CDM

Butte County Department of Water and Resource Conservation

Integrated Water Resources Program

Agricultural Water Demand Forecast

October 2003

Technical Memorandum

Technical Memorandum
Agricultural Water Demand Forecast

Section 1 - Introduction

1.1 Project Description

This technical memorandum describes the process used to forecast agricultural water demand for the Butte County Integrated Water Resources Program (Program). *The Program is intended to improve water management in the County and to maintain agricultural viability, meet urban and environmental needs, and ensure a future groundwater supply to overlying users, enhance the economy, and protect the citizens and natural resources of Butte County.*

As part of the Program, Butte County will develop:

- Basin Management Objectives
- Water Demand Forecasts
- An Environmental Monitoring Plan
- A Drought Preparedness Plan
- An AB 3030 Groundwater Management Plan
- An Integrated Watershed and Resource Conservation Plan
- An Updated Conservation Element of the County General Plan

Butte County seeks to develop these plan elements through an inclusive process that informs, educates, and involves local stakeholders.

Stakeholders in Butte County understand the value of their water resources and have been proactive in advancing water management through groundwater modeling, monitoring and cataloging of the resource. Development and implementation of the Program will benefit from the active participation of those who have knowledge of – and a stake in – the outcome of the planning process. Locally-driven plan development contributes to plan elements that are appropriate, equitable, and implementable.

1.2 Purpose and Scope

1.2.1 Purpose

The Department of Water and Resource Conservation is developing a Program that will recommend policies for consideration by the Butte County Water Commission and Board of Supervisors. Development of an integrated water resources plan focuses on policies that lead to a long-term sustainable supply of water to meet future needs for all sectors of water users. To facilitate water resource planning, it is necessary to understand the magnitude and location of future water demand in the county.

The purpose of the agricultural water demand forecast is to develop a set of reasonable scenarios for agricultural water use into the future. Scenarios are based on a set of assumptions about future economic, land use, and hydrologic conditions affecting Butte County. Understanding changing demand into the future allows local planners to develop recommended actions that will complement the effects of water purveyors toward sustaining or improving water quantity and quality into the future.

1.2.2 Scope

This analysis developed and evaluated five agricultural water demand scenarios using an economic model of agricultural production developed specifically for Butte County. A "Delphi" group of agricultural experts from Butte County was convened for several meetings to review and provide independent evaluation of the approach, assumptions, data, and results. Forecasts were made for five geographic regions within the County.

1.3 Document Overview

This document contains the following sections:

- Section 1 – Introduction
- Section 2 – Demand Forecast Methodology
- Section 3 – Model Input Data
- Section 4 – Results
- Section 5 – Findings
- References
- Appendices

Section 2 – Demand Forecast Methodology

2.1 Delphi Process

A Delphi process uses structured communication among a group of experts to facilitate the formation of group judgment. The objective of the Program's modified Delphi process was to collect knowledge from a group of experts to evaluate the procedure used to forecast agricultural water under potential future conditions. The experts, representing key agricultural interests in the County assembled for this purpose, included:

- Tito Cervantes – Department of Water Resources, Northern District
- Ed Craddock – Butte County Department of Water and Resource Conservation
- Chuck Crain – Crain Walnut
- Jarald Davidson – Ag Vise Consulting
- Charlie Ferchaud - Department of Water Resources, Northern District (retired)
- Tod Kimmelshue – Butte County Farm Bureau
- Kent McKenzie – California Cooperative Rice Research Foundation – Rice Research Station
- Cass Mutters – University of California Cooperative Extension
- John Nock – Nock Orchards
- Bill Olson – University of California Cooperative Extension
- Richard Price – Butte County Agricultural Commission

A key element of the Delphi process is to generate discussion among experts without allowing one member's opinion to be strongly affected by others. There are typically three distinguishing characteristics for implementing the Delphi process:

1. The experts were asked their opinion in several successive rounds.

Iteration promoted group learning and allowed members to refine their individual opinions. The Butte County Delphi process consisted of three rounds. In the first round, the Delphi group evaluated the general model approach to forecasting agricultural water demand. The second round consisted of evaluating the scenarios used in forecasting. In the third round, the Delphi group received a copy of the draft report and had the opportunity to provide comments. In each round, experts were permitted to refine previous opinions.

2. The experts were allowed to give most of their responses anonymously.

Anonymity avoided influence by reputation, authority, or affiliation. This process permitted members to form opinions or change them without revealing themselves. In the first Butte County Delphi meeting, the experts met and held group discussions. This meeting did not follow the traditional Delphi process; instead it was used to inform members of the study and discuss initial approaches. During the second round, experts were given a questionnaire about model components and model scenarios, which was completed anonymously. Appendix A includes the questionnaire.

3. The results of the questionnaire were presented statistically.

During the second Delphi meeting, the experts received immediate feedback on the outcome of the questionnaire. The group then discussed any opinions falling outside the median group response.

The Delphi process resulted in local agricultural experts participating in the development of the agricultural water demand forecast. Suggestions from the Delphi group were incorporated into the forecast assumptions and data so that results more accurately reflected potential future agricultural conditions in Butte County. This document indicates areas where Delphi input was incorporated into the analysis. These areas included:

- Geographic regions;
- Crop categories;
- Forecast scenarios;
- Magnitudes of change for scenarios;
- Applicable regions for scenarios; and
- Model input data.

2.2 Demand Forecast Model

The following sections describe the Butte County forecast model and its important components, and describes the scenarios that were evaluated using the model.

2.2.1 Model Description

The overall structure of the Butte County model is based on the Central Valley Production Model (CVPM) and the Cal-Ag models used by California DWR and others to estimate agricultural responses to changing water supply and economic conditions. CVPM (or Cal-Ag) is a large, regional model developed to estimate changes in irrigated acreage, crop production, water use, and net returns resulting from changes in economic or resource conditions. The model mimics the production decisions of agricultural producers (farmers) in the Central Valley of California. It assumes that farmers maximize net farm income subject to resource, technical, and market constraints. The major constraints are: 1) linear marginal cost functions estimated using the technique of positive mathematical programming; 2) commodity demand functions that relate market price to the total quantity produced; 3) acreage response functions, which relate changes in crop acreage to changes in net returns and other cost information; 4) irrigation technology tradeoff functions, which model the tradeoff between applied water and irrigation technology, and; 5) a variety of constraints defining land and water resources and other legal, physical, and economic limitations.

