,736.4 |
| *Total 5yr Val (Objective Function)* | $12,039 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $131 | $365 | $421 | $621 | $1,281 | 0 | 0% |
| D2 | $256 | $357 | $537 | $741 | $668 | 8.8 | 2% |
| D3 | $244 | $170 | $242 | $668 | $328 | 118.2 | 27% |
| D4 | $580 | $410 | $694 | $705 | $1,015 | 310.9 | 71% |
| D5 | $346 | $213 | $309 | $279 | $458 | 0 | 0% |
| RegVal | $1,557 | $1,515 | $2,203 | $3,014 | $3,750 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 0: 56.4: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 11.2: 0: 0 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 0: 43.7: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 9.2: 13.2: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 |
| *RegTot* | *77.2* | *133.6* | *133.6* | *133.6* | *133.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 23.2: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 3.8: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 4.1: 0 | 4.1: 0: 0: 0: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *52.2* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 12.7 | 12.7 | 12.1 | 0 | 0 |
| D2 | 0 | 0 | 0 | 0 | 0 |
| D3 | 4 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 41.1 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B18.** *Deterministic Periodic SY* Model Results (Average, All Scenarios)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,238.9 |
| *Total 5yr Val (Objective Function)* | $7,767 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $163 | $226 | $223 | $242 | $434 | 61.3 | 14% |
| D2 | $71 | $146 | $191 | $242 | $554 | 48.2 | 11% |
| D3 | $231 | $209 | $222 | $554 | $229 | 96.3 | 22% |
| D4 | $547 | $293 | $613 | $555 | $878 | 201.4 | 46% |
| D5 | $215 | $171 | $179 | $172 | $207 | 30.7 | 7% |
| RegVal | $1,227 | $1,045 | $1,428 | $1,765 | $2,302 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0.2: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 1.7: 0: 0: 0 | 26.5: 0: 0: 0 | 44.9: 0: 0: 0 | 52.8: 0.9: 0: 0.1 | 52.2: 0: 0: 4 |
| D3 [D1: D2: D4: D5] | 8.9: 0.6: 0: 1 | 6.4: 0: 0: 4.2 | 2.8: 0: 0: 7.8 | 2.2: 0: 0: 8.5 | 2.2: 0: 0: 8.6 |
| D4 [D1: D2: D3: D5] | 26.6: 16: 0: 0 | 36.1: 3: 0: 3.8 | 22.4: 0.1: 0: 20.7 | 16.5: 0.1: 1: 26.1 | 9.7: 0: 0: 33.6 |
| D5 [D1: D2: D3: D4] | 8.5: 0.8: 0.1: 0 | 7.8: 0: 0.2: 0 | 4.3: 0: 0.1: 0 | 4.5: 0: 0: 0 | 3: 5.6: 0.1: 0 |
| *RegTot* | *64.2* | *88* | *103.5* | *112.6* | *118.9* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 20.1: 0.9: 0: 0 | 11.8: 0.4: 0.2: 0.2: 8.5 | 16.1: 0.1: 0.2: 0: 4.6 | 0: 0: 0: 0.8: 20.2 | 0: 0: 0: 0: 0 |
| D2 | 0: 0.1: 0: 0: 23.1 | 0: 21.8: 0.3: 1.1: 0 | 0: 0.2: 0.3: 6.9: 3.1 | 0.9: 0.5: 16.6: 0: 4.7 | 0: 0: 0: 0: 0 |
| D3 | 0.1: 0: 0: 3.6: 0.1 | 0.1: 3.2: 0.2: 0.2: 0.1 | 0: 0: 0: 0: 0 | 0: 0: 0: 0.7: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 3.3: 0: 0.8 | 0: 0: 0: 4: 0.1 | 1.1: 0: 0.1: 2.9: 0 | 0: 4: 0.1: 0: 0.1 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *35.6* | *48.6* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 4.4 | 3.7 | 2.9 | 0.8 | 0 |
| D2 | 34.5 | 23.5 | 8.7 | 0 | 0 |
| D3 | 3.4 | 0 | 0 | 0 | 0 |
| D4 | 15.6 | 0 | 0 | 0 | 0 |
| D5 | 11.8 | 1.3 | 0.3 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B19.** *Deterministic Periodic SY* Model Results (Scenario 635, '2013-2017' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 4,227.9 |
| *Total 5yr Val (Objective Function)* | $5,974 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $170 | $158 | $128 | $141 | $326 | 35 | 8% |
| D2 | $24 | $59 | $-33 | $44 | $523 | 0 | 0% |
| D3 | $228 | $214 | $68 | $523 | $207 | 105.1 | 24% |
| D4 | $541 | $171 | $534 | $467 | $905 | 227.7 | 52% |
| D5 | $69 | $62 | $91 | $81 | $273 | 70.1 | 16% |
| RegVal | $1,032 | $664 | $788 | $1,256 | $2,234 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | $170 | $158 | $128 | $141 | $326 |
| D2 [D1: D3: D4: D5] | $24 | $59 | ($33) | $44 | $523 |
| D3 [D1: D2: D4: D5] | $228 | $214 | $68 | $523 | $207 |
| D4 [D1: D2: D3: D5] | $541 | $171 | $534 | $467 | $905 |
| D5 [D1: D2: D3: D4] | $69 | $62 | $91 | $81 | $273 |
| *RegTot* | *$1,032* | *$664* | *$788* | *$1,256* | *$2,234* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 0: 0: 0: 0: 21 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 23.2: 0 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 0 | 0 | 48.3 | 0 | 0 |
| D3 | 0 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B20.** *Deterministic Periodic SY* Model Results (Scenario 2626, '2011-2015' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 4,121.4 |
| *Total 5yr Val (Objective Function)* | $6,092 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $143 | $218 | $165 | $165 | $177 | 0 | 0% |
| D2 | $82 | $155 | $26 | $14 | $539 | 0 | 0% |
| D3 | $196 | $69 | $73 | $539 | $68 | 113.9 | 26% |
| D4 | $514 | $599 | $604 | $498 | $474 | 140.1 | 32% |
| D5 | $346 | $125 | $101 | $95 | $107 | 183.9 | 42% |
| RegVal | $1,281 | $1,166 | $969 | $1,311 | $1,365 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 38.6: 0: 0: 17.9 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 0 | 6.8: 0: 0: 4.4 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 0: 0: 0: 0 | 43.7: 0: 0: 0 | 0: 0: 0: 43.7 | 1.4: 0: 0: 42.3 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 9.2: 0: 13.2: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 22.3: 0: 0 |
| *RegTot* | *22.3* | *111.3* | *111.3* | *111.3* | *133.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 21: 0: 0: 0: 0 | 0: 21: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 23.2 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 3.8: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 0 | 0 | 0 | 0 |
| D3 | 0 | 0 | 0 | 0 | 0 |
| D4 | 0 | 0 | 0 | 0 | 0 |
| D5 | 41.1 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B21.** *Deterministic Periodic SY* Model Results (Scenario 2402, '2005-2009' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,011.1 |
| *Total 5yr Val (Objective Function)* | $7,632 |

