Master Response 8.2
Regional Agricultural Economic Effects

Overview

In the San Joaquin Valley, the success of the agricultural industry has encouraged growth of businesses throughout the economy. When growers produce a certain crop and sell it, they generate revenue directly for themselves. Growers will likely need to reinvest a portion of that total *direct revenue* back into the business to pay workers and buy supplies for the next year; anything leftover is the net revenue or profit, which can be used to provide some kind of benefit to the grower, such as expanding the agricultural business. When a grower spends money to purchase supplies, a portion of the total revenue goes to the supply company, such as companies that produce fertilizer, tractors, and pesticides. When growers pays workers, the workers then have funds to spend throughout the economy on goods and services, providing revenue to many other businesses, such as grocery stores, car dealerships, and movie theaters. The revenue generated by supply companies is generally less than what the grower directly receives, otherwise the grower's business would not be sustainable. Figure 8.2-1 depicts cash flow relationships between the agricultural industry and the rest of a region's economy.

If there is a change in the direct revenue generated by an industry (e.g., because of changes in market conditions or availability of inputs like water), it could have an effect on the economic output and employment of the industry and the wider economy. The economic effects are broken down into three types: direct, indirect, and induced effects*. Direct effects* are the actual changes in economic output and employment for the sector being analyzed (i.e., agricultural production). *Indirect effects* are the changes in economic output and employment for industries that supply inputs to the sector being analyzed (i.e., less agricultural production means less fertilizer is needed and, in turn, those companies will have less money to spend). *Induced effects* are the changes in economic output and employment throughout the economy caused by changes in labor income in the sector being analyzed (i.e., fewer workers are needed for agricultural production, therefore those workers have less money to spend).

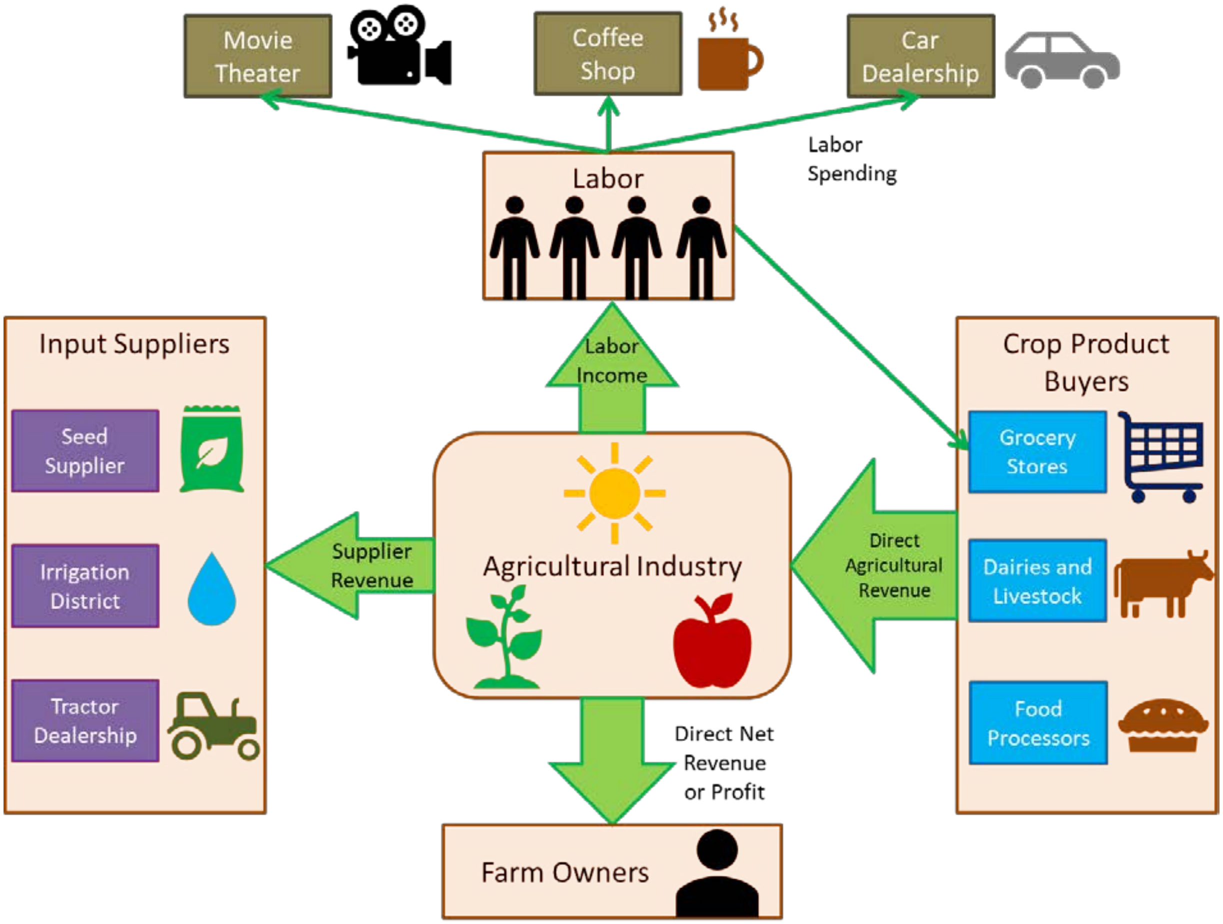

Figure 8.2-1. Cash Flow Relationships through the Agricultural Industry and Regional Economy

Every year growers will make numerous decisions regarding how to operate their businesses so that their profits are maximized. Decisions include how much land to cultivate, what crops to grow, how many workers to hire, and how much water, fertilizers, and other supplies to use. While the large number of decisions individual growers can make regarding their agricultural operations do not have a perceptible effect on the overall economy, large scale shifts in agricultural decision making are known to affect connected sectors. For example, a single grower facing a water supply shortage may choose to fallow a portion of their land to preserve the remaining acres and/or employ deficit irrigation to compensate for full water availability. The grower will receive less direct revenue because there is less crop product to sell, but will also not need to purchase supplies or labor for that land, reducing spending. The direct revenue loss by a single grower fallowing a portion of their land is relatively small, as are the associated indirect and induced effects, when compared to total economic output of the entire industry. However, if enough growers make the same decision, the revenue effects can add up. Capturing the indirect and induced relationships between the various economic sectors in a model is a complex endeavor, as the connections among economic sectors in a region are not always evident. The Impact Analysis for Planning (IMPLAN) model provides a framework for analyzing these relationships and estimates the direct, indirect, and induced effects on a region's economy after an economic event such as fallowing has occurred.

IMPLAN is a product of the Rural Development Act of 1972 and reflected the U.S. government's need at that time for functional economic statistics. In 1976, the National Forest Management Act required the U.S. Forest Service to develop a 5-year management plan with alternative land management strategies. In order to meet the need of modeling potential economic impacts of various choices, the U.S. Forest Service played a role in creating IMPLAN and started using it in 1978. The U.S. Forest Service still uses IMPLAN, but the task of refining and updating the IMPLAN database and software became too large for the agency. As a result, the responsibility was shifted to the University of Minnesota. Demand grew for the use of a tool like IMPLAN by non-Forest Service organizations, so the private Minnesota IMPLAN Group, also known as MIG, was established "for the purpose of developing and selling all future iterations of the IMPLAN database and software" (IMPLAN 2018). As stated by the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service, "over 1,500 clients across the country use the IMPLAN Model, making the results acceptable in inter-agency analysis" (NRCS 2018). In justifying the use of IMPLAN for the analysis of cooperatives, the University of Wisconsin highlighted the fact that an "advantage of the IMPLAN system is the open access philosophy instilled by the Forest Service… The combination of detailed database, flexibility in application, and the open access philosophy has made IMPLAN one of the most widely used and accepted economic impact modeling systems in the U.S." (UWCC 2018).

IMPLAN was employed to provide a reasonable representation of the regional economic effects associated with the LSJR alternatives. IMPLAN provides a portrait of the direct, indirect, and induced relationships between all economic sectors and institutions using "multipliers." These multipliers relate the change in revenue of one sector to another or relate the change in employment to the change in revenue of a sector such as agriculture, which undergoes an economic event. The multipliers in IMPLAN are obtained following longstanding and peer-reviewed economic methods that date back to the first half of the twentieth century, and remain widely used in impact analysis. Sector economic information from county-level databases are employed to trace economic relationships among sectors and institutions and calculate multipliers. Appropriate multipliers were extracted from the IMPLAN 2010 database for each IMPLAN crop type and applied to the Statewide Agricultural Production (SWAP) model results for agricultural gross revenue to determine the regional economic effects of the LSJR alternatives. Once multipliers are extracted from IMPLAN, they can be applied to any change in direct revenues calculated in the SWAP model. This eliminates the need to run the IMPLAN model for every year when direct agricultural revenue is reduced in the SWAP model.

This master response addresses comments raised regarding the application of the IMPLAN multipliers to analyze and disclose potential regional economic and employment effects resulting from the LSJR alternatives. Specifically, The State Water Resources Control Board (State Water Board) considered the regional economic effects of the LSJR alternatives in Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results,* and Chapter 20, *Economic Analyses.* As was discussed in Master Response 8.1, *Local Agricultural Economic Effects and the SWAP Model*, to reasonably protect fish and wildlife, the LSJR flow objectives will increase the volume of water instream in some years, thus reducing the water available for other beneficial uses, such as agriculture. Application of the SWAP model showed that reductions in water supply would lead to reduced agricultural economic output (i.e., lower revenues) in the plan area. The IMPLAN multipliers were then applied to the direct agricultural revenue results provided by the SWAP model to estimate the region-wide effect of that reduced agricultural production.

Several commenters asserted that the substitute environmental document (SED) underestimates the regional agricultural economic effects of the LSJR flow objectives, as described in the plan amendments in Appendix K, *Revised Water Quality Control Plan*, on the dairy, livestock, and processing industries. These industries are part of the regional economy of the plan area because they use inputs from agriculture (e.g., alfalfa hay and silage) to produce goods and services. The commenters argued that the SED underestimates the regional economic impact associated with dairies and livestock because it does not quantify how reduced feed crop production would affect these particular industries. Several commenters performed their own economic analyses and arrived at higher regional economic effects by using extreme assumptions compared to those made in the SED. The assumptions used in the economic analyses performed by the commenters include the following.

- Restrictions on how much groundwater will be used to supplement reduced surface water supplies and assumptions that the Sustainable Groundwater Management Act (SGMA) will prevent increased groundwater pumping.
- A one-to-one relationship between a reduction in feed crop production and a reduction in dairy and livestock sector production.
- The assumption that the dairy and livestock industries cannot replace reduced grain and pasture production in the plan area with other feed crops or with supplies from outside of the plan area.
- Reductions in crops, such as vegetables, will proportionally reduce production of processed products.

There are multiple valid ways to conduct an evaluation of regional economic effects, including the SED's method. The SED agricultural economic analysis assumes that, generally, the irrigation districts (districts) would be restricted to 2009 groundwater pumping capacities as the 2014 levels of pumping are less sustainable over long periods of time. However, in times of severe surface water shortage, the modeling assumes the districts can strategically employ groundwater pumping up to their 2014 pumping capacity in order to maintain permanent crops and some corn silage acres. SGMA compliance is not included in the SED because SGMA groundwater sustainability plans have not yet been developed, thus it is speculative to assume how SGMA will be implemented in each groundwater basin. However, this use of groundwater to help offset surface water reductions and reduce potential economic effects has been seen in recent droughts and is not inconsistent with SGMA. SGMA contemplates "overdraft during a period of drought…if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods" (Wat. Code § 10721(x)). Thus, it is reasonable to assume that the strategic use of pumping during drought will also occur under SGMA in a sustainably managed basin.

With regards to the dairy and livestock industries, the SED assumes that reduced agricultural production of feed crops in the plan area would not cause dairies and cattle ranches to close because substitute feed crops that require less water are available, and it is possible to import dry feed supplies from other areas. Although increased transportation costs could reduce proprietor net income for dairy and livestock owners, it would allow them to stay in business. Furthermore, water supply has not been the primary factor controlling dairy production, rather markets and milk prices are stronger indicators of the viability of the industry.

For the processing industry, many of the crops that often serve as inputs in processing are usually high revenue producing crops and are less likely to be impacted under water shortage. Cases in which processing facilities were closed due to water shortage or lack of crops are rather uncommon. Often, economic conditions, including crop prices, are major drivers in processing production decisions.