The Butte County model is a smaller and simplified version of the CVPM. Instead of representing large regions encompassing the entire Central Valley or state, it is limited to Butte County. Crop categories are chosen specifically for Butte County conditions. Because of the much smaller geographic scope, crop prices are assumed to be unaffected by changes in Butte County acreage, so CVPM's commodity demand functions are excluded. Finally, irrigation technology is incorporated in a simplified way based on the data presented in the *Butte County Water Inventory and Analysis (2001)*. Because of its smaller scale and simplifications, the Butte County model is constructed and solved within a set of Microsoft Excel® spreadsheets.

The Butte County spreadsheet model provides various approaches for estimating changes in irrigated crop production and water use. The model maximizes profit from irrigated crop production subject to assumptions about resource constraints, market conditions, and other economic conditions, with crop acreage changes regulated by estimated, non-linear cost functions.

2.2.2 Model Structure

The model is designed to approximate the decision process that Butte County's growers use to make cropping and water use decisions. The model assumes that growers attempt to maximize profit, but are subject to conditions and constraints on land availability and suitability, water supply and cost, and markets. Profit is defined as returns to land, management, and risk and is calculated as:

- Profit = Crop revenue (price x yield x acres, by crop and region) - water costs - other quantified production costs (excluding land).

An additional set of cost functions (one for each region and crop category) are estimated during a model calibration step. These functions use information on the observed baseline crop acreage, net returns, and acreage response elasticities. (For a complete description of the mathematical structure of the CVPM and the Butte County model, see Reclamation, 1997: Central Valley Project Improvement Act, Draft Programmatic Environmental Impact Statement, Technical Appendix Volume 8. Mid-Pacific Region.)

The model maximizes profit to irrigated crop production subject to the following constraints:

- Total crop acreage in a region cannot exceed available irrigable land;
- Acreage in each crop cannot exceed the land suitable for growing that crop;
- For lands with access to surface water, total applied water cannot exceed the available surface water; and
- For lands with access to groundwater, total applied water cannot exceed the available groundwater.

2.2.3 Model Components

The Butte County model has three major components:

- Crop categories;
- Geographic regions; and
- Forecast scenarios.

The following sections describe these components and how they are incorporated into the model. The Delphi group reviewed these components and suggested a few revisions. After revisions, the group agreed that they were appropriate for the purposes of forecasting demands for the Program.

2.2.3.1 Crop Categories

To forecast agricultural demand, the analysis developed six crop categories by first identifying standard crop categories in the county (e.g., rice, field crops, or orchards), then refining them by considering relative evapotranspiration of applied water (ETAW) demand[1]. Of the field crops, rice had a significantly higher ETAW than other crops and therefore was separated into a single category. Safflower had a significantly lower ETAW than other crops and was also placed into a separate category. The six crop categories used in the model include:

- Field crops;
- Forage;
- Grain;
- Rice;
- Safflower; and

[1] Evapotranspiration (ET) is the combined water loss by evaporation from a soil or plant surface and transpiration. The ET value accounts for water used from both irrigation and precipitation. ETAW represents the ET of the crop supplied by irrigation water and not precipitation.

- Orchards.

Each crop category is represented by a proxy crop, which was chosen based on acreage and ETAW rates. Table 2-1 summarizes the crop categories and associated proxy crops. Generally, crops with the highest acreage and closest to average ETAW were chosen as the proxy crop. The analysis assumes that the crop budget data for the proxy crop is representative of other crops in the category.

Table 2-1
Summary of Crop Categories and Proxy Crop

Crops Planted in Butte County	Crop Category	Proxy Crop
Dry Beans	Field Crops	Dry Beans
Corn	Field Crops	Dry Beans
Sunflowers	Field Crops	Dry Beans
Sugar Beets	Field Crops	Dry Beans
Other Truck	Field Crops	Dry Beans
Other Field	Field Crops	Dry Beans
Cucurbits	Field Crops	Dry Beans
Alfalfa	Forage	Alfalfa
Pasture	Forage	Alfalfa
Grain	Grain	Wheat
Rice	Rice	Rice
Safflower	Safflower	Safflower
Almonds	Orchards	Almonds
Pistachios	Orchards	Almonds
Prunes	Orchards	Almonds
Walnuts	Orchards	Almonds
Other Deciduous	Orchards	Almonds
Kiwi	Orchards	Almonds
Citrus-Olives	Orchards	Almonds

2.2.3.2 Geographic Regions

The analysis forecasted agricultural water demand in five distinct geographical areas in Butte County, as defined by the *Butte County Water Inventory and Analysis Report, 2001.* The various regions were developed on the basis of hydrologic basins and common water sources, and to a lesser degree, administrative boundaries such as the county border. The *Water Inventory and Analysis* further divided the regions into sub-units representing water suppliers or unorganized areas with common water sources and uses; however, the demand forecast analysis does not focus on specific subunits. Figure 2-1 shows the Butte County geographic regions.

East Butte

The East Butte region is in the central and southwestern portion of the valley floor. Most soils in the region are categorized as Class III, moderately good, cultivatable soils. The majority of crop acreage in the East Butte region is rice, though the soil is suitable for various types of crops. Orchards and forage crops are also important crops in the region. Crops in the East Butte region are mostly irrigated with surface water; groundwater is used to irrigate about 20 percent of crops. Sub-units in the East Butte region include Biggs-West Gridley, Butte, Butte Sink, Cherokee, Esquon, Pentz, Richvale, Thermalito, and Western Canal.