| **Val[1]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** | **GW Supl** | **%SY** |
|---|---|---|---|---|---|---|---|
| D1 | $154 | $255 | $233 | $192 | $219 | 0 | 0% |
| D2 | $65 | $274 | $284 | $240 | $552 | 0 | 0% |
| D3 | $240 | $234 | $229 | $552 | $228 | 96.3 | 22% |
| D4 | $558 | $404 | $658 | $545 | $757 | 157.6 | 36% |
| D5 | $150 | $315 | $75 | $104 | $118 | 183.9 | 42% |
| RegVal | $1,167 | $1,482 | $1,479 | $1,633 | $1,874 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| **Dist Out [To][2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 55: 0: 0: 1.4 | 44: 0: 0: 12.5 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 6.6: 0: 0: 4.6 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 25.9: 10.5: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 0: 0: 0: 43.7 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 22.3: 0: 0 |
| *RegTot* | *36.4* | *66* | *111.3* | *111.3* | *133.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| **Dist Out[2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 21: 0 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 23.2: 0 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 4.1: 0: 0: 0: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| **EOY[3]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 34.7 | 0 | 0 | 0 |
| D3 | 4 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B22.** *Deterministic Periodic SY* Model Results (Scenario 839, '2001-2009' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,112.8 |
| *Total 5yr Val (Objective Function)* | $7,577 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $170 | $189 | $189 | $182 | $558 | 35 | 8% |
| D2 | ($11) | $52 | $161 | $197 | $554 | 0 | 0% |
| D3 | $236 | $221 | $233 | $554 | $234 | 78.8 | 18% |
| D4 | $541 | $187 | $617 | $548 | $988 | 219 | 50% |
| D5 | $247 | $64 | $234 | $191 | $241 | 105.1 | 24% |
| RegVal | $1,183 | $713 | $1,434 | $1,672 | $2,575 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 34.4: 9.3: 0: 0 | 38.4: 5.4: 0: 0 | 0: 0: 0: 43.7 | 4.1: 0: 0: 39.7 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *77.2* | *77.2* | *111.3* | *111.3* | *111.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 21: 0: 0: 0: 0 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 23.2: 0: 0: 0 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *25.2* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 48.3 | 0 | 0 | 0 |
| D3 | 4 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B23.** *Deterministic Periodic SY* Model Results (Scenario 3082, '1998-2002' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 6,107.6 |
| *Total 5yr Val (Objective Function)* | $9,519 |