The State Water Board reviewed all comments related to regional economic analyses and the application of IMPLAN multipliers and developed this master response to address recurring comments and comment themes. This master response references related master responses, as appropriate, where recurring comments and common comment themes overlap with other subject matter areas. This master response includes for ease of reference a table of contents after the *Overview* section to help guide readers to specific subject areas. The table of contents is based on general recurring and common themes found in the comments that were received. In particular, this master response addresses, but is not limited to, the following topics.

- Existing regional economic setting.
- Updated results for the regional economic analyses in the Final SED.
- Potential economic effects on existing dairies and livestock operations.
- Potential economic effects on the food processing industry.
- Discussion of the regional economic analyses provided by commenters.

For responses to comments regarding potential physical environmental impacts on agricultural resources, please see Master Response 3.5, *Agricultural Resources*. For responses to comments regarding local agricultural economic effects, please see Master Response 8.1, *Local Agricultural Economic Effects and the SWAP Model*. For responses to comments regarding other economic issue, please see Master Response 8.4, *Non-Agricultural Economic Considerations*.

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Regional Economic Setting

An economic profile is a detailed description of the regional economy that provides context for how the analysis of proposed actions affect businesses, individuals, and government entities and their economic relationship within the region. The economic profile for the plan area identifies the geographic scope of the analysis; describes the some socioeconomic indicators; and provides an overview of the agricultural economy of the region, including crop acreage, production value, and other factors of interest.

Geographic Scope

The economic analysis includes the counties of Merced, San Joaquin, and Stanislaus. The geographic scope of the economic analysis largely mirrors the plan area but differs importantly by containing whole counties rather than being divided based on watershed boundaries. This is because economic data is nearly always organized on a county-level basis. The analysis ensures that the counties included in the profile provide an effective and appropriate representation of the plan area.

Economic Profile

This section describes the existing economic profile, including some socioeconomic indicators, in the plan area, as well as how the plan area compares to the economic profile of the state of California overall. The section is organized into three main components: (1) population trends and projections; (2) income-related measures of social well-being; and (3) major industrial sectors. The discussion focuses on those socioeconomic parameters most likely to be affected by the LSJR alternatives. These key parameters include local residents' demographic characteristics, employment, and income levels.

Recent population growth in the plan area is shown in Table 8.2-1. According to the U.S. Census, the plan area population in 2015 was more than 1.5 million persons, or 3.9 percent of the state's population. The plan area grew at a slightly higher rate (5.3 percent) than the state as a whole.

Table 8.2-1. Population in the Plan Area and California (2010–2015)

	Population Estimate		Change
Population Area	April 1, 2010	July 1, 2015	
California	37,254,503	39,144,818	1,890,315 (5.1%)
Plan Area	1,455,557	1,532,949	77,392 (5.3%)

Source: U.S. Census Bureau 2017.

Population projections for the state and plan area are presented in Table 8.2-2. These projections were prepared by the California Department of Finance Demographic Research Unit and are shown for each 5-year period following a July 2015 estimate, through 2030. For the state as a whole, the population is expected to increase 12.5 percent by 2030, while the plan area is expected to increase at a considerable rate of 21.1 percent over the same period. In recent years, most of the population growth in this region has been from natural increases (births), but employment growth in professional and business services, health care and education, and transportation and utilities are expected to cause in-migration and result in San Joaquin County becoming among the state's fastest growing counties (California Economic Forecast 2017). Merced and Stanislaus Counties will also grow, though at a slower pace than San Joaquin County, due to differences in growth in health care, education, and other sectors (California Economic Forecast 2017).

Table 8.2-2. Population Projections for the Plan Area and California

Population Area	July 1, 2015 Estimate	July 1, 2020 Projection	July 1, 2025 Projection	July 1, 2030 Projection	Change
California	39,059,415	40,639,392	42,326,397	43,939,250	12.5%
Plan Area	1,535,588	1,641,408	1,750,361	1,860,093	21.1%

Source: DOF 2018.

Total personal income (per capita) and median household income, poverty rates, and unemployment rates represent commonly used economic indicators of social well-being. Table 8.2-3 presents the most recent (2015) comparative statistics for California and the U.S. median and per capita income levels for Californians exceed those for the U.S. as a whole. In addition, the poverty rate in California, at 15.3 percent, is higher than in the U.S. rate.

Table 8.2-3. Income, Poverty Rates, and Unemployment Rates (2015)

	United States	California
Per Capita Income ($/year)	$29,979	$31,587
Median Household Income ($/year)	$55,575	$64,500
Poverty Rate	14.7%	15.3%
Unemployment Rate	6.3%	7.3%

Source: U.S. Census Bureau 2017.

The recession that began in 2008 and extended into the current decade affected California as a whole, but the plan area even more severely. In particular, the San Joaquin Valley[1] was at the epicenter of a housing crisis, which made construction employment the worst performing job sector declining from a high of around 60,000 jobs in 2006 to a low of around 30,000 jobs in 2011 (CSUS 2013). Construction is now once again one of the fastest growing sectors whereas interest rate hikes, rising inflation, and newly imposed tariffs that could induce a retaliatory response are all negatively affecting agricultural exports (CSUS 2017).

Table 8.2-4 presents unemployment rates for the three plan area counties and California from 2013 through 2017. Although unemployment rates declined over the time period, each county's rate was consistently higher than the state as a whole.

[1] This San Joaquin Valley includes eight counties: San Joaquin, Merced, Stanislaus, Fresno, Kern, Kings, Madera, and Tulare.

Table 8.2-4. Unemployment Rates (%), Plan Area Counties and California (2013–2017)

	Merced County	San Joaquin County	Stanislaus County	California
2017	9.3	7.0	7.5	4.8
2016	10.5	8.1	8.5	5.4
2015	11.3	8.9	9.5	6.2
2014	12.8	10.5	11.2	7.5
2013	14.5	12.3	12.9	8.9

Source: EDD 2018.

Employment and Income

As shown in Table 8.2-5, total employment in 2015 was approximately 652 thousand jobs, and labor income associated with these jobs was approximately $29 billion.

Table 8.2-5. Employment by Select Aggregate Sectors—Plan Area (2015)

Sector	# Employees	Annual Payroll $ (thousands)
Agriculture, Forestry, Fishing and Hunting	37,174	1,090,342
Mining, Quarrying, and Oil and Gas	22,855	756,535
Utilities	2,646	351,523
Construction	30,324	1,168,884
Manufacturing	52,577	3,544,402
- *Food Processing*	*23,584*	*1,426,033*
- *Other Non-Durables Manufacturing*	*13,270*	*1,054,075*
- *Durables Manufacturing*	*15,723*	*1,064,294*
Wholesale Trade	35,142	1,463,106
Retail Trade	64,329	1,868,754
Transportation and Warehousing	36,942	1,730,346
Information	4,058	230,354
Finance, Insurance, and Real Estate (FIRE)	44,921	926,190
Professional, Scientific, and Technical	32,889	1,487,292
Administrative and Support and Waste Management and Remediation	32,260	782,950
Healthcare, Education Services, and Social Assistance	83,982	4,452,010
Arts, Entertainment, and Recreation	7,003	113,610
Accommodations and Food Services	43,481	874,496
Other Services Except Public Administration	34,951	939,217
Government and Miscellaneous	86,171	7,235,940
Total for Plan Area	651,706	29,015,949

Source: MIG data 2015.

Federal, state, and local government, including education, is the largest employment category and also has the highest payroll. More than 86,000 persons are employed in government services, and payroll is over $7 billion annually. Healthcare and social assistance is a close second in employment at nearly 84,000 persons, with a payroll of nearly $4.5 billion. Retail trade; all manufacturing; finance, insurance, and real estate; and accommodations and food services round out the top six employment sectors. However, transportation and professional, scientific, and technical services and wholesale trade have the fourth, fifth, and sixth largest payrolls, respectively, in the plan area.

In aggregate, there are over 52,000 manufacturing jobs in the region, generating about $3.5 billion in labor income. Manufacturing sectors represent a little over 8 percent of total employment in the plan area but 12 percent of the labor income in the region. Table 8.2-6 shows a breakout by specific kinds of manufacturing. Food manufacturing is by far the largest employer among manufacturing sectors in the plan area, with about 23,600 total jobs. Fruit and vegetable canning and freezing; cheese manufacturing and fluid milk manufacturing; and poultry processing are the most significant components of the food manufacturing sector. Additional details are provided in the section entitled, *Considerations of Economic Effects on Industries Supported by Agricultural Industries*, in this master response. The beverage sector, the second largest within manufacturing, is dominated by wineries, which account for over 80 percent of the jobs in this sector. Fabricated metal manufacturing is a highly diversified sector which includes machine shops, sheet metal work, and fabricated structural metal manufacturing.

Table 8.2-6. Manufacturing Sectors in Plan Area

Manufacturing Sector	Employment (jobs)	Share (%) of Manufacturing Employment	Share (%) of Manufacturing Payroll
Total Food Manufacturing	23,584	45	40
Total Beverage and Tobacco Product Manufacturing	6,397	12	17
Fabricated Metal Product Manufacturing	5,083	10	11
Nonmetallic Mineral Product Manufacturing	2,616	5	6
Paper Manufacturing	2,195	4	4
Machinery Manufacturing	1,850	4	4
Transportation Equipment Manufacturing	1,814	3	4
Printing and Related Support Activities	1,809	3	2
Plastics and Rubber Products Manufacturing	1,705	3	4

Source: MIG data 2017.

Agricultural Economy

Agricultural production is the dominant water-using sector in the plan area, and has a large presence and history in the three counties. This section summarizes the agricultural economy, including crops, acreage, production levels, and value of production in recent years.

Plan area agricultural production reflects a large volume and diversity of crops in production. Table 8.2-7 provides a list of the top 10 crops in terms of acreage as an average of 2011–2016 production. As demonstrated in Table 8.2-7, the largest agricultural production area in terms of acreage is devoted to almonds, with nearly 325,000 acres. Almonds are followed by silage, corn silage, and alfalfa,[2] which are grown primarily to serve the needs of the large dairy industry present in the plan area.

Both wine grapes and walnuts represent more than 100,000 acres each within the plan area. Nearly equal numbers of acres of irrigated pasture, grain corn, grain hay, and processing tomatoes are grown in the three counties. They range from an average of 66,000 to 73,000 acres each.

Table 8.2-7. Top Producing Crops in the San Joaquin Valley, by Acreage (2011–2016 average)

Crop	Acreage
Almonds	324,683
Silage	242,383
Corn Silage	230,761
Alfalfa	165,867
Grapes, Wine	112,050
Walnuts	102,198
Pasture, Irrigated	73,050
Grain Corn	67,765
Grain Hay	66,700
Tomatoes, Processing	65,900
Total—All Crops	2,926,367

Source: California Agricultural Commissioners 2012–2017.

The acreage over time demonstrates that cropping patterns are fairly dynamic, as growers respond to commodity markets and prices, long-term market trends, and hydrologic conditions (droughts or variations in water supply). Figure 8.2-2 provides a visual perspective on how the total acreage and the top 10 crops in the San Joaquin Valley have changed over the period 2011–2016. Total acres declined each year from a high of 2.99 million acres in 2011 to a low of 2.81 million acres in 2016, an indicator of the extent of drought-reduced water supplies.

[2] *Silage* is fermented, high-moisture stored fodder which can be fed to cattle, sheep, and other ruminants. Silage includes that made from barley, oats, triticale, and wheat. Depending on the individual county reports, silage also may include sorghum or green chop, or those crops may be counted separately. However, silage made from corn is typically tallied separately from silage in the Agricultural Commissioners reports.