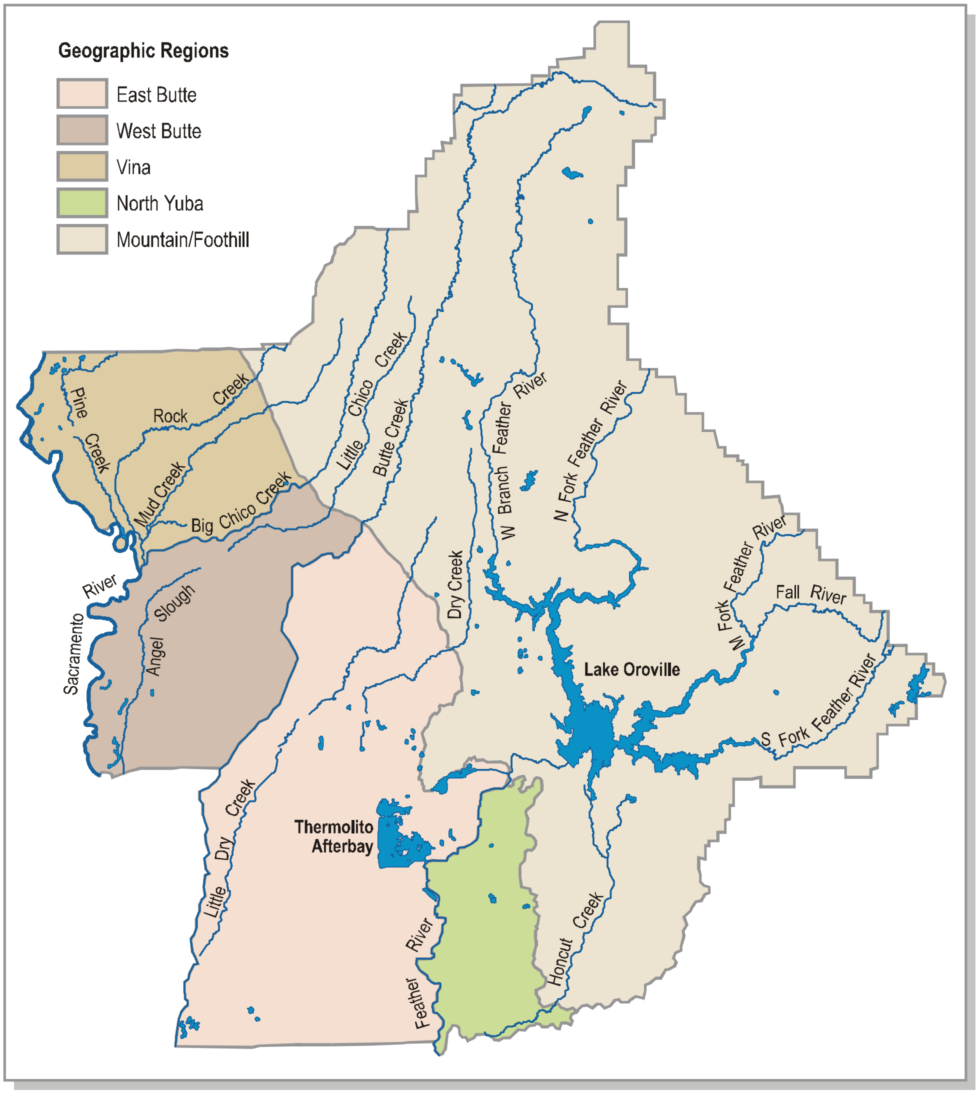

Figure 2-1
Geographic Regions in Butte County

West Butte

The West Butte region lies northwest of Butte Creek and south of Big Chico Creek and extends to the County border. Class II and Class III soils are predominant in the region and are suitable to grow various types of crops. Major crops found in the region include rice and orchards. Approximately half of the irrigation water applied in the West Butte region comes from surface sources and half from groundwater pumping. Rice is mainly irrigated with surface water and orchards are mainly irrigated with groundwater. Sub-units in the West Butte region include Angel Slough, Durham/Dayton, Llano Seco, M&T, and Western Canal.

North Yuba

The North Yuba region lies on the valley floor east of the Feather River. The soils are classified as Class IV, fairly good and suitable for occasional cultivation. Orchards are the primary crop type; however, rice, grains and forage crops are also grown. Groundwater is the major source of irrigation water in the North Yuba region. The North Yuba region is not further divided into sub-units.

Vina

The Vina region lies within the valley area in the northwestern portion of the county. Soils in the region are classified as Class I, very good cultivatable land, or Class VII, well suited for grazing or forestry. Orchards, including almonds, prunes and walnuts, are the primary crop in the Vina region. Limited acreage of forage, grain, field crops and safflower are grown in the region. The Vina region uses mainly groundwater for irrigation; surface water use is less than 3 percent. The Vina region is not further divided into sub-units.

Mountain-Foothill

Mountain and foothill regions were combined due to the relatively small amount of irrigated acreage. Most soils in the region are Class VI, unsuited for cultivation, though well-suited for grazing and forestry. Crops are typically not grown in this region; however there are some orchards, grain and forage crops. The region uses mostly surface water for irrigation. The Mountain-Foothill region includes Cohasset, Ridge, Wyandotte, and Mountain sub-units.

2.2.4 Model Scenarios

The analysis models several scenarios to evaluate potential long-term changes in agricultural water demand. The model scenarios implemented for an average water year include:

- Agricultural land conversion;
- Increased crop prices;
- Increased crop idling;
- Water conservation;
- Combination scenario – average water year; and
- Combination scenario – dry water year.

The Delphi group contributed to the formation of the scenarios by recommending scenario types, magnitudes of change, and applicable regions. The group indicated the forecast scenarios would be reasonable through the year 2030. The following sections describe the assumptions used to model the scenarios.

Figure 2-2
Cities with Potential Agricultural Land Conversion

2.2.4.1 Agricultural Land Conversion

Recent trends reflect agricultural land conversion for urban and environmental uses, resulting in less irrigated crop land in production. Population growth and urban development require cities to extend their boundaries, sometimes into agricultural land. According to the Center for Economic Development (CED) of California State University, Chico, population is expected to increase by 52 percent, 87 percent, 49 percent, and 141 percent in Biggs, Chico, Gridley, and Oroville, respectively, by 2030, necessitating further urban development. Figure 2-2 shows locations of these cities.

In addition to urban development, local governments, and land trusts in Butte County are purchasing permanent agricultural conservation easements, which remove land from production to protect its conservation values.

The model incorporates agricultural land conversion as a decrease in the amount of irrigated agricultural land in production. The analysis assumes a three percent decrease of irrigated crop land in the Vina and West Butte regions, and a one percent decrease in the East Butte region. These percents represent total change between now and the year 2030 (**not** an annual percent rate of conversion). The Delphi group agreed that these changes would be reasonable for Butte County in the future. These changes account for population increases in the aforementioned cities and new conservation easements. As suggested by the Delphi group, the agricultural land conversion scenario would not apply in the North Yuba region because any growth resulting from Oroville into the North Yuba region would not likely be into irrigated cropland.

2.2.4.2 Increased Crop Prices

Crop prices frequently increase or decrease as a result of changing market demands, competition from other production regions, and government programs. Price changes can affect the amount of land in production and the demand for water. Price changes tend to be disproportionate, meaning that some commodity crop prices would increase relative to other crops.

Commodity price forecasting was not a goal of this analysis, and recent, reliable estimates of future crop prices were not available. Therefore, this analysis was used to evaluate changes in water demand associated with a hypothetical increase in the relative prices of the two largest water-using crop types: rice and orchards.

Specifically, this scenario assumes a ten percent increase in the price of rice and orchards, holding other crop prices constant. Note that because this assumption is hypothetical, it was not carried into the combination scenario described in Section 2.2.4.5.