| **Val[1]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** | **GW Supl** | **%SY** |
|---|---|---|---|---|---|---|---|
| D1 | $143 | $378 | $347 | $280 | $282 | 0 | 0% |
| D2 | $256 | $357 | $433 | $437 | $578 | 52.5 | 12% |
| D3 | $244 | $237 | $238 | $578 | $240 | 105.1 | 24% |
| D4 | $580 | $410 | $710 | $623 | $860 | 280.3 | 64% |
| D5 | $346 | $324 | $269 | $243 | $126 | 0 | 0% |
| RegVal | $1,569 | $1,706 | $1,997 | $2,161 | $2,086 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| **Dist Out [To][2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 0: 11.2: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 | 0: 0: 0: 11.2 |
| D4 [D1: D2: D3: D5] | 0: 43.7: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 | 0: 0: 0: 43.7 |
| D5 [D1: D2: D3: D4] | 20.9: 1.4: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| *RegTot* | *77.2* | *133.6* | *111.3* | *111.3* | *111.3* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| **Dist Out[2]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 23.2: 0 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 0: 0: 4.1 | 0: 0: 0: 4.1: 0 | 4.1: 0: 0: 0: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| **EOY[3]** | **Yr1** | **Yr2** | **Yr3** | **Yr4** | **Yr5** |
|---|---|---|---|---|---|
| D1 | 12.7 | 12.1 | 0 | 0 | 0 |
| D2 | 0 | 0 | 0 | 0 | 0 |
| D3 | 4 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 41.1 | 39 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B24.** *Deterministic Periodic SY* Model Results (Scenario 400, '1992-1996' Historic)

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 5,398.8 |
| *Total 5yr Val (Objective Function)* | $7,452 |

| Val[1] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $134 | $254 | $132 | $344 | $806 | 0 | 0% |
| D2 | $11 | $118 | $4 | $198 | $543 | 0 | 0% |
| D3 | $228 | $221 | $217 | $543 | $233 | 135.7 | 31% |
| D4 | $514 | $340 | $551 | $536 | $797 | 245.2 | 56% |
| D5 | $60 | $102 | $94 | $168 | $304 | 56.9 | 13% |
| RegVal | $947 | $1,035 | $998 | $1,789 | $2,683 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same year.*

| Dist Out [To][2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 15.1: 0: 0: 0 | 0: 0: 0: 0 | 56.4: 0: 0: 0 | 56.4: 0: 0: 0 |
| D3 [D1: D2: D4: D5] | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 | 0: 0: 0: 11.2 | 11.2: 0: 0: 0 | 11.2: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 16.9: 26.8: 0: 0 | 43.7: 0: 0: 0 | 0.5: 0: 0: 43.2 | 43.7: 0: 0: 0 | 43.7: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 0: 0: 0: 0 | 22.3: 0: 0: 0 | 22.3: 0: 0: 0 |
| *RegTot* | *54.9* | *92.3* | *54.9* | *133.6* | *133.6* |