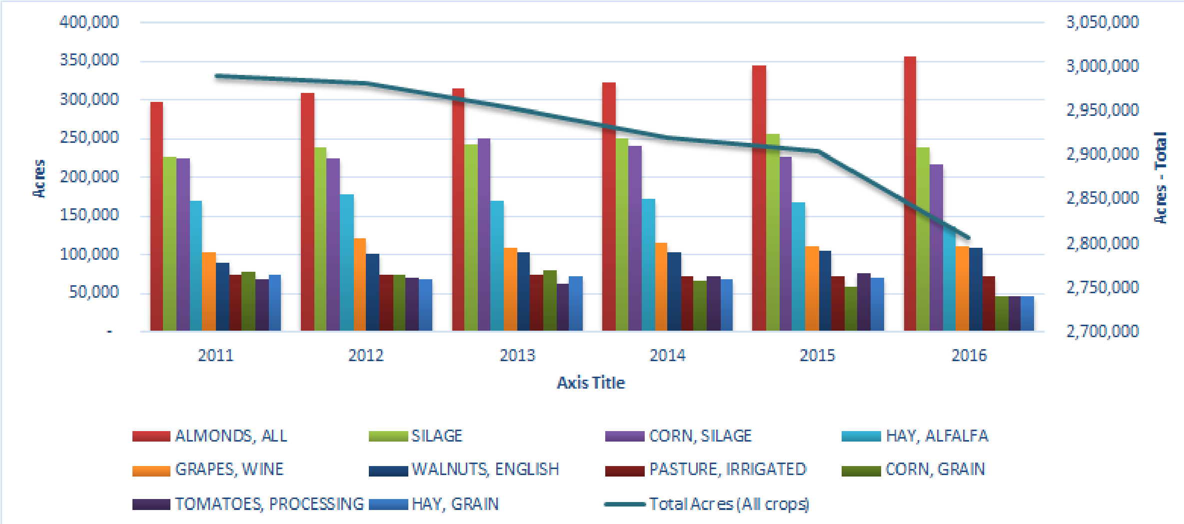

Figure 8.2-2. Top Producing Crops, and Total of All Crops, by Acreage, San Joaquin Valley (2011–2016) (Source: California Agricultural Commissioners 2011–2016)

Producing almond acreage is the largest producing crop, and it grew steadily from 297,000 to 357,000 acres from 2011–2016, leading growth in all crops during the period. Silage and corn silage were the second and third highest acreage crop over the time period, and maintained relative consistency from year to year. The uniformity of silage acreage even during the 2011–2016 drought is due in part to the importance of silage as a feedstock in dairy production, also a major industry in the plan area. Other permanent crops, including walnuts and wine grapes, also held steady during the time period. In contrast, during the last years of the recent drought, the acreage of grain corn, grain hay, and processing tomatoes declined sharply from previous years.

In terms of production value, as shown in Table 8.2-8, milk products, almonds, walnuts, wine grapes, and cattle and calves provided the highest commodity value in the plan area over the period of 2011–2016. Milk production is the most dominant agricultural product, at $2.2 billion per year, with almonds a close second at just under $2.0 billion. Walnut orchards, wine grapes, and cattle and calves all generate more than $400 million in revenue annually. In total, four of the top 10 plan area commodities are derived from livestock production.

Table 8.2-8. Top Producing Commodities in the Plan Area, by Production Value (2011–2016 average)

Commodity	Value ($)
Milk, Fluid, All	2,181,662,167
Almonds	1,962,434,833
Walnuts	613,518,500
Grapes, Wine	486,495,833
Cattle and Calves, All	407,656,167
Chickens, Broilers	332,416,167
Corn Silage	300,122,000
Tomatoes, Processing	234,920,333
Chickens, Unspecified	226,014,167
Sweet Potatoes	210,001,167
Total—All Commodities	9,954,247,108

Source: California Agricultural Commissioners 2011–2016.

Combined for all agricultural products at the farm gate, the total average production was nearly $10.0 billion per year during 2011–2016. Figure 8.2-3 displays the production value during the 2011–2016 period for the top commodities and all commodities combined.

As demonstrated in Figure 8.2-3, commodity value can vary considerably from year to year. Milk products were the top producing commodity in three of the six years during 2011–2016, but the value ranged from a high of $2.9 billion in 2014 to a low of $1.8 billion in 2016. Similarly, almond production value was highest in 3 of 6 years, and producers harvested $1.2 billion in crop value in 2010, and a peak of $2.7 billion in 2014. However, like dairy, almonds can be highly influenced by markets. For example, in 2016, a bumper harvest combined with lower demand led to an almost 50 percent drop in the almond market, from $4.70 per pound to $2.60 (Terazono 2016). For most of the remaining crop commodities, including some not shown in Figure 8.2-3, the production value in 2016 was lower than in previous years due in large part to the prolonged drought.

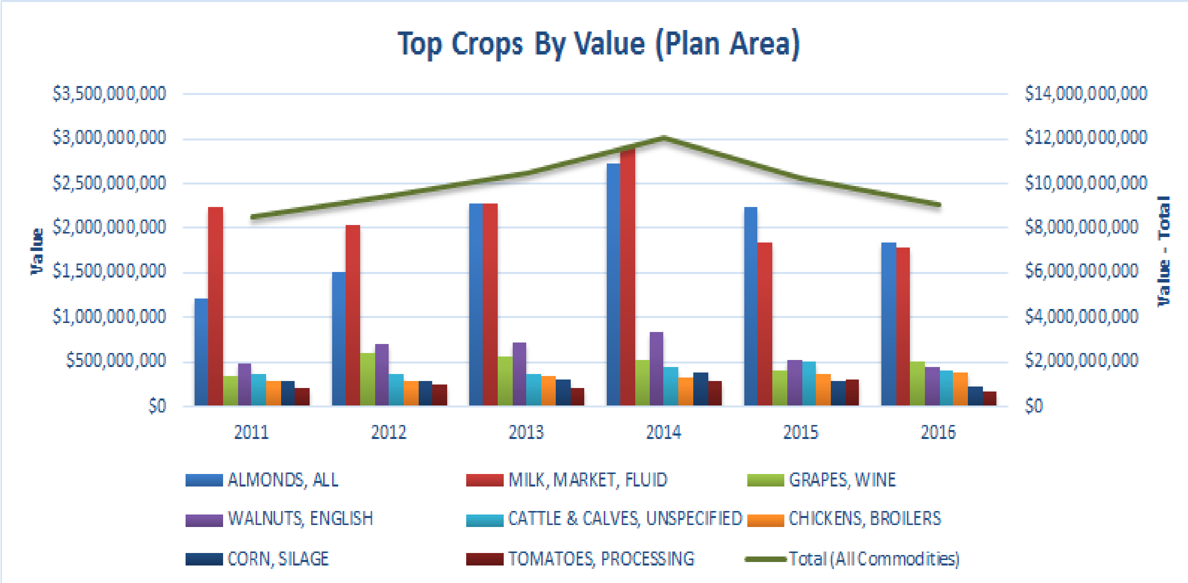

Figure 8.2-3. Top Producing Commodities, and Total of All Commodities, by Value in the Plan Area (2011–2016) (Source: California Agricultural Commissioners 2011–2016)

Agricultural Services, Food Processing, and Dairy Sectors in the Plan Area

Farms in the plan area irrigate and grow crops that are harvested and sold, generating output and jobs that are directly involved in farming and on-farm activities. Farms also provide income and employment for those providing agricultural services to farms, and to businesses that purchase raw farm products and process them for sale to wholesalers, retailers, and consumers. In addition, dairies and wineries have a high dependence upon irrigated crops.

Table 8-9 provides a summary of selected economic sectors that provide agricultural services or process agricultural crops or commodities, or which rely directly on irrigated cropland within the plan area. The agricultural support services sector provides nearly 22,000 full- and part-time and seasonal jobs in the plan area, mostly in and near farm communities, and contributes nearly $746 million annually in employee compensation. Among food processing industries, fruit and vegetable canning is the largest employer with 5,600 jobs and $349 million in employee compensation. Next is poultry processing and cheese manufacturing, with 3,700 jobs and 1,900 jobs, respectively. Other processing industries of importance include bread and bakery products, frozen fruits and vegetables, roasted nut manufacturing, and fluid milk manufacturing.

Table 8.2-9. Economic Characteristics of Selected Agricultural Services and Food Processing Sectors in the Plan Area (2015)

Sector	Jobs (thousand)	Output (Sales) ($ million)	Employee Compensation ($ million)
Agricultural Services			
Support Activities For Agriculture and Forestry	21.6	1,395.3	745.6
Fertilizer and Pesticide Manufacturing and Mixing	0.3	596.1	35.4

Sector	Jobs (thousand)	Output (Sales) ($ million)	Employee Compensation ($ million)
Food Processing			
Canned Fruits and Vegetables Manufacturing	5.6	2,800.5	349.1
Poultry Processing	3.7	1,059.7	134.0
Cheese Manufacturing	1.9	2,174.3	155.3
Bread and Bakery Product, Except Frozen, Manufacturing	1.7	220.2	59.9
Frozen Fruits, Juices and Vegetables Manufacturing	1.3	600.7	81.3
Roasted Nuts and Peanut Butter Manufacturing	1.2	871.6	73.3
Fluid Milk Manufacturing	1.2	1,038.6	105.2
Other Animal Food Manufacturing	1.1	1,444.1	78.3
Meat Processed from Carcasses	1.0	575.2	64.7
Dehydrated Food Products Manufacturing	0.8	360.2	46.1
Other Snack Food Manufacturing	0.8	532.6	54.4
Wet Corn Milling	0.4	730.1	32.0
All other Food Processing[a]	3.0	2,221.0	192.4
Other Farm-Dependent Businesses			
Beef Cattle Ranching and Farming, including Feedlots and Dual-Purpose Ranching and Farming	1.3	529.8	9.3
Dairy Cattle and Milk Production	6.3	3,013.5	129.6
Wineries	5.7	2,098.6	558.0

Source: Minnesota IMPLAN Group 2017.

[a] Processors may or may not utilize raw products raised or grown within the plan area.

Revised Results for the Regional Economic Analysis

As discussed in Master Response 8.1, *Local Agricultural Economic Effects and the SWAP Model*, a revised SWAP model run was performed to address some commenter concerns and to refine several assumptions in the SWAP model. This section presents corresponding revised regional economic impacts for San Joaquin, Stanislaus, and Merced Counties by using the gross agricultural revenue results from the revised SWAP model run and following the same methods as the regional economic analysis described in Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results*. The revised regional economic analysis includes potential effects on total economic output and employment. These effects are summarized below in Tables 8.2-10 and 8.2-11 as annual averages across all years and by year types.

Table 8.2-10. Average Annual Regional Economic Output Related to Crop Production under Baseline and the Change under the LSJR Alternatives, by Year Type Conditions

Alternative	Average Annual Economic Output ($Million, 2008/y)					
	All Years	Wet Years	Above Normal Years	Below Normal Years	Dry Years	Critical Years
Baseline	2,665	2,685	2,685	2,685	2,682	2,589
	Change Relative to Baseline ($Million, 2008/y)					
LSJR Alternative 2	-18	0	0	-2	-3	-88
LSJR Alternative 3	-69	-1	-14	-39	-97	-229
LSJR Alternative 4	-190	-24	-99	-216	-360	-369

Table 8.2-11. Average Annual Regional Employment Related to Crop Production under Baseline and the Change under the LSJR Alternatives, by Year Type Conditions

Alternative	Average Annual Employment (Jobs/y)					
	All Years	Wet Years	Above Normal Years	Below Normal Years	Dry Years	Critical Years
Baseline	19,227	19,350	19,350	19,350	19,332	18,734
	Change Relative to Baseline (Jobs/y)					
LSJR Alternative 2	-123	0	0	-11	-20	-604
LSJR Alternative 3	-458	-7	-88	-248	-617	-1,548
LSJR Alternative 4	-1,287	-163	-651	-1,405	-2,427	-2,585

Consideration of Economic Effects on Industries Supported by the Agricultural Industry

This section discusses potential economic effects on industries that are supported by the local agricultural industry and crop production. These industries include dairies, livestock operations, and food processors.

Potential Economic Effects on Existing Dairies

The effect on dairies of an irrigation water supply reduction is complex and not easily quantified without a detailed study of dairy operations, the market for milk and milk products (both domestic and export), and the supply and costs of the many (and varied) sources of feedstock. The State Water Board is not required to conduct exhaustive, industry-specific studies based on the water code requirement to consider economic effects as part of the water quality control planning process for a programmatic action (see Chapter 20, *Economic Analyses*). As acknowledged in Chapter 11, *Agricultural Resources* (Impact AG-2) and Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results*, it is unlikely dairies would cease to operate as a result of changes in feed costs and local availability due to the LSJR alternatives given the following considerations: the cost of feed input compared to other dairy inputs and the availability of the feed input for both dairy and beef cattle; the value of dairy production in the LSJR area of potential effects; and the potential use of equitable distribution of local water suppliers. However, as acknowledged, some cost increase for inputs is expected, primarily during water-short years. As noted in Appendix G, dairies have the ability to modify their feed rations in response to availability and prices of various feedstock options, including silage, hay, grains, and byproducts, each of which has its own market and supply flow. As such, identifying the marginal effects on dairies based on a substitution of feed or increase in costs is not possible, given the variety of factors influencing dairy operator decisions. These factors include the price of milk and relative prices and availability of feedstock options. Attributing the marginal shift associated with feedstock or potential increase in cost of feedstock to a collapse in the dairy industry to the LSJR flow objectives is speculative and unfounded. This is because of the documented trends in feedstock, alfalfa, and milk prices and the number and production of dairies have remained relatively stable in the last two decades (or more) in the plan area under a variety of hydrologic and market conditions.