The Delphi group recommended that the amount of land in production be constrained because Butte County has limited agricultural land suitable for crop production.

2.2.4.3 Increased Crop Idling

Agricultural water has been identified as a potential water source to meet new and increasing water demand for environmental resource protection and water supply reliability. Urban water districts and government programs have initiated or proposed to initiate water purchases from agricultural water districts through idling of irrigated crop land. In 2001, Metropolitan Water District purchased 110,000 acre-feet of water via crop idling from several Sacramento Valley water districts, including Western Canal Water District and Richvale Irrigation District in Butte County. Government programs, including the California Bay Delta Authority Environmental Water Account and Department of Water Resources Dry Year Purchase Program, could also purchase water through crop idling for environmental and water supply purposes.

Crop idling would decrease the amount of applied surface water in the County. Specifically, the analysis assumes a ten percent reduction in surface water deliveries. The analysis also assumes that groundwater replacement for surface water losses would not occur or would be prohibited.

2.2.4.4 Conservation

Water conservation is an important component of managing water demands and supplies in the future. Agricultural practices that could conserve water include reduction of applied water through the installation of more efficient irrigation systems, including drip irrigation. Conservation can also be achieved at a district level, through such methods as canal lining, spill recovery, and automation. This scenario only looked at savings from on-farm irrigation systems and management.

This analysis assumes that conservation is achieved by moving from an existing irrigation efficiency to a target irrigation efficiency for each crop category. The Delphi group agreed that these target numbers represent achievable application rates in the County. In some instances, target irrigation efficiencies are identical to the existing applied water rates. The target irrigation efficiencies consider applied water use only and not any potential cost effects of achieving the target rates. Table 2-2 indicates target irrigation efficiencies for each crop category.

Table 2-2 Base and Target Irrigation Efficiencies by Region										
Crop Category	**East Butte**		**West Butte**		**Vina**		**North Yuba**		**Mountain-Foothill**	
Surface Water	**Base**	**Target**	**Base**	**Target**	**Base**	**Target**	**Base**	**Target**	**Base**	**Target**
Forage	0.66	0.70	0.65	0.70	--	--	0.85	0.85	0.73	0.73
Grains	0.72	0.75	0.70	0.75	--	--	0.70	0.75	0.66	0.75
Rice	0.61	0.65	0.61	0.65	--	--	--	--	--	--
Other Field	0.66	0.75	0.71	0.75	0.71	0.75	--	--	--	--
Orchards	0.67	0.75	0.72	0.75	0.73	0.75	0.73	0.75	0.80	0.80
Safflower	1.10	1.10	0.99	0.99	--	--	--	--	--	--
Groundwater										
Forage	0.75	0.75	0.75	0.76	0.74	0.75	0.75	0.75	0.83	0.83
Grains	0.73	0.75	0.78	0.78	0.78	0.78	0.78	0.78	--	--
Rice	0.63	0.65	0.64	0.65	--	--	0.63	0.65	--	--
Other Field	0.69	0.75	0.74	0.75	0.73	0.75	0.70	0.75	--	--
Orchards	0.75	0.75	0.77	0.78	0.77	0.77	0.73	0.75	0.56	0.75
Safflower	0.50	0.50	0.99	0.99	0.98	0.98	--	--	--	--

2.2.4.5 Combination Scenario

This analysis models a combination scenario in which agricultural land conversion, crop idling, and conservation scenarios are all implemented. The combination scenario is intended to forecast likely changes in agricultural water demand in Butte County taking into account a combination of the most probable land and water use changes. The crop price scenario was not included because of the uncertainty in predicting future crop prices.

The Delphi group suggested modeling a drought condition that would include increased groundwater pumping. The Delphi group recognized that a future drought is certain and that it would be beneficial to forecast drought effects on agricultural water demand. Therefore, the combination scenario was performed with both average and dry water year data.

2.2.4.6 Summary of Model Scenarios

Table 2-3 summarizes applicable regions, implementation methods, and magnitudes of the above scenarios.

Table 2-3
Summary of Agricultural Demand Forecasting Scenarios

Scenario	Applicable Regions	Implementation Method	Magnitudes
Land Conversion	Vina, West Butte (Chico) East Butte (Oroville, Biggs and Gridley)	Decrease total land in production	Decrease irrigated land 3% in Vina and West Butte Decrease irrigated land 1% in East Butte
Crop Idling	All Regions	Decrease surface water used for irrigation	Decrease surface water delivery 10%
Crop Prices	All Regions	Increase relative crop prices	Increase rice and orchards price 10%
Water Conservation	All Regions	Increase crops irrigation efficiency	Set target irrigation efficiencies for each crop
Combination Scenario – average and dry water years	All Regions	Combines agricultural land conversion, crop idling and water conservation scenarios	Decrease irrigated land 3% in Vina and West Butte Decrease irrigated land 1% in East Butte Decrease surface water delivery 10% Set target irrigation efficiencies for each crop

Section 3 – Model Input Data

3.1 Model Baseline

The Butte County forecasting model has two different baseline scenarios: average and dry year conditions. The baseline scenarios consist of crop budget data, including surface water and groundwater costs, and irrigation water requirements. Most crop budget data is the same for average and dry years. The dry year scenario takes into account decreases in the groundwater levels from increased pumping; therefore, groundwater costs differ between the two baselines. In addition, irrigated acreage and applied water rates differ between the average and dry years. The following sections describe the assumptions of the model baseline in average and dry years.

3.1.1 Average Year

The average year baseline uses applied water rates and ETAW values from the average year analysis in the *Butte County Water Inventory and Analysis Report (2001).*

3.1.2 Dry Year

The dry year baseline uses applied water rates and ETAW values from the dry year analysis in the *Butte County Water Inventory and Analysis Report (2001).* Surface water supplies and groundwater use were also derived from estimates in the report. The increased groundwater pumping costs reflect greater pumping lifts.

3.2 Data Categories

The model input data reflects the economics of crop production, including crop prices, yields, costs of production, and applied water rates. Major sources of information include:

- County Agricultural Commissioner reports for crop price and yield data;
- University of California Cooperative Extension crop budget analysis for fixed and variable costs data;
- Discussions with water district personnel for water cost data;
- *Butte County Water Inventory and Analysis Report (2001)* for irrigation acreage and irrigation water requirements data;
- Cal-Ag model for acreage elasticities; and
- Delphi group (see Section 2.1).