*Groundwater Recharge Out (R-out) Data: includes Recharge 'credit(s)' to other Districts.*

| Dist Out[2] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 0: 21: 0: 0: 0 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 21 | 0: 0: 0: 0: 0 |
| D2 | 0: 0: 0: 0: 23.2 | 0: 23.2: 0: 0: 0 | 0: 0: 0: 23.2: 0 | 0: 0: 23.2: 0: 0 | 0: 0: 0: 0: 0 |
| D3 | 0: 0: 0: 3.8: 0 | 0: 3.8: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 | 0: 0: 4.1: 0: 0 | 0: 0: 0: 4.1: 0 | 0: 0: 0: 4.1: 0 | 0: 4.1: 0: 0: 0 | 0: 0: 0: 0: 0 |
| *RegTot* | *52.2* | *52.2* | *48.4* | *48.4* | *0* |
| EOY 1[3] | 18.9 | 36 | 52.2 | 0 | 0 |
| EOY 2[3] | 19.8 | 0 | 0 | 0 | 0 |
| EOY 3[3] | 3.4 | 0 | 0 | 0 | 0 |
| EOY 4[3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5[3] | 3.7 | 0 | 0 | 0 | 0 |

*Carryover/Surface Storage (CO) Data*

| EOY[3] | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 |
|---|---|---|---|---|---|
| D1 | 12.7 | 0 | 0 | 0 | 0 |
| D2 | 48.3 | 45.9 | 48.3 | 0 | 0 |
| D3 | 4 | 0 | 0 | 0 | 0 |
| D4 | 16.2 | 0 | 0 | 0 | 0 |
| D5 | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Year (EOY) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies.

**Table B25.** *Probabilistic* Model Results *(scenario-type occurrence).*

| | |
|---|---|
| *Sustainable Yield (SY) Set* | 437.9 |
| *Minimum Demand Fulfillment (%)* | 33% |
| *Total Water Available* | 4,908.9 |
| *Total 5yr Val (Objective Function)* | $6,041 |

| Val[1] | S1 | S2 | S3 | S4 | S5 | GW Supl | %SY |
|---|---|---|---|---|---|---|---|
| D1 | $140 | $188 | $478 | $150 | $103 | 140.1 | 32% |
| D2 | $26 | $39 | $185 | $56 | $52 | 21.9 | 5% |
| D3 | $71 | $236 | $238 | $240 | $189 | 52.5 | 12% |
| D4 | $159 | $531 | $542 | $551 | $560 | 113.8 | 26% |
| D5 | $69 | $273 | $288 | $292 | $304 | 109.6 | 25% |
| RegVal | $465 | $1,267 | $1,731 | $1,289 | $1,208 | 437.9 | 100% |

*Water Transfer (Tx) Data: to other Districts within same scenario-type.*

| Dist Out [To][2] | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|
| D1 [D2: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D2 [D1: D3: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 56.4 | 9.2: 0: 47.3: 0 |
| D3 [D1: D2: D4: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D4 [D1: D2: D3: D5] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 |
| D5 [D1: D2: D3: D4] | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 0 | 0: 0: 0: 22.3 |
| *RegTot* | *0* | *0* | *0* | *56.4* | *78.8* |

*Carryover/Surface Storage (CO) Data*

| EOS[3] | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|
| D1 | 0 | 0 | 12.7 | 0 | 12.7 |
| D2 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 |
| D3 | 0 | 4 | 4 | 4 | 4 |
| D4 | 0 | 16.2 | 16.2 | 16.2 | 16.2 |
| D5 | 41.1 | 41.1 | 41.1 | 41.1 | 41.1 |