Modeled Effects on Dairy Feedstock: Corn Silage

The State Water Board used the SWAP agricultural economics model to forecast the potential effects of the LSJR alternatives on crop selection and crop production, including potential changes in the production of corn silage. As described in Master Response 8.1, *Local Economic Effects and the SWAP Model*, a constraint was placed on corn silage prior to running the SWAP model. The constraint places a limit on the amount of silage that can be removed from production, which has the effect of forcing the model to place a "higher" value on corn silage than it otherwise might when compared to other crops represented in the model. The constraint was included in the model because, in general, dairies places a higher implicit value on corn silage than represented in the model based on a review of dairy operator practices.

Table 8.2-12 presents the total acreage of corn modeled in the revised SWAP model run and the division of acreage between grain corn and silage corn. In the model output, SWAP does not differentiate between the two types of corn and only reports total fallowing of acres in the Corn crop category. To model the potential decrease in corn silage acreage under the LSJR alternatives for the revised SWAP analysis, it is assumed that any reduction in Corn acres first comes from the portion of corn silage that can be fallowed (30 percent of the total corn silage acres) and then from the grain corn. This is a conservative method (*more* worst case) for estimating the corn silage reduction as it assumes that grain corn is maintained over corn silage, until the silage constraint forces grain corn to be fallowed.

Table 8.2-12. Total Corn Acreage in the SWAP Model and the Breakdown between Corn Silage and Grain Corn

Irrigation District	Total Corn (Acres)	Corn Silage (Acres)	Grain Corn (Acres)
SSJID	8,335	4,397	3,938
OID	9,841	7,770	2,072
SEWD/CSJWCD	16,096	8,496	7,600
MID	12,218	12,116	103
TID	40,243	39,981	261
Merced ID	20,050	17,571	2,480
All Districts	106,783	90,330	16,454

Figure 8.2-4 displays the modelled annual reduction in acreage of corn silage under each of the LSJR alternatives by water year exceedance level. An analysis of reported yields for corn silage in the four counties of the plan area (Merced, San Joaquin, Stanislaus, and Tulare) for the period 2011 through 2015 showed an overall average of 27.9 tons per acre, rounded up to 28 (CDFA 2018). Figure 8.2-5 shows the modelled annual reduction in corn silage production (yield) under each of the LSJR alternatives by water year exceedance level, assuming a yield of 28 tons per acre. The figure shows silage production is reduced from the baseline levels as water availability declines. For example, reductions in silage production are experienced in the baseline beginning at the 80 percent exceedance level of water supply. For the 40 percent unimpaired flow requirement, reductions in corn silage are experienced sooner (at about 50 percent exceedance, or approximately half of the years) and decline by 22 percent of total production during the driest years.

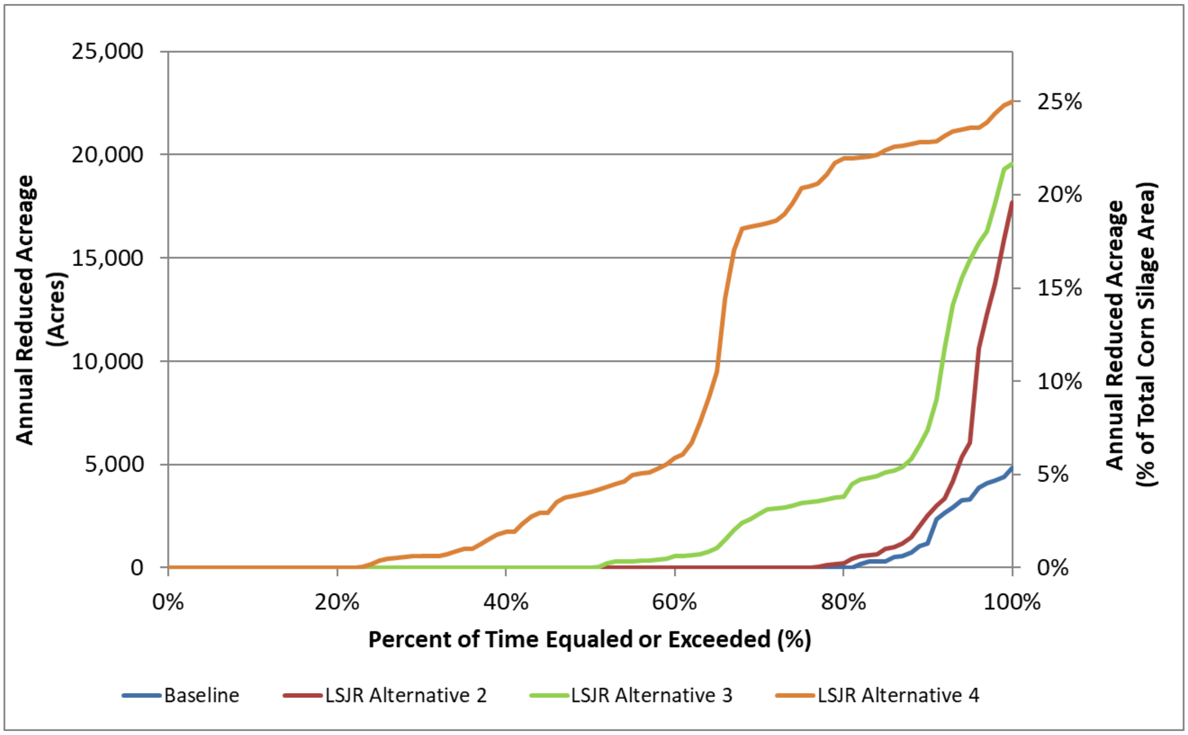

Figure 8.2-4. Annual Reduction in Corn Silage Acreage under the LSJR Alternatives, by Water Year Exceedance

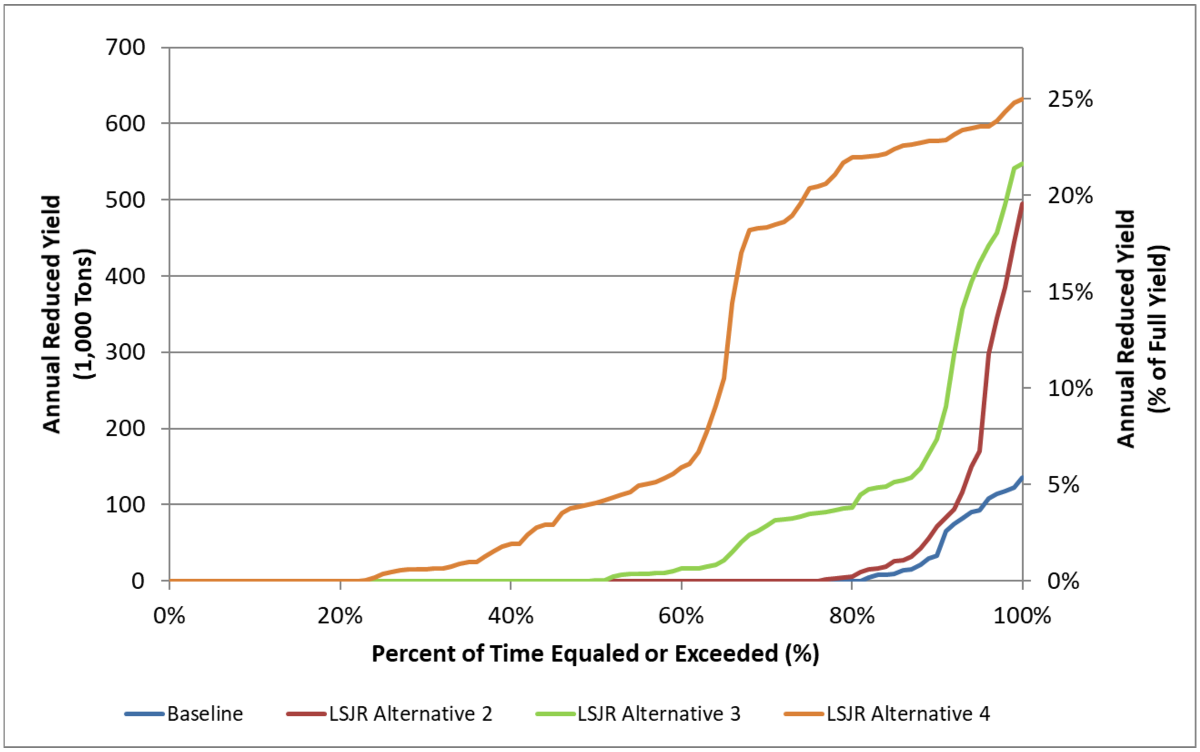

Figure 8.2-5. Annual Reduction in Corn Silage Production under the LSJR Alternatives, by Water Year Exceedance

To illustrate the change in corn silage by water year type, Figure 8.2-6 shows the volume of corn silage reduced from the baseline (in thousands of tons) by water year type for the 40 percent unimpaired flow requirement. As the figure demonstrates, some reductions in silage production are experienced in most years, but are greatest—an average of about 218,000 tons—in critically dry years. This volume represents the amount of corn silage that must be replaced in dairy rations.[3]

[3] The estimate of corn silage volume is based on acreage estimates from the SWAP model and an assumed yield of 28.0 tons per acre, which is a multi-year average yield for the plan area.

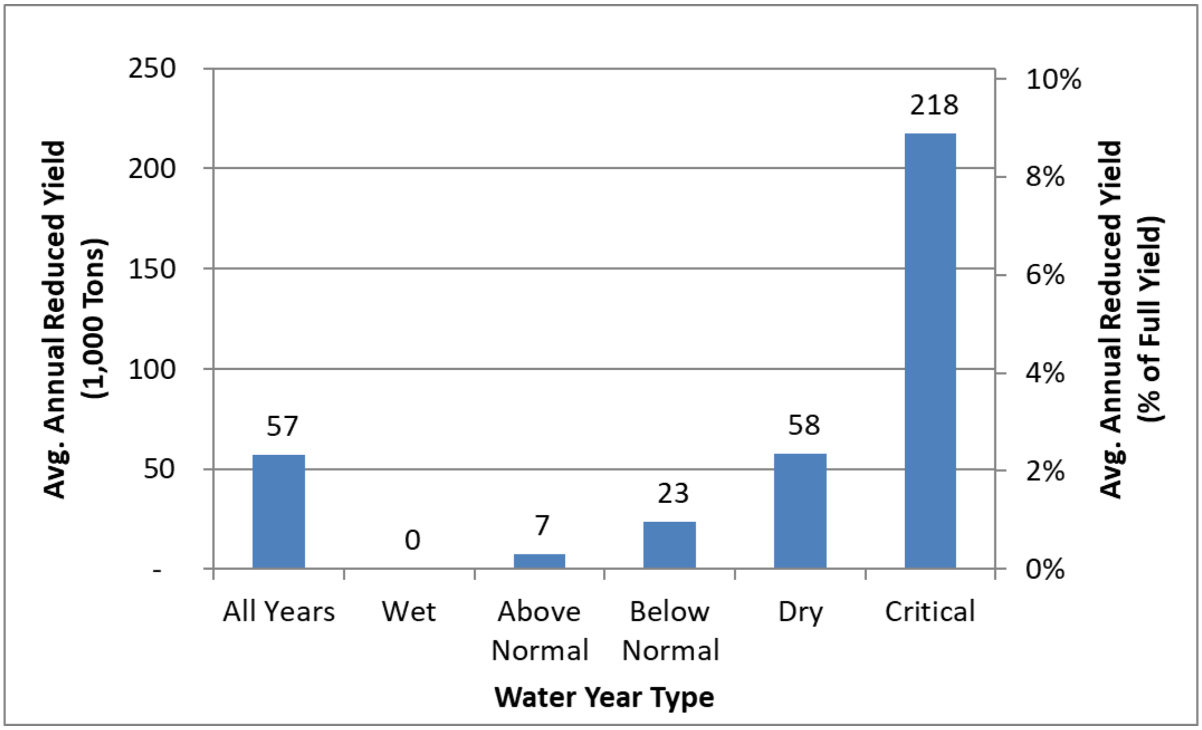

Figure 8.2-6. Average Annual Reduction in Corn Silage Production Volume Relative to Baseline Conditions under 40 percent unimpaired flow (LSJR Alternative 3), by Water Year Type

Cost Role of Silage in Dairy Operations

The dairy industry has placed considerable emphasis on the significance of corn silage availability to the economic viability of dairies. However, a review of *California Cost of Milk Production Annual 2015* (CDFA 2016) suggests that the "economic viability" argument may be overstated. Although all feed costs are approximately 59 percent of total costs for dairy operations, "wet feed & wet roughage," which includes corn silage, represent only about 14 percent of total costs (CDFA 2016, p. 7). The remainder of feed costs is for concentrates, dry roughage, minerals and supplements, and pasture. These costs levels remained consistent throughout the recent drought: from 2011 through 2015, feed costs ranged from 59 to 66 percent of total costs (CDFA 2016, p. 9). Therefore, based on the results of the revised SWAP model run, the potential for feed substitution, and the relative cost of silage in a dairy operation, any increase in cost due to reduced silage production is expected to be quite modest.