Each region has individual data characterizing applied surface and groundwater costs and applied water rates. Crop prices, yields, and production costs (excluding water) are uniform for crops across the regions. Appendix B includes model input data for all regions.

3.2.1 Crop Price and Yield

The crop prices and yields are those of the proxy crop associated with each category. The crop price, reported in price per ton, reflects the price of the crop at market value, including any per-unit government payment. Crop yield is reported in tons per acre. Crop price and yield averages over 10 years (1992-2001) are used to account for fluctuating market prices and hydrologic conditions. The price is adjusted to 2002 dollars.

3.2.2 Fixed and Variable Costs

Fixed costs apply regardless of the amount of crop produced. These costs include property taxes, equipment, office expenses, and insurance. The fixed cost is representative of the proxy crops associated with the crop categories.

Variable costs are based on the amount of crop produced. These costs include labor, fuels, lube and repairs, and material costs. Water costs are also variable costs; however, they are reported separately. The variable cost is representative of the proxy crops associated with the crop categories. Variable costs are reported in 2002 dollars per acre. Fixed and variable costs, excluding water costs, are the same for average and dry years.

3.2.3 Water Costs

Surface water prices were estimated from existing data and conversations with water district personnel. The analysis assumes surface water costs were the same for average and dry years. Water districts sometimes reported retail prices in dollars per acre-foot, which were then converted into dollars per acre using applied water rates from the *Water Inventory and Analysis*. In addition to retail prices, surface water costs include several other fees:

- A rice decomposition water use fee ranging from $3 to $6 per acre, depending on the water district and geographic location;
- A standby fee for conveyance ranging from $3 to $20 per acre, depending on water district and geographic location; and
- A flat rate for surface water costs of $45 per acre-foot for the Mountain-Foothill region.

Groundwater costs incorporate fixed costs for the well and pumps and variable costs for pumping water. A cost to amortize well construction and pump equipment purchases and replacement was estimated to range from $6.40 to $11.40 per acre-foot pumped, depending on the well depth and capacity. Variable costs were based on a dynamic lift, ranging from 32 to 57 feet depending on the region and a cost factor of $0.20 per acre-foot per foot of lift representing fuel and energy costs.

3.2.4 Irrigated Acreage

This analysis uses irrigated acreage amounts identified in the *Water Inventory and Analysis.* That study derived irrigated acreages from 1997 DWR agricultural survey data, Butte County Agricultural Commissioner reports, and discussions with water suppliers and landowners. Irrigated acreage data reflects a full cropping pattern in typical average and dry years, with some acres idle. Appendix C includes base values of irrigated acreage for each crop in each region.

3.2.5 Irrigation Water Requirements

This analysis uses applied water rates and ETAW from the *Water Inventory and Analysis,* which calculated evapotranspiration (ET) values for each crop. ET values account for water used from both precipitation and applied water; however, this analysis considers the ETAW for each crop, which is the applied water component of ET.

Irrigation water requirements vary between average and dry years. Among other factors, the applied water is dependent on the amount of soil moisture present at the beginning of the irrigation season. Relative to a dry winter, the soil moisture is higher after an average winter, which would reduce applied water needs. Therefore, the average year data reflects conditions of average precipitation and average crop ET, and dry year data reflects conditions of low precipitation and high crop ET.

The applied water and ETAW rates used in the model are the weighted averages of applied water or ETAW and acreage of each crop in the category. (Refer to Table 2-1 for crop and crop categories.)

3.2.6 Acreage Elasticities

The model uses acreage elasticities developed for the CVPM model. An acreage elasticity estimates the rate of change in a crop's acreage that results from a change in the crop's revenue (both expressed in percentage terms). The elasticities are based on estimates derived for Central Valley agriculture and used in the CVPM.

Section 4 – Results

The following sections highlight notable results for each scenario in the agricultural water demand forecast analysis. Appendix C includes detailed modeling results for each scenario in all regions.

4.1 Agricultural Land Conversion

The agricultural land conversion scenario models a decrease of land in production. As explained in Section 2.2.4.1, land conversion would likely occur in the East Butte, West Butte and Vina regions.

The results indicate that the least profitable crops per acre (forage, grains, and safflower) would have the largest percentage reductions in total acreage. Table 4-1 summarizes base acreages and changes under the land conversion scenario. Although rice shows large acreage reduction in the East Butte and West Butte regions, the decrease would be small relative to the base acreage grown, 0.98 percent and 1.5 percent, respectively.

Table 4-1
Acreage Base Values and Modeled Changes under the Agricultural Land Conversion Scenario (1000 acres)

Crop Category	***East Butte Region***				***West Butte Region***				***Vina Region***			
	Surface Water		***Groundwater***		***Surface Water***		***Groundwater***		***Surface Water***		***Groundwater***	
	Base	***Δ***	***Base***	***Δ***	***Base***	***Δ***	***Base***	***Δ***	***Base***	***Δ***	***Base***	***Δ***
Forage	3.88	-0.09	1.28	-0.03	0.82	-0.03	1.98	0.00	--	--	1.15	-0.05
Grains	0.19	-0.01	0.20	-0.01	4.23	-0.34	2.96	0.00	--	--	1.43	-0.14
Rice	81.50	-0.80	9.83	-0.09	14.41	-0.22	0.77	0.00	--	--	0.00	0.00
Other Field Crops	0.48	0.00	0.51	0.00	1.74	-0.02	1.39	0.00	0.10	0.00	3.20	-0.05
Orchards	10.72	-0.05	11.75	-0.05	0.72	-0.01	26.36	0.00	0.75	-0.02	29.47	-0.25
Safflower	0.11	-0.01	0.05	-0.04	0.79	-0.07	1.05	-1.04	0.00	0.00	0.59	-0.59

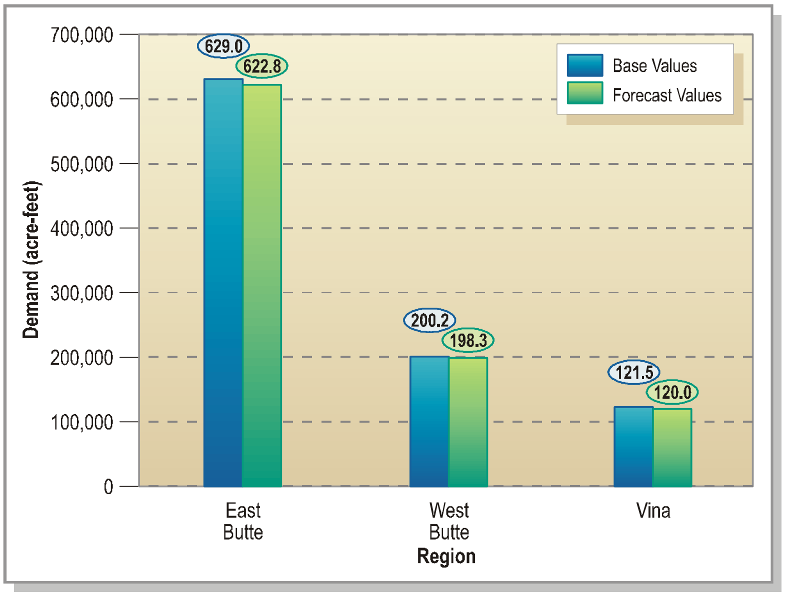

Figure 4-1
Comparison of Total Applied Water Under Base and Agricultural Land Conversion Scenarios