*Groundwater Recharge Out (R-out) Data by Scenario: includes Recharge 'credit(s)' to other Districts.*

| Dist Out [S][2] | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|
| D1 [S1] | 0: 0: 0: 0: 0 | 0: 21: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D2 [S1] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 19.4: 3.8: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D3 [S1] | 3.8: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 [S1] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 [S1] | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| EOS 1 [S1][3] | 0 | 21 | 0 | 0 | 0 |
| EOS 2 [S1][3] | 0 | 0 | 23.2 | 0 | 0 |
| EOS 3 [S1][3] | 3.8 | 0 | 0 | 0 | 0 |
| EOS 4 [S1][30] | 0 | 0 | 0 | 0 | 0 |
| EOS 5 [S1][34.1] | 0 | 0 | 0 | 0 | 0 |

*Note: All units TAF unless otherwise specified.*

[1] District/year value output in $ mil; based on income from crop demand fulfillment and expenses for water supplies.

[2] Transfer/recharge to districts shown each year in format "D1: D2: D3: D4: D5" (e.g., Out D1, "D2: D3: D4: D5" in year cell).

[3] End of Scenario (EOS) recharge or carryover storage; references groundwater 'banked' or in/out-of-district reservoir supplies. In case of specified to other Scenario, indicates recharged amount during scenario in preparation for future scenario-type.

*Groundwater Recharge Out (R-out) Data by Scenario (Continued)*

| Dist Out [S][2] | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|
| D1 [S2] | 1.4: 10.1: 0: 0: 0 | 7.4: 2.2: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D2 [S2] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 21: 2.2: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D3 [S2] | 3.8: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 [S2] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 [S2] | 4.1: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| EOY 1 [S2][3] | 11.5 | 9.6 | 0 | 0 | 0 |
| EOY 2 [S2][3] | 0 | 0 | 23.2 | 0 | 0 |
| EOY 3 [S2][3] | 3.8 | 0 | 0 | 0 | 0 |
| EOY 4 [S2][3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5 [S2][3] | 4.1 | 0 | 0 | 0 | 0 |
| D1 [S3] | 0: 13.1: 3.8: 0: 4.1 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D2 [S3] | 0: 0: 0: 0: 0 | 13.6: 0: 3.8: 0: 4.1 | 0: 1.6: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D3 [S3] | 3.8: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D4 [S3] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 [S3] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 4.1: 0: 0: 0 |
| EOY 1 [S3][3] | 21 | 0 | 0 | 0 | 0 |
| EOY 2 [S3][3] | 0 | 21.5 | 1.6 | 0 | 0 |
| EOY 3 [S3][3] | 3.8 | 0 | 0 | 0 | 0 |
| EOY 4 [S3][3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5 [S3][3] | 0 | 0 | 0 | 0 | 4.1 |
| D1 [S4] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 4.1 | 0: 16.9: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D2 [S4] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 6.3: 3.8: 0: 4.1 | 0: 9: 0: 0: 0 |
| D3 [S4] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 3.8: 0: 0: 0 |
| D4 [S4] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 [S4] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 4.1: 0: 0: 0 |
| EOY 1 [S4][3] | 0 | 0 | 4.1 | 16.9 | 0 |
| EOY 2 [S4][3] | 0 | 0 | 0 | 14.2 | 9 |
| EOY 3 [S4][3] | 0 | 0 | 0 | 0 | 3.8 |
| EOY 4 [S4][3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5 [S4][3] | 0 | 0 | 0 | 0 | 4.1 |
| D1 [S5] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 21: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D2 [S5] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 16.9: 2.2: 0: 0: 4.1 |
| D3 [S5] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 3.8: 0: 0: 0: 0 |
| D4 [S5] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 |
| D5 [S5] | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0: 0: 0: 0: 0 | 0.3: 0: 3.8: 0: 0 |
| EOY 1 [S5][3] | 0 | 0 | 0 | 21 | 0 |
| EOY 2 [S5][3] | 0 | 0 | 0 | 0 | 23.2 |
| EOY 3 [S5][3] | 0 | 0 | 0 | 0 | 3.8 |
| EOY 4 [S5][3] | 0 | 0 | 0 | 0 | 0 |
| EOY 5 [S5][3] | 0 | 0 | 0 | 0 | 4.1 |