Substitution and Alternative Feedstock Options to Corn Silage

Dairies in California are very adaptable at determining the ration of feeds from many sources, including alfalfa hay, corn silage, corn grain, soy and canola meals, small grain forage, and byproducts such as almond hulls (Silva-del-Rio et al. 2011; Putnam et al. 2016; Asmus 2015). The ration chosen depends upon relative prices of each commodity, availability of sources, and nutritional requirements (Putnam 2016); San Joaquin Valley dairies typically reformulate rations multiple times during the year (Silva-del-Rio et al. 2011). As evidenced by dairy operator behavior during the drought, and even outside of drought conditions, some reduction in corn silage production led growers to utilize sudan silage, purchase more grain corn, incorporate more almond hulls, or stockpile more alfalfa (Lee 2014). In addition to adjusting rations, some growers traveled further for corn silage, even with (1) increased cost of transport, and (2) prices that were nearly double that of a few years earlier (Lee 2014; CDFA 2018).

These numerous decisions all occur within the context of the commodity prices for milk (which were very high in 2014, but fell considerably in 2015) (CDFA 2017). The commodity price for milk is a strong influence on operators' willingness to adapt rations and purchase feedstocks. As described in Master Response 3.5, *Agricultural Resources*, commodity prices cannot be reliably predicted by the State Water Board or commenters.

Because corn silage is primarily grown in proximity to dairies, sudan grass provides a good alternative crop under reduced water conditions (Nolte 2010; Wright et al. 1998). The difference in output may require that operators adjust their rations to purchase other feeds, many of which are already supplied as imports from other states. This includes alfalfa, grain corn, and soy and canola meals. Locally produced feedstocks, such as almond hulls and cottonseed meal, may also be readily available.[4] The LSJR flow objectives could result in some shifts by dairies to other feedstocks, or require additional imports of hay from nearby counties, more distant counties, and neighboring states.

Sudan Silage

Sudan grass is a warm season grass known for being drought resistant. It is more efficient in water absorption because it has twice as many roots as corn and has only half as much leaf area as corn for water evaporation. Sudan grass yields are somewhat lower than corn when harvested for silage (20 tons versus 32 tons for corn under full water supply and good management), but they have the advantage of requiring much less water (24.5 inches versus 44 to 48 inches for corn), can be cut two to three times during the season, and can also be stored as compressed or uncompressed bales or cubes (Wright et al. 2016; Mitchell et al. 2015; Frate et al. 2012; Nolte 2010). Sudan silage grown on land previously used for corn silage will also allow dairies the opportunity for continued waste disposal. A common silage grower practice is producing corn silage during the warm season and grain (winter wheat) silage in the cool season. The grower option of summer cropping sudan silage and winter cropping wheat silage would still be possible.

Alfalfa Hay

Premium quality alfalfa hay is important to dairies and domestic dairies are the primary market for alfalfa. However, the ration of alfalfa fed to dairy cows decreased from 12.5 pounds per day in 2005 to 8 pounds per day now (Putnam 2016; CDFA as cited by Hoyt 2016). This decrease reflects a substitution of alfalfa by other commodities (Silva-del-Río et al. 2011; Putnam 2016). This substitution occurs because the market for alfalfa is complex and is influenced by a wide variety of factors including the following (Putnam 2016).

- Price of milk.

[4] A recent survey of San Joaquin Valley dairies identified 28 different locally grown byproducts and grains fed to their dairy cows (Silva-del-Rio, et al., 2011).

- Rate of inclusion of alfalfa in dairy rations and competition from other feedstuffs such as corn silage and almond hulls.
- Relative price of other commodities including corn grain.
- Acreage of alfalfa and yield variation each year.
- Export demand for hay and milk and international forces, such as currency value and price.
- Relative demand by horse and other domestic markets.
- Political and policy decisions by governments.

Alfalfa acreage in California has already been on the decline, down to 820,000–860,000 acres in the past few years, from 1.1 million acres in 2008 (Putnam 2016). The top five counties for alfalfa acreage include Merced County, which is in the plan area, as well as, Fresno, Tulare, and Kern, which are in relatively close proximity to the plan area, and Imperial, which ships alfalfa as far away as China, Japan, or the United Arab Emirates (Geisseler and Horwath 2016; National Geographic 2014). In addition, California has for decades drawn "much of the alfalfa hay produced in neighboring states, particularly Nevada and Utah, but also Oregon, Arizona, and sometimes Idaho" (Klonsky et al. 2007; Knapp 1990). Ten years ago it was estimated that 8 to 12 percent of alfalfa utilized in California was imported from other states. Recent estimates indicate that "California also attracts between 600,000 and 1 million tons of hay from neighboring states, some of which is for dairies, and some for export or horses (or minor uses like beef and sheep)" (Putnam et al. 2016).

Almond Hulls

Almond hulls are a byproduct of the almond industry. Almond hull is the outer covering of the almond, while the shell is the fibrous casing from around the kernel. The hulls are considered a good quality feed ingredient for dairy cows that is also palatable and digestible (Asmus 2015). Almond shells, however, do not add nutritional value, and their presence with almond hulls reduces the cost (and worth) to dairies. Almond hulls can be used as a silage supplement, silage replacement, and concentrate (Asmus 2015).

Almond acreage in the San Joaquin Valley has increased dramatically over the past decade. California Agricultural Commissioners data from the National Agricultural Statistical Service indicates that there were nearly 750,000 acres of producing almonds in 2015 in the San Joaquin Valley, up from 568,000 in 2010 (CDFA 2018).[5] This indicates availability of almond hulls as feedstock is high and would likely continue under the LSJR flow objectives. Some dairy producers already replaced their silage fields with almonds, and feeding the hulls to their cows (CDFA 2017; Asmus 2015).

Soy and Canola Meals

Dairy operators currently use soy and canola meals as part of feed ration (Putnam et al. 2016). Soybeans and canola are not grown in the San Joaquin Valley, and virtually all of it is imported into California from Midwestern and Mountain states, respectively, where it is grown.

[5] Acreage for the San Joaquin Valley includes Fresno, Kern, Kings, Merced, Stanislaus, and Tulare Counties.

Transport of Corn Silage

If corn silage acreage declines under the LSJR flow objectives, some dairy operators may choose to transport silage from more distant locations, something that occurred during the last drought (Lee 2014). Because of its large bulk density, silage material transport may be more expensive than for other feedstocks. Custom harvesting of corn silage is common, with a typical price of $10.35 per ton for both harvest and short distance hauling (Mitchell et al. 2015). Transport for more distant truck hauling (greater than one mile) is typically an additional $2.40 per ton (Mitchell et al. 2015). Long-range transport already occurs in years when the entire state is affected by drought. Under the LSJR flow objectives silage from outside the plan area would not be affected by the same market forces as during drought, when short supplies drive up prices. It would likely be less expensive compared to a drought, because dairy operators can plan ahead and enter into contracts or more permanent, long-run hauling arrangements.

Conclusion

Any adjustment from a dairy operators' ideal ration would likely result in some higher costs during some years. However, quantifying the effects is not reasonably possible with so many complex and independent components. The use of the corn silage constraint in the SWAP model provides one lens through which to view one of the components that is important to dairies. Silage is considered "undervalued" in the SWAP model based on the mathematical configuration of the model. The silage constraint used in the revised SWAP model run reflects the higher value of silage to dairies (as opposed to grain corn) and the potential ability of dairies to substitute with sudan grass-based silage, which can be grown with less water; however, sudan grass substitution is only one option available to dairies. No modeling constraint can account for all of the individual choices that are discussed above. If dairy operators decide to feed more alfalfa and less silage imported from Nevada or Arizona (as occurs now), then vegetable crops that the SWAP model forecasts as being reduced may remain; silage corn might be reduced; and silage might not be trucked from anywhere. A model is not capable of capturing all of the trade-offs and decisions that can occur (and have occurred) within the dairy industry and between industries. For further discussion of the effects related to the potential conversion of designated farmland and other changes to the existing environment that could result in the potential conversion of agricultural lands to nonagricultural uses, and how these issues relate to the dairy and cattle industries, please see Master Response 3.5, *Agricultural Resources*.

Potential Effects on Livestock Operations

As noted above in Table 8.2-8, cattle and calves and poultry are among the top 10 highest valued commodities in the plan area. Several types of beef operations are present in the plan area. Cow-calf operations rely on forage as the primary feed component, including dryland and irrigated pasture. Stocker operations rely on seasonal grazing, but stocker cattle are typically moved to feedlots at the end of the grazing season. Feedlots combine many cattle in a concentrated area, and the cattle are fed directly with feed grains, byproducts (e.g., rice bran, almond hulls, cottonseed), and hay. However, because of the presence of the large dairy industry, a very large component of the beef industry is associated with the dairies, where male offspring are raised on forage, if available to cattle owners, and then in feedlots. In the plan area, feedlots are by far the dominant cattle operation and the most likely cattle operation to be affected by the plan amendment.

In a similar manner as with dairies, the potential impacts of the LSJR flow objectives on beef cattle operations are complex. Any reduction in irrigated pasture and associated forage would require replacement by hay. As noted above, alfalfa and other grass hay is currently grown locally but also imported from other parts of California and neighboring states. Imports of hay into the plan area may increase as a result the plan amendments. (In contrast to dairies, which rely on premium quality hay, beef cattle may sustain on lesser grades of hay, with supplements of vitamins, minerals, and feed supplements (UC ANR 2007, pp. 19–20).) Beef cattle can also utilize feeds and byproducts from many sources, including corn grain, soy and canola meals, small grain forage, and byproducts such as almond hulls, brewers' grain, citrus pulp after juice extraction, cottonseed meal, and milling commodities after production of flour (UC ANR 2007, p. 19).

The manner in which poultry operations in the plan area are potentially affected by the plan amendment is in terms of reductions to locally grown feed. However, poultry feed consists of many ingredients—e.g., corn, soybeans, wheat, flax—that may not be grown in the plan area, and are instead imported from other areas of the state and elsewhere; this makes it unlikely that poultry production would be much affected, if at all, by the plan amendments.

Potential Economic Effects on the Food Processing Industry

Food and agricultural product processing is an important component of California's economy, in both rural and urban areas of the state. Many food and beverage processing facilities are located near the source of raw materials to be processed; others are located within larger cities, in or near coastal ports or other transportation centers, for ease of distribution and sale. A recent University of California study found that in 2012, all food and beverage processors combined accounted for $82 billion of value added and 760,000 full- and part-time jobs in California (Sexton et al. 2015). While this is notable, not all of the food and beverage processing sector is connected to California agriculture, as a considerable share of the sector's raw materials either originate elsewhere or do not involve agricultural output at all. It is, therefore, important to consider the individual crops and commodities that could be affected by changes in agricultural production in order to determine the extent of effects on food processing.