Because of the reduction in crop acreage, applied water would decrease. In East Butte and West Butte regions, applied water reductions would occur mainly in surface water because it is the dominant water source for crops that decline in acreage. The Vina region has little surface water use; therefore, decreased groundwater use would account for the majority of reductions. Figure 4-1 shows changes in total applied water between the base and forecast values for East Butte, West Butte, and Vina regions under this scenario.

Results illustrate that when crop land is constrained and growers have cropping flexibility, the least profitable crops would primarily be taken out of production. In Butte County, many low profit crops have less than average water use; therefore, a given percent conversion of agricultural land would tend to result in a low percent reduction in agricultural water demand.

4.2 Crop Prices

This scenario modeled a ten percent increase in the price of rice and orchard crops while holding other crop prices constant. The analysis constrained the amount of land in production, limiting it to existing levels. Therefore, results showed a shift in cropping patterns without putting additional non-irrigated land into production.

Because the price of rice and orchards increases, crop production of these commodities would also increase. For these increases to occur, land is taken out of less profitable crops, including forage, safflower, and grains. In the East Butte region, total rice acreage would increase by 150 acres and total orchard acreage would increase by 360 acres under this scenario. Land would be primarily taken out of forage crops because the region grows only limited acres of safflower and grains. In the West Butte region, more land would be taken from low water using crops like safflower and grains and placed into 310 acres of rice and 810 acres of orchards. Orchard production would increase by a larger percent than rice production because orchards have higher net revenue.

Changes in applied water depend on the shift in crop patterns. If land were shifted out of a high water use crop and into a lower water use crop, total applied water would decrease, and vice versa. Figure 4-2 summarizes changes in applied water in all regions. In the East Butte region, total applied water would decrease because land would come out of forage, a high water use crop, and would go into orchards, an average water use crop. In West Butte, the opposite would occur; total applied water increases because safflower and grains acreage shifted into higher water use crops (rice and orchards). The Vina, North Yuba, and Mountain Foothill regions have little or no rice acreage; therefore, all crop shifts would be into orchards. In these regions, applied water would be transferred between relatively similar water use crops and applied water would only slightly increase or decrease.

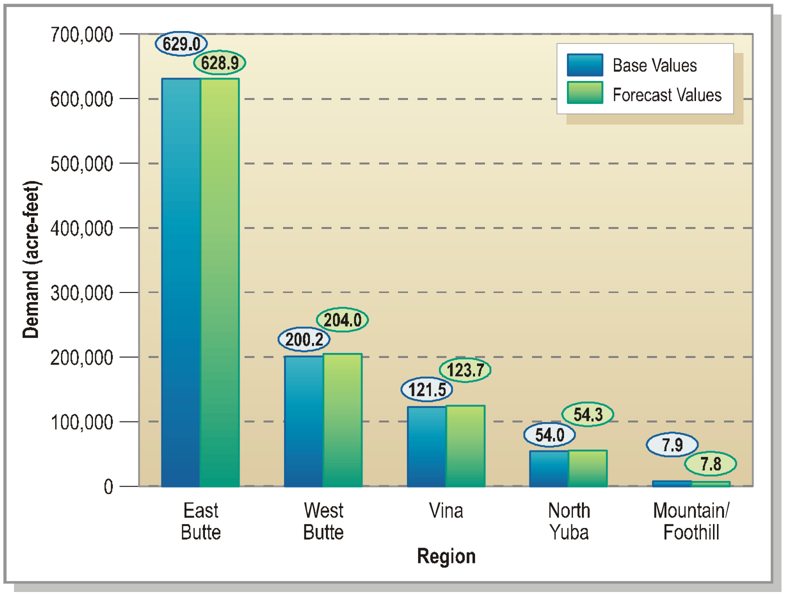

Figure 4-2
Comparison of Total Applied Water Under Base and Crop Price Scenarios

Increasing crop prices results in shifts of the crop patterns, which can increase or decrease applied water, depending on the relative water use of affected crops. Because of the difficulty predicting future crop prices, the analysis should be viewed as an illustration of a scenario in which agricultural water demands could slightly increase in the future. This scenario should not be viewed as a "prediction" of price increases.

4.3 Crop Idling

The scenario modeled a ten percent decrease in surface water supply in all regions. The analysis assumed that there would be no groundwater replacement for the surface water reductions.

To accommodate a decrease in surface water supply, the model estimated greater reduction in acreage of crops with the highest water requirements, mainly forage and rice. Because the scenario focuses on the development of surplus water through land idling, the model focused on those crops with the *lowest net return per unit of water applied*. (In general, these are not the same crops as those with the lowest net return per acre.) In the East Butte region, total acreage would decrease 9,420 acres (7.82 percent). Rice acreage would account for about 85 percent (7,990 acres) of total acreage reductions. In regions with little or no rice acreage, the model reduced acreages of forage crops and orchards. In the North Yuba region, orchard acreage would decrease 5.26 percent (90 acres). Growers do not idle orchards in the short-run; therefore, the crop would be removed from production in the regions in which orchard acreage decreases. The analysis forecasts long-term changes in water demand; therefore, orchard land could be removed from production.