The food processing sector utilizes raw farm outputs and converts them into food and fiber products sold domestically and internationally. For many food processors, there is a direct relationship between farm production levels and value-added processing, including both output (sales) and employment. Therefore, if farm acreage and associated production is forecasted to decline by more than a modest amount, the processing businesses could be affected, unless it is able to obtain product from other locations. In general, processing facilities rely upon product flow from farms, and processing plants are sized according to anticipated quantities of raw product.

Food processors in California operate in an economic environment that is cognizant of, and influenced by, global, national, and regional markets. In order to remain competitive, processors continuously seek ways to maintain profitability by reducing costs, and that includes automation as a means of reducing labor needs and costs (Allsup 2015). Automation, or the substitution of technology for labor in production, is a long-term trend in food processing that mirrors more broadly the situation in agriculture and manufacturing and the forecast for labor markets in the future (Martin 2018; California Agriculture 2018; NCCI 2017). In other words, adoption of technology in food processing, and associated increase in labor productivity per unit of output, is likely to mean a future decline in food processing employment, irrespective of the implementation of a plan amendment.

The Food Processing Industry in the Plan Area

Many crops grown in the three counties of the plan area are sold or provided to processors for eventual sale to consumers. General information regarding several important processing industries that could be affected by reduced local agricultural production are presented in the following subsections.

Dairy Product Manufacturing

As discussed previously, there is a very large dairy industry in the San Joaquin Valley. This industry, in turn, supports an equally as important dairy product processing industry that takes raw milk and either prepares it for sale and human consumption or transforms it into other dairy products. The level of processing needed will depend on the product(s) being produced. Fluid milk usually must be pasteurized (heat treated to destroy microorganisms), and may be homogenized to prevent fat globules from separating out of the liquid solution. In addition, fat content is regulated to produce several types of milk (whole, 2%, 1%, skim). With more processing milk can be used to produce various dairy products, such as butter, cheese, yogurt, and ice cream (Milk Facts n.d.). Table 8.2-9 suggests that in the plan area manufacturing of fluid milk and cheese support about 3,100 jobs and produce about 3.2 billion in economic output. Based on County Business Patterns (CBP) data from the U.S. Census Bureau, in 2015 there were 24 dairy product manufacturers within the three counties (four each in San Joaquin and Merced Counties and 16 in Stanislaus County) (U.S. Census Bureau 2015); some of the major dairy processors include Hilmar Cheese Co., Gallo Cattle Co., and California Dairies Inc.

Recent trends in the dairy industry nationwide have led to some contraction and closure of plants. This is the result of low prices due to excess supply in the face of waning fluid milk demand (Opperman 2018; Erwin 2018). California milk processors are seeing a decline in milk production because fluid milk prices have decreased, which lead to the closure of one plan area plant recently (Cornall 2018).

Animal Slaughtering and Processing

Both extensive beef and poultry processing sectors exist in the San Joaquin Valley. Meat processing includes slaughtering, carcass division and cleaning, preservation treatments such as curing, and packaging. In addition, meat processing also leaves parts of the animal that are initially inedible, such as fat and bones, that can be rendered to produce more useful products like tallow and bone meal. Table 8.2-9 suggests that in the plan area, the processing of poultry supports about 3,700 jobs and produces about 1 billion in economic output and processing of non-poultry meats supports about 1,000 jobs and produce about 575 million in economic output. Based on County Business Patterns (CBP) data from the U.S. Census Bureau, in 2015 there were 30 animal processing companies within the three counties (9 each in Stanislaus and Merced Counties and 12 in San Joaquin County) (U.S. Census Bureau 2015).

Fruit and Vegetable Preservation and Packaging

The processing of fruits and vegetables is primarily focused on preservation of products to prolong shelf life and packaging to facilitate transport of the product. The common processes include freezing, canning, and dehydration. Fruits and vegetables may also be processed to produce juices, sauces, or other products. Crops grown in the three counties that may contribute to the processing industry include tomatoes, cherries, potatoes, beans, peaches, and various other fruits and vegetables. Table 8.2-9 suggests that in the plan area, the manufacturing of canned and frozen fruits and vegetables supports about 7,000 jobs and produces about $3.4 billion in economic output. Based on County Business Patterns (CBP) data from the U.S. Census Bureau, in 2015 there were 34 fruit and vegetable processing facilities within the three counties in the plan area (11 each in San Joaquin and Merced Counties and 12 in Stanislaus County) (U.S. Census Bureau 2015). Some of the major fruit and vegetable processing companies in the plan area include Seneca Foods, Del Monte Foods, Con Agra, and Morningstar Foods Inc.

Tomato Processing

In 2010, Over 82,000 acres of processing tomatoes were grown over San Joaquin, Stanislaus, and Merced Counties (USDA 2018). Tomatoes grown for processing are manufactured into paste and resold as a raw ingredient in other foods. Many firms also manufacture pulp-based products, such as stewed, whole-peeled, and diced tomatoes. Bulk items can be remanufactured into sauces, ketchup, salsas, soups, and other foods. Several small processors produce dried tomato products (Hartz et al. 2008). Growers typically contract with specific processors to grow processing-type tomatoes. Tomatoes have the most value when they arrive to the market during a certain time interval. Growers recognize the importance of this timing and plan their planting times accordingly. Processing tomatoes are generally delivered to market within a 2-week period, with that time period set by the processor (Hartz et al. 2008). Because of the bulk density of the ripe product, processing plants are located near production areas. California accounts for approximately 94 percent of the area harvested for processing tomatoes within the United States (ERS 2016).

Cherry Processing

The largest producing area for California cherries is in San Joaquin County, near the small farming town of Lodi. About 21,000 acres of cherries were grown in San Joaquin County in 2010 (USDA 2018). Fresh cherries have an extremely short shelf life and must be handled carefully to reduce bruising. After harvest, cherries are quickly cooled using chilled water – a process called hydro cooling and brought to packing facilities where they are then sorted by size and color and packed for shipping (CFAITC 2017a; California Cherries n. d.), Cherries are consumed in a variety of ways, including fresh, frozen, and canned, or as juice, wine, brined, or dried (Marzolo 2015a). In 2016, about 90 percent of sweet cherries produced in California were sold on the fresh market, with the remaining 10 percent used for processing (USDA 2017).

Sweet Potato Processing

The most significant truck crop grown in the plan area, in terms of acreage and value, is sweet potatoes, with more than 16,000 acres grown in Merced County in 2010 (USDA 2018). Merced County accounts for about 90 percent of the state's production overall production of sweet potatoes (Stoddard et al. 2013). During harvest, most sweet potatoes are dug up, put in bins, and stored until ready for packing. Post-harvest processing includes cleaning and putting into 40-pound shipping boxes for marketing west of the Rocky Mountains. Approximately 25 percent of sweet potato volume is processed, mostly as frozen fries, but also sweet potato chips, flour, and dehydrated animal foods (Stoddard et al. 2013, p. 6).

Peach Processing

In 2016, about 14,700 acres of peaches were grown over the three counties, representing about 20 percent of the California's total peach production (USDA 2018). In 2016, about 75 percent of peaches produced in California (including both clingstone and freestone) were used for processing (USDA 2017). At the processing plant, peaches are sized, pitted, and sliced into various size pieces. Generally, peaches are then either canned or frozen for shipment to consumers (CFAITC 2017b). However, peaches can also be processed for products such as, pies, cobblers, sorbets, yogurts, peach oil used in beauty products, and beer (Marzolo 2015b).

Bean Processing

Dry beans have been grown in California for more than a century and are concentrated in the Sacramento and northern San Joaquin Valleys. Beans fit well in a crop rotation because of the soil nitrogen-fixing features of these legumes, and are sometimes used as a double crop following grains (Long et al. 2010). They are typically grown under contract with marketing warehouses or elevators, also based in California. Elevators are the first level of processing where beans are sorted, cleaned, graded, and packed for transport. The elevators will then sell the packaged beans to other canners and other processors. Beans are then further processed by being cooked and canned, preserved in brine, ground into flour, or dry bagged for later use (Schumacher and Boland 2017).

Nut Processing

Nut crops, including almonds and walnuts, represent a substantial part of agricultural production in the plan area, and processing is a significant component of preparing nuts for end use by consumers. Across the state there are about 100 handlers who process almonds (ABC 2016) and about 90 handlers who process walnuts (Amisy n. d.). Nuts are harvested from orchards and transported to processing facilities, where they are hulled and shelled. Nuts may then be processed into different forms (blanched, roasted, sliced, slivered, diced or ground) for ingredient or direct (snacking) use. According to a study of the almond industry, approximately 40 percent of California's almonds are marketed as manufactured products (Sumner et al. 2014, p. 11). In the food processing supply channel, almonds are used to produce a number of different processed items: ready-to-eat cereals, energy and granola bars, baked goods, almond butter, almond snack mixes, chocolate and non-chocolate confectionary, frozen novelties, ice cream, and milk substitute (Sumner et al. 2014, p. 38). Almond exports, including processed almond products, to other countries is an increasingly important component of almond sales. Table 8.2-9 suggests that in the plan area manufacturing of fluid milk and cheese support about 1,200 jobs and produce about $872 million in economic output. Based on County Business Patterns (CBP) data from the U.S. Census Bureau, in 2015 there were 21 nut processing facilities within the three counties that use nuts to produce snack foods (9 in San Joaquin, 8 in Stanislaus, and 4 in Merced) (U.S. Census Bureau 2015).

Wineries

The San Joaquin Valley grows a majority of the wine, table, and raisin grapes in California and includes more than 30 wineries (Wine Institute n. d.). Grapes grown for wine are produced on more than 100,000 acres in the plan area. After the harvest, the grapes are taken into a winery and crushed or pressed to prepare the juice for fermentation. Although wine grape production is relatively high valued in terms of costs of production (and revenue) per acre, the processing of wine grapes into wine also requires considerable labor and inputs. Three categories of wineries are present in California: wineries producing their own wines brands, wineries/production facilities contracted to produce wines for other companies, and companies marketing their own wine brand, but not producing the wine itself (John Dunham & Associates 2016). Table 8.2-9 suggests that in the plan area wineries produce about 5,700 jobs and produce about $2.1 billion in sales (economic output). Based on County Business Patterns (CBP) data from the U.S. Census Bureau, in 2015 there were 45 wineries within the three counties with the vast majority in San Joaquin County (U.S. Census Bureau 2015).

Other Crop Processing Industries

Grain Corn Processing

In the plan area, during 2010, about 235,900 acres of corn silage is grown on average, compared to about 58,300 acres of grain corn (USDA 2018). Grain corn may be processed through corn mills for livestock feed, human consumption, and industrial products. Food products made from corn include starch, sweeteners, and oil. Industrial products include industrial alcohol and fuel ethanol. California grain corn acreage tends to fluctuate in response to market conditions. When market prices for grain are high, more corn is harvested as grain, and when prices are low, growers either substitute the corn with a different crop or harvesting corn as silage (UC ANR 2017).

Rice Processing

At approximately 500,000 acres, California ranks as the second-largest rice-growing state in the U.S., after Arkansas. California is the only U.S. producer of the high-quality japonica rice. The sticky, moist characteristics of japonica varieties make them particularly suited for Mediterranean and Asian cuisines (University of California Agricultural Issues Center 1994; USA Rice 2017). As a result, a substantial share (45–55 percent annually) is exported to Japan, South Korea, and elsewhere (Rice Growers of America 2017). The majority of California rice is grown in the Sacramento Valley, though a small amount is still grown in the plan area. Rice processors are involved in all aspects of preparing rice for market. This preparation includes hulling, cleaning, milling (removing the bran), packaging, and marketing, and may also include drying and transport. Historically, grower cooperatives including the Rice Growers Association and the Farmers' Rice Cooperative formed and expanded at a pace similar to the growth in crop acreage, as did smaller cooperatives and independent millers and marketers. By the early 1990s, milling capacity was 42 million hundredweight statewide, with cooperatives owning about half (University of California Agricultural Issues Center 1994, pp. 6, 9). As a result of cooperative ownership, growers control significant amounts of both production and processing.

Safflower Oilseed Processing

Safflower is an oilseed crop typically grown in rotation with other crops, such as processing tomatoes, cotton, alfalfa, wheat, or dry beans. The crop is particularly useful in drought conditions and where salinity buildup, such as in the San Joaquin Valley, is a problem (CA IPM 2016). Although acreage peaked at more than 350,000 acres in California in the 1960s, it has declined to a relatively stable 50,000 acres due to competition from olive and canola oils. Acreage is concentrated in Sacramento Valley, but there is a small portion that remains in San Joaquin County (Lazicki and Geisseler 2016). In the past, safflower was grown to be used in making red and yellow dyes for clothing and food preparation. However, safflower processing has expanded to include production of oil, animal meal, and birdseed. Safflower seed oil are used in production of paints, infant formulas, cosmetics, and salad and cooking oils. Safflower meal is about 24 percent protein and high in fiber and is used as a protein supplement for livestock and poultry feed. Safflower production is generally contracted in the spring between a grower and a birdseed or oil company for fall delivery (AgMRC 2017).

Olive Processing

California is the only state in the U.S. listed as commercially producing olives. Furthermore, virtually all of the olives grown in the state are processed, mostly to be canned or to produce olive oil (USDA 2017). In recent years, increased production of olive oil is responsible for a recent expansion of olive production in the San Joaquin Valley, especially San Joaquin County. Approximately 3,300 acres of olives were grown in 2016 in San Joaquin County, which is 8 percent of olive acreage grown in the state. Oil processors are usually located near the production areas.

Potential Effects on the Food Processing Industry

The processing industry could be affected by reduced crop production in the area of potential effects if replacement supplies cannot be found. It is, therefore, important to have a sense of the magnitude of the reductions in crop production of each crop type under alternative conditions and the relative availability of each crop in the areas beyond the irrigation districts. If replacement crops are available processor production could be maintained, but there may still be a reduction in net revenue for the processor if transportation costs would be higher to bring in replacement supplies. Furthermore, importing some crops, such as tomatoes, long distances could make it more difficult to maintain ripeness and quality. As such, to illustrate the potential effects on the food processing industry, Table 8.2-13 presents a summary of the aggregate crop categories analyzed in the SED as part of the revised SWAP model run, as well as the estimated average annual reduction in acreage for all years and for critical years under the 40 percent unimpaired flow requirement, relative to baseline. This information is then discussed within context of typical crop variation and industry changes below the table to illustrate the very small changes to various important crops to food processing. In addition, the table also summarizes the total acreage of each crop type grown over the three-county area and over the entire state based on county Agricultural Commissioner data for 2010.

Table 8.2-13. SWAP Model Crop Categories and Average Annual Increase in Fallowed Acreage across all Modeled Irrigation Districts under 40 Percent Unimpaired Flow (LSJR Alternative 3) in the Revised SWAP Model Run

	Total California Acreage, 2010[1]	Total Three County Acreage, 2010[1]	Avg. Annual District Acreage under Baseline		Increase in Fallowed Acreage under LSJR Alternative 3	
			Averaged for All Years	Averaged for Critical Years	Averaged for All Years	Averaged for Critical Years
Crop Category	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Alfalfa	1,008,019	189,800	34,005	31,429	3,551	14,128
Almond and Pistachio	986,232	296,550	115,839	115,129	674	2,332
Corn	725,605	299,100	106,365	104,695	2,424	9,783
Cotton	309,920	39,300	2,597	2,506	19	82
Cucurbits	82,579	22,391	2,678	2,624	96	417

Crop Category	Total California Acreage, 2010[1] (acres)	Total Three County Acreage, 2010[1] (acres)	Avg. Annual District Acreage under Baseline: Averaged for All Years (acres)	Avg. Annual District Acreage under Baseline: Averaged for Critical Years (acres)	Increase in Fallowed Acreage under LSJR Alternative 3: Averaged for All Years (acres)	Increase in Fallowed Acreage under LSJR Alternative 3: Averaged for Critical Years (acres)
Dry Bean	73,190	33,430	2,441	2,319	213	865
Fresh Tomato	33,726	20,420	10,418	10,405	8	28
Grain	808,665	84,690	14,417	14,344	66	254
Onion and Garlic	78124	2,000	781	780	2	7
Other Deciduous	636,230	155,146	78,606	78,391	219	750
Other Field	1,386,766	413,000	51,917	42,320	9,063	29,412
Other Truck	881,773	67,477	28,669	28,151	572	2,229
Pasture	1,296,859	78,900	33,156	22,178	6,931	14,993
Processing Tomato	319,786	82,700	1,900	1,834	72	304
Rice	596,253	10,480	6,152	5,100	887	3,145
Safflower	29,597	4,880	158	143	25	99
Sugar Beets[2]	25,201	0	291	289	1	3
Subtropical	389,220	4,488	1,988	1,965	27	80
Vine	813,375	118,254	22,946	22,880	58	203

[1] Acreage for California and the three counties (Merced, Stanislaus, and San Joaquin) were determined from 2010 County Agricultural Commissioner data (California Agricultural Commissioner 2010)

[2] Though no specific acres of sugar beets are reported for the counties, the Stanislaus county agricultural commissioner report for 2010 indicates that sugar beet acreage was grouped into miscellaneous field crops. (Stanislaus County Department of Agriculture 2011)

In this example, the Fresh Tomato crop category in the SWAP model represents tomatoes grown for market sale with minimal to no need for processing. Therefore, changes in production of this crop category is assumed to have no effect on food processors. In addition, Sugar Beets are no longer processed in the local area (the only remaining processing plant in California is in Imperial Valley), so any change in acreage would not have an effect on food processors (Kaffka n.d.).

As illustrated in Table 8.2-13, animal feed crops such as Alfalfa, Pasture, and Other Field crops show some of the largest increases in fallowed area. These feed crops are not usually processed directly, but serve as an important input for the livestock industry, which, in turn, supports the large milk and beef processing industries.

For many of the non-permanent crops shown in Table 8.2-13, the change in acreage, even in critical years, is extremely small compared to the total production in the three plan area counties. The critical year average annual reduction in acres for the Cotton, Grain, Onion and Garlic, and Processing Tomatoes crop categories are all less than 1 percent of the production in the three counties. Processors of these crop categories should not to be affected by such small changes in production, as this level of change is likely to fall within their normally anticipated annual variation in yields.

For other crop categories the change in acreage is a slightly larger proportion of the total production in the three plan area counties, but still does not indicate that there would be a severe shortage in processing inputs. The critical year average annual reduction in acres for the Cucurbits, Dry Bean, and Safflower crop categories are all between 1 and 3 percent of the production in the three counties. Processors of these crop categories may experience minor shortages in critical years, but there is still likely enough local production for them to find substitute suppliers and it would not likely cause significant disruption to processing operations since annual yield variations are already anticipated and built into their production capacity.

Dairy and Livestock Processing

Corn silage and other field crops are relied upon by the dairy industry. Alfalfa and irrigated pasture are utilized by both the beef industry and dairies. To the extent that dairy and beef production would be affected by reductions in overall feed supply without replacement sources, so too would be fluid milk processors, cheese manufacturing, meat packaging plants, and other milk-based or beef-based food products manufacturing. However, if dairies and beef producers are able to replace the feed supply from sources in other locations, or other feedstock types, such that milk output or beef production is not changed, then processors of those products would be similarly unaffected.

As discussed in some detail in the previous section, *Potential Economic Effects on Existing Dairies*, the effects of the LSJR flow objectives on dairies and livestock operations, as well as their associated downstream processing, is complex and not easily projected. However, some feed crops, such as alfalfa, can be imported from other regions of California or from neighboring states, as currently happens, or substitute feed crops could be used in dairy or beef feed rations. As noted in the previous section, dairy operators and beef producers are more likely to be responsive to market prices in decisions to change herd size or production levels. If cost of replacement feed is negligible, raw supplies for processors will be unaffected. If replacement feed cost is higher, there may be an impact on producer profits; but the extent to which producer output level changes, and thus the availability of raw supplies for processors, is uncertain but expected to be nominal.

Almond and Pistachio

Pistachios represent a very small percentage of the Almond and Pistachio crop category for both the districts and the three-county area, so any potential effects from the estimated decrease in Almond and Pistachio production would be incurred mostly by almond processors. Almonds and Pistachios are primarily processed to produce snack foods and as ingredients for other manufactured foods. In 2010, average annual irrigation district almond and pistachio production is estimated to have been about 39 percent of the three-county production and 12 percent of the state's production. The average annual reduction in almond and pistachio acreage illustrated in Table 8.2-13 relative to baseline represents about 0.2 percent of the total almond and pistachio acreage in the three plan area counties. On average for critical years, the reduction increases to about 0.8 percent of the acreage in the three counties. Furthermore, the average fallowing of almond and pistachios in critical years is about 0.2 percent of the statewide production.

To account for the yield effects of deficit irrigation, the reduction in gross revenue per acre can be used as a proxy for changes in yield per acre. For critical years under baseline, average annual acreage of almonds and pistachios is 115 thousand acres and the average annual gross revenue is $518 million, which means almonds and pistachios produce about $4,498 per acre. For critical years, average annual acreage of almonds and pistachios is 113 thousand acres and the average annual gross revenue is $493 million, which means almonds and pistachios produce about $4,368 per acre. The difference in revenue per acre is about $130, which is about a 2.9 percent reduction in baseline revenue per acre. In other words, on average for critical years there is a 2.9 percent reduction in district yield per acre relative to baseline. Reducing yield by 2.9 percent on the 113 thousand acres remaining in production would have the same effect as if there was 2.9 percent less acres (3,263 acres). An average loss of 3,263 acres worth of almond and pistachio yield in critical years would represent an additional 1.1 percent reduction in almond and pistachio production for the three-county area.

The reduction in almond and pistachio production during critical years, both from fallowing and reduced yield per acres, would average about 1.9 percent of the total production of almonds and pistachios in the three counties. Overall, almond and pistachio processors could experience minor shortages in critical years, but this small amount likely falls within anticipated production variability to not affect processing capacity.

Corn

The Corn crop category represents acres of both grain and silage corn. Silage corn is not usually processed directly, but is a major source of roughage for dairy cows. As noted in the previous section, *Potential Economic Effects on Existing Dairies*, the effects of the plan amendment on dairies and downstream processing is complex and not easily projected. Though silage corn is heavy and, therefore, expensive to transport long distances, there are other silage crops that can be used as substitutes for corn silage in dairy rations.

Grain corn, as stated previously, can be processed for sweeteners, oils, and some industrial products. Looking specifically at grain corn production, in 2010 the state produced about 167,000 acres, and the three plan area counties produced about 58,300 acres (USDA 2018). Under baseline, it was estimated in the revised SWAP model run that 16,443 acres of grain corn would be grown annually on average over all years and that 16,051 acres would be grown annually on average in critical years. Relative to baseline under LSJR Alternative 3, it was also estimated in the revised SWAP model run that 392 acres of grain corn would be fallowed annually on average over all years and that 2,008 acres would be fallowed annually on average in critical years. In 2010, the average annual irrigation district grain corn production would have been about 28 percent of the three-county production and 10 percent of the state's production. The average annual reduction in grain corn acreage under LSJR Alternative 3 relative to baseline represents about 1.2 percent of the total grain corn acreage in the three counties. On average for critical years, the reduction increases to about 3.4 percent of the acreage in the three counties. Furthermore, the average fallowing of corn in critical years is about 1.2 percent of the statewide production. Overall, grain corn processors could experience minor shortages in critical years. However, this is well within the expectations of processors; as indicated in the *Regional Economic Setting* section, grain corn production is highly variable and subject to relative prices between grain and silage, so there may be little grain to process in years when silage is more profitable for growers.

Other Deciduous

The Other Deciduous crop category includes walnuts and many fruit orchard crops, such as cherries, peaches, apricots, and apples. In 2010, average annual irrigation district orchard and walnut production is estimated to have been about 51 percent of the three-county production and 12 percent of the state's production. The average annual reduction in orchard and walnut acreage illustrated by Table 8.2-13 relative to baseline represents about 0.1 percent of the total orchard and walnut acreage in the three counties. On average for critical years, the reduction increases to about 0.5 percent of the acreage in the three counties. Furthermore, the average fallowing of orchards and walnuts in critical years is about 0.1 percent of the statewide production.