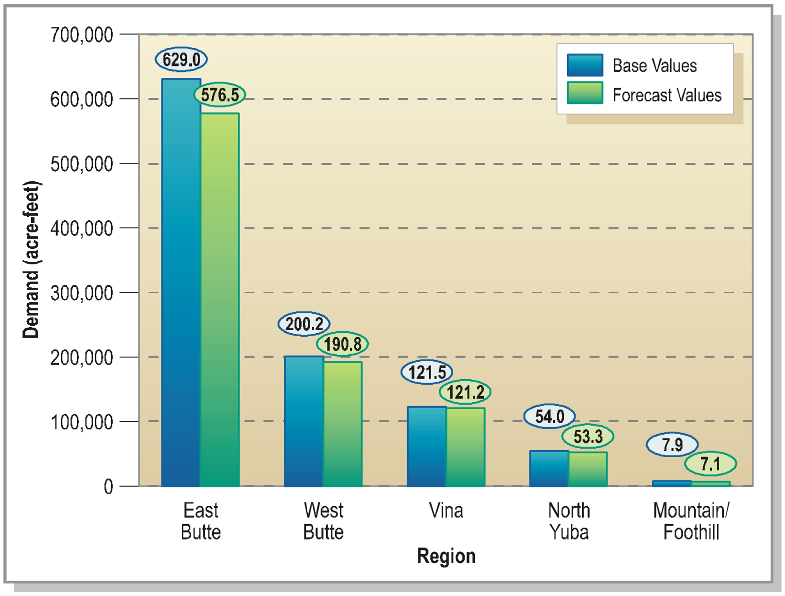

Figure 4-3
Comparison of Total Applied Water Under Base and Crop Idling Scenarios

The reduction in total applied water depends on the proportion of surface water used in the region. The scenario specifies a 10 percent reduction of surface water supplies; however, reductions in total applied water would (groundwater plus surface water) range from 0.25 percent (300 acre-feet) in the Vina region to 8.35 percent (52,521 acre-feet) in the East Butte region. Figure 4-3 compares base and forecast values of total applied water in each region.

Crop idling generates additional water that can be used for municipal, industrial and environmental purposes within and outside of the County. Water could be sold to urban water districts or government programs to increase revenue to participating farmers and the associated water purveyor.

4.4 Water Conservation

The water conservation scenario sets target irrigation efficiencies for each crop category. Target irrigation efficiencies are based on achievable applied water rates and do not consider any cost effects.

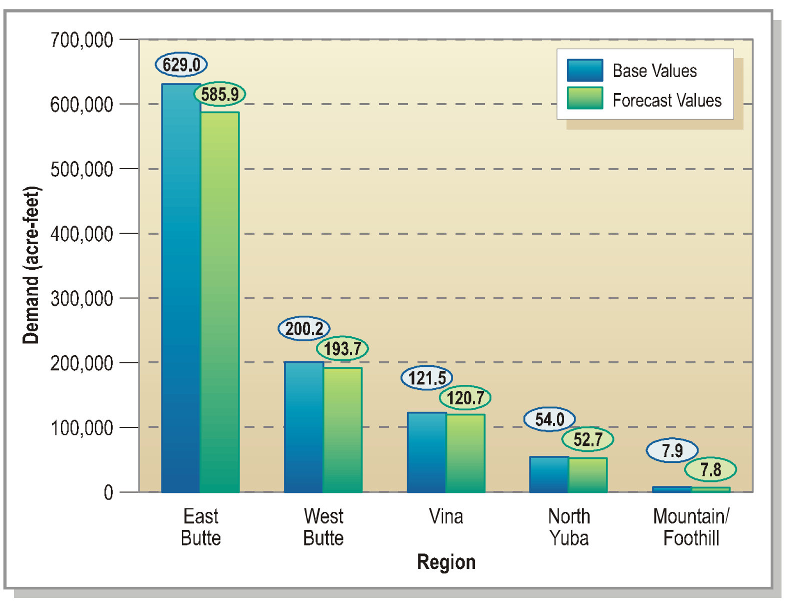

Figure 4-4
Comparison of Total Applied Water Under Base and Conservation Scenarios

The model indicates that achieving target irrigation efficiency levels would decrease applied water and would not change the existing crop patterns. In other words, the small saving in water cost that result from improved efficiency would not be enough to generate noticeable changes in relative costs or net revenues. Figure 4-4 summarizes reductions in applied water in each region.

Specific reductions in surface water or groundwater depend on the base value used in the region. In the East Butte region, surface water is approximately 83 percent (525,060 acre-feet) of total water use. Under the conservation scenario, surface water reduction would account for about 90 percent (38,760 acre-feet) of total reductions. Results are opposite in the Vina region where groundwater is the major source of applied water. In the Vina region, groundwater would account for about 98 percent (118,520 acre-feet) of total water use, and groundwater reductions are about 90 percent (730 acre-feet) of total applied water reductions. Crop patterns remain the same because the analysis did not significantly change the crop costs or net revenues.

Agricultural water conservation would result in decreased water demand. It provides the opportunity to use the conserved water for other purposes, including marketing. Grower, however, must still maintain a system for frost protection of crop, particularly orchards. Crops require approximately 30 gallons per minute per acre for frost protection. Conservation could also reduce groundwater recharge. Reductions in surface water use in crop fields and unlined distribution systems would decrease groundwater percolation. This document does not analyze effects to groundwater levels.

4.5 Combination Scenario

The combination scenario implements land conversion, crop idling and water conservation. The magnitudes of change in the forecast are the same as the under individual scenarios:

- Land in production decreases 1 percent in East Butte, and 3 percent in West Butte and Vina;
- Surface water delivery decreases 10 percent in all regions; and
- Water conservation increases to achieve target irrigation efficiencies in all regions.

The model forecasts demand under the combination scenario for both average and dry year conditions.

4.5.1 Average Year Combination Scenario

The combination scenario, including agricultural land conversion, crop idling, and water conservation, would result in a cumulative reduction to agricultural water demand. The breakdown of effects under the combination scenario would be similar to the effects of each individual scenario:

- Agricultural land conversion would decrease acreages of crops with the lowest net return per acre;
- Crop idling would decrease acreages of crops with the lowest net return per unit of water applied; and

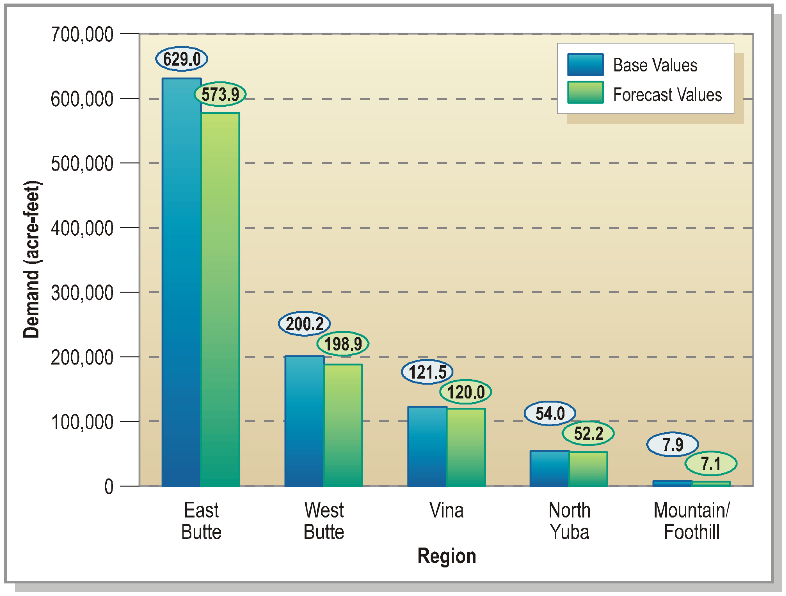

Figure 4-5
Comparison of Total Applied Water
Under Base and Combination (Average Year) Scenarios

- Water conservation, agricultural land conversion, and crop idling would decrease total applied water demand.

Figure 4-5 summarizes changes to total applied water under the combination scenario in all regions.

In the East Butte region, total crop acreage would decrease 3,340 acres (2.77 percent) and total applied water would decrease 55,020 acre-feet (8.75 percent). All other regions also experience decreases in total acreage and applied water.

The combination scenario emphasizes that all of these conditions could potentially occur concurrently in the future and provides a cumulative analysis for County agricultural water demand. In general, the scenario forecasts that there would not be a large change in future agricultural water demands.

4.5.2 Dry Year Combination Scenario

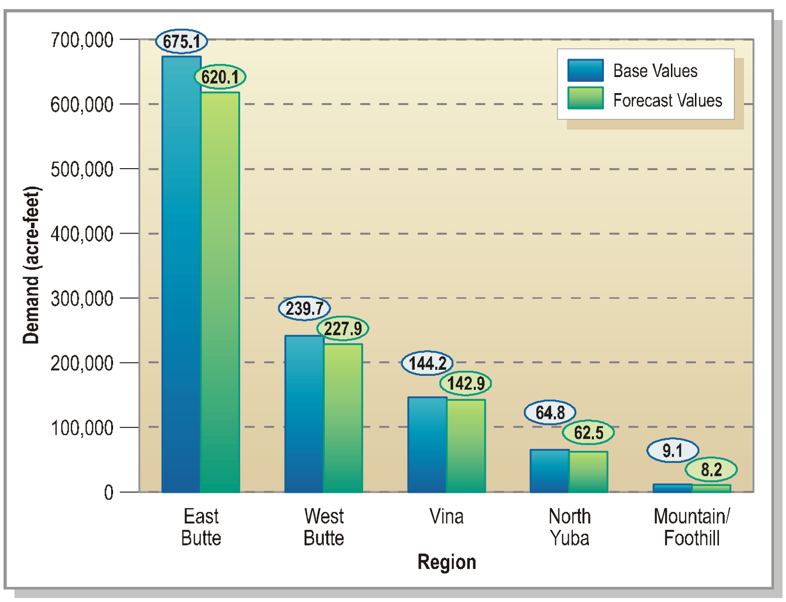

Figure 4-6
Comparison of Total Applied Water
Under Base and Combination (Dry Year) Scenarios

The dry year combination scenario reflects agricultural land conversion, crop idling, and conservation under dry year conditions. The model assumes increased groundwater pumping because less surface water is available during dry years. Similar to average years, in dry years, total water demand would also decrease. However, the base values for water demand in dry years would be larger than those in normal years. Figure 4-6 summarizes changes to total agricultural demand in all regions under the dry year conditions.

In the East Butte region, applied water would decrease 55,080 acre-feet (8.16 percent) from a base value of 675,100 acre-feet. This reduction is very similar to reductions under the average year combination scenario 55,020 acre-feet (8.75 percent) from a base value of 629,000 acre-feet. Total acreage reductions under the dry year combination scenario also would be similar to those of the average year combination scenario. The similar incremental changes in demand under average and dry year conditions would occur across all geographic regions.

The dry year conditions start from the same base level of crop acreage and higher base level of water use, but the incremental change resulting from the combination scenario would be quite similar to the average conditions. It is worth noting, however, that economic impacts on the agricultural sector may be more important in the dry year, because impacts are in addition to those already caused by the drought itself.

Section 5 – Findings

5.1 Conclusions

The agricultural water demand forecast generated several conclusions important for future water resource planning.

- In general, the analysis indicates that most of the reasonably foreseeable changes evaluated would not result in significant long-term changes in agricultural water demand in Butte County. Total agricultural water demand under the combination scenario would result in a minimum reduction of 0.6 percent (1,300 acre-feet) in the West Butte region and a maximum reduction of 8.75 percent (55,020 acre-feet) in the East Butte region.

- Crop idling results in the largest decreases to agricultural water demand and provides purveyors with surplus water that could be used by government programs or other water districts. Total agricultural water demand in the County under the crop idling scenario would decrease 63,700 acre-feet (6.3 percent).

- Agricultural land conversion results in a small reduction in irrigated cropland and agricultural water use in the County. Total agricultural water demand in the County under the agricultural land conversion scenario would decrease 9,600 acre-feet (0.9 percent).

- Water conservation would reduce applied water and provide purveyors with surplus water that could be used by government programs or other water districts; however, costs of conservation could be expensive. Total agricultural water demand in the County under the water conservation scenario would decrease 51,800 acre-feet (5.1 percent).

- The crop price scenario presents one plausible case that could increase water demand. However, price forecasting is inexact and has not been attempted in this study. Results of the price change scenario indicate that moderate crop price changes do not significantly affect water demand.

- A combination scenario was evaluated that included assumptions of three other scenarios. All three assumptions result in a reduction in agricultural water demand. Although the combination scenario is plausible, readers should consider it a cumulative analysis of potential future conditions.

- The combination scenario was evaluated for both an average year and a dry year condition. The dry year conditions start from the same base level of crop acreage and a higher base level of water use, but the incremental change resulting from the combination scenario is similar to the average conditions. Total agricultural water demand in the County would decrease 60,500 acre-feet (6.0 percent) in a normal year and 71,300 acre-feet (6.3 percent) in a dry year under the combination scenario.

5.2 Limitations

Based on guidance from the Delphi group, a reasonable set of scenarios was evaluated using the model, but many other sets of assumptions could have been evaluated. For example, scenarios could have been expanded to include water for rice decomposition or sprinkler irrigation for frost protection. The model, however, provides an appropriate structure for future analyses.

The model was designed to provide planning-level analysis. Use of the model for site-specific conditions would be inappropriate without further data collection and model testing.

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