To account for the yield effects of deficit irrigation, the reduction in gross revenue per acre can be used as a proxy for changes in yield per acre. For critical years under baseline, average annual acreage of orchards and walnuts is 78.4 thousand acres and the average annual gross revenue is $350 million, which means orchards and walnuts produce about $4,471 per acre. For critical years, average annual acreage of orchards and walnuts is about 77.6 thousand acres and the average annual gross revenue is about $343 million, which means orchards and walnuts produce about $4,420 per acre. The difference in revenue per acre is about $51, which is about a 1.2 percent reduction in baseline revenue per acre. In other words, on average for critical years there is a 1.2 percent reduction in district yield per acre relative to baseline. Reducing yield by 1.2 percent on the 77.6 thousand acres remaining in production would have the same effect as if there was 1.2 percent less acres (893 acres). An average loss of 893 acres worth of orchard and walnut yield in critical years would represent an additional 0.6 percent reduction in orchard and walnut production for the three-county area.

The reduction in orchard and walnut production during critical years, both from fallowing and reduced yield per acres, would average about 1.1 percent of the total production of orchards and walnuts in the three counties. It is difficult to assign production changes to any one specific Other Deciduous crop; likely the production impacts would spread over all Other Deciduous crops proportional to their area. Overall, orchard and walnut processors could experience minor shortages in critical years, but this amount is within normally anticipated variation in annual yields so as to not affect processing capacity.

Other Truck

The Other Truck crop category includes sweet potatoes, berries, and many vegetable crops, such as broccoli, spinach, and peppers. In 2010, average annual irrigation district truck crop production is estimated to have been about 42 percent of the three-county production and 3 percent of the state's production. The average annual reduction in truck crop acreage illustrated in Table 8.2-13 relative to baseline represents about 0.8 percent of the total truck crop acreage in the three counties. On average for critical years, the reduction increases to about 3.3 percent of the acreage in the three counties. Furthermore, the average fallowing of truck crops in critical years is about 0.3 percent of the statewide production. It is difficult to assign production changes to any one specific Other Truck crop; likely the production impacts would spread over all Other Truck crops based on the relative area and prices among truck crops. Overall, truck crop processors could experience minor shortages in critical years, but the decrease is small compared to normally anticipated crop yields and production levels as to not affect processing operations.

Rice

The San Joaquin Valley represents very little of the state's overall production. In 2010, average annual irrigation district rice production is estimated to have been about 59 percent of the three-county production, but only 1 percent of the state's production. The average annual reduction in rice acreage illustrated in Table 8.2-13 relative to baseline represents about 8 percent of the total rice acreage in the three counties. On average for critical years, the reduction increases to about 30 percent of the acreage in the three counties. However, the average fallowing of rice in critical years is about 0.5 percent of the statewide production. As the reduction in rice production represents a very small proportion of the total Central Valley production it is unlikely to have any noticeable effect on rice processors outside of the San Joaquin Valley.

On a local scale, any rice processors in the San Joaquin Valley region could see a reduction in local supplies. However, some local production and processing takes place under common ownership; for these circumstances, the SWAP model is unable to forecast individual decision making, and so it is possible that rice may continue to be grown in lieu of other crop choices. Even so, raw rice for processing could be trucked in from the Sacramento Valley, although there may be a small reduction in net revenue due to higher transportation costs.

Subtropical

The Subtropical crop category includes olives and citrus crops, such as oranges, but olives represent the vast majority of the vine production in the plan area (primarily in San Joaquin County). In 2010, average annual irrigation district subtropical crop production is estimated to have been about 44 percent of the three-county production, but only 0.5 percent of the state's production. The average annual reduction in subtropical crop acreage illustrated in Table 8.2-13 relative to baseline represents about 0.6 percent of the total subtropical crop acreage in the three counties. On average for critical years, the reduction increases to about 1.8 percent of the acreage in the three counties. Furthermore, the average fallowing of subtropical crops in critical years is about <0.1 percent of the statewide production.

To account for the yield effects of deficit irrigation, the reduction in gross revenue per acre can be used as a proxy for changes in yield per acre. For critical years under baseline, average annual acreage of subtropical crops is 2,000 acres and the average annual gross revenue is $11.4 million, which means subtropical crops produce about $5,779 per acre. For critical years illustrated in Table 8.2-13, average annual acreage of subtropical crops is about 1.9 thousand acres and the average annual gross revenue is about $10 million, which means subtropical crops produce about $5,321 per acre. The difference in revenue per acre is about $458, which is about a 7.9 percent reduction in baseline revenue per acre. In other words, on average for critical years there is a 7.9 percent reduction in district yield per acre illustrated in Table 8.2-13 relative to baseline. Reducing yield by 7.9 percent on the 113 thousand acres remaining in production would have the same effect as if there was 7.9 percent less acres (149 acres). An average loss of 149 acres worth of subtropical crop yield in critical years would represent an additional 3.3 percent reduction in subtropical crop production for the three-county area.

The reduction in subtropical crop production during critical years, both from fallowing and reduced yield per acres, would average about 5.1 percent of the total production of subtropical crops in the three counties. As olives represent the majority of the Subtropical crop category for both the districts and the three-county area, potential effects from the estimated decrease in Subtropical crop production would be incurred mostly by olive processors. Overall, subtropical crop processors could experience some shortage in critical years, but it would not likely cause significant disruption to processing capacity.

Vine

The Vine crop category includes, table, raisin, and wine grapes, but wine grapes represent the vast majority of the vine production in the three-county area. In 2010, average annual irrigation district grape production is estimated to have been about 19 percent of the three-county production and 3 percent of the state's production. The average annual reduction in grape acreage illustrated in Table 8.2-13 relative to baseline represents <0.1 percent of the total grape acreage in the three counties. On average for critical years, the reduction increases to about 0.2 percent of the acreage in the three counties. Furthermore, the average fallowing of grapes in critical years is <0.1 percent of the statewide production.

To account for the yield effects of deficit irrigation, the reduction in gross revenue per acre can be used as a proxy for changes in yield per acre. For critical years under baseline, average annual acreage of grapes is about 22.9 thousand acres and the average annual gross revenue is about $100 million, which means grapes produce about $4,387 per acre. For critical years illustrated in Table 8.2-13, average annual acreage of grapes is about 22.7 thousand acres and the average annual gross revenue is about $98.6 million, which means grapes produce about $4,349 per acre. The difference in revenue per acre is about $38, which is about a 1 percent reduction in baseline revenue per acre. In other words, on average for critical years there is a 1 percent reduction in district yield per acre illustrated in Table 8.2-13 relative to baseline. Reducing yield by 1 percent on the 113 thousand acres remaining in production would have the same effect as if there was 1 percent less acres (196 acres). An average loss of 196 acres worth of grape yield in critical years would represent an additional 0.2 percent reduction in grape production for the three-county area.

The reduction in grape production during critical years, both from fallowing and reduced yield per acres, would average about 0.4 percent of the total production of grapes in the three counties. Overall, wineries should not to be affected by such small changes in production, as there is likely enough local production for them to find substitute suppliers.

Conclusion

The effects of the LSJR flow objectives on food processors can be summarized as follows.

- Impacts on dairy product processing and beef processing are highly dependent upon the effects on production by dairy operators and beef producers. As discussed in the previous section, *Potential Economic Effects on Existing Dairies*, there is considerable opportunity for producers to locate replacement feedstock, and historically, those decisions are market-based, thus the impact on milk and beef processors are anticipated to be nominal.
- Rice processors could experience some shortage in local-sourced supplies during critical years. However, San Joaquin Valley rice production represents a very small portion of the total Central Valley production, and processors may be able to import raw rice for processing from other regions, with some higher transportation costs.
- Olive production could be reduced by about 5.1 percent in critical years. Processors may see a similar reduction in output in those years.
- Production of almonds, walnuts, orchard crops, cucurbits, grain corn, dry beans, safflower, and other truck crops, such as sweet potatoes, could have a reduction in plan area production between 1 and 3.5 percent of the three-county area production during critical years. Processors of these crop categories may experience minor shortages in critical years. However, these crops

normally experience year to year variations in raw product supply due to weather and water supply, market prices affecting crop selection, consumer preferences affecting demand, and export markets. The anticipated reductions during critical years are likely indistinguishable from normal variations that are already built into the operations of processors. In some cases, there may be enough production elsewhere in the region for processors to find replacement raw product.

- Tomatoes, wine grapes, grains, onions, and cotton may see an acreage reduction in critical years that is less than 1 percent of the overall production in the three counties. Effects on processing are anticipated to be negligible.

As illustrated by the example of potential changes to crops provided above, although the LSJR flow objectives are likely to cause some land fallowing, as well as a shift in cropping patterns toward higher net revenue and lower water-using crops, the effects of such changes to crop agriculture is likely to have a small effect on food processing. The crop changes forecasted by the SWAP model do not account for possible mitigating factors, such as adoption by growers of additional water efficiency measures, furtherance of irrigation technology and seed breeding for improved yields, and increased use of water transfers during times of shortage. Food processing companies are also responsible for making decisions that affect their operations on a larger scale, such as whether businesses should consolidate; whether to employ technology advancements in automation that reduce need for labor (NCCI 2017); or how to respond to changes in market conditions, which could include contracting, expanding, or moving production (Seattle Times 2017). In limited cases, there may be a small change in availability of raw produce or product to processors, but it is not likely to result in widespread closure of processor businesses.

IMPLAN Limitations Regarding Regional Economic Effects on Dairies and other Downstream Industries

As noted in the *Overview*, IMPLAN is a proprietary data and modeling software system, originally designed by the U.S. Forest Service, which enables users to predict the effects of a proposed action on economic activity in a defined region (IMPLAN n.d.). IMPLAN is widely used and accepted, and IMPLAN model output is often reported as measures of the regional economic consequences of a proposed action. These types of effects are reported as changes in total sales, personal income, and employment because these are measures of the potential changes in the regional economy that are forecast to occur as a result of a proposed action.

However, regional economic effects differ from the costs directly associated with an action, as for example, changes to agricultural production. They include secondary impacts that occur in a region's economy *as a result of* the direct impacts, and are not additive with other calculations of direct costs (or benefits) of an action. Direct costs reflect a shrinking of the economy as a whole (or expansion, in the case of direct benefits), whereas secondary impacts demonstrate the distributional effect resulting from direct costs. As such, economists present and treat regional economic effects separately from other common measures of costs and benefits.

The SED considers the economic impacts of the LSJR alternatives. As described in Chapter 20, *Economic Analyses*, the *direct* impact is the outcome resulting from a change in irrigation water supply to farmers, as measured using the SWAP model. The *secondary* impacts affect agricultural support businesses and those which rely on agricultural products, including dairies (which purchase alfalfa and silage) and food processing, which rely upon raw products grown on irrigated farms.

The economic impacts reported in Chapter 20 represent the combined direct, indirect, and induced impacts resulting from the backward linkages of the agricultural crops modeled in the SWAP model within the local economy. *Backward linkages* consist of the expenditures on commodities, supplies, services, and labor purchased during an industry's production process—in this case, irrigated farms.

No attempt was made to quantify the secondary economic impacts of LSJR alternatives attributable to dairies or to other agricultural processing activities that may be directly affected by change in the local production of silage, pasture, or other crops. In order to include the economic effects of cropping reductions on dairy farms and dairy processing in the plan area, it would be necessary to conduct a separate, detailed study that would develop specific information relating the following information.

- The proportional dependence and reliance of dairies to local crops modeled in the SWAP model.
- The supply presence and pricing structure of alternative feedstocks.
- The extent to which dairy operations and production would be affected by change in the availability of locally-produced alfalfa and silage, as compared to hay imported from other states.

There is no information within IMPLAN or comparable economic impact modelling products that would quantify the likely economic response of dairy or other agricultural processing industries to a change in local production of certain crops because the relationships between irrigated crops and dairies noted above are not an inherent feature within IMPLAN. This is not to suggest that dairies and agricultural processors would not experience some effects resulting from the LSJR alternatives, as qualitatively addressed above and in Chapter 20, just that IMPLAN is not suitable for providing quantitative estimates without considerable additional study and modification to the model.

Some commenters have argued that though IMPLAN is not set up to calculate downstream economic impacts, it can be done, and as support the commenters suggest a procedure prepared by USDA that could have been used. The document referenced by the commenters (*A Practitioners Guide to Conducting an Economic Impact Assessment of Regional Food Hubs using IMPLAN*) outlines an approach for estimating the impacts of local food hubs using IMPLAN. However, as discussed further in the following paragraphs, following the procedure in the USDA guide would require a very extensive study, and is otherwise oriented towards a much smaller geographic scale and community level farm produce, as opposed to the complex and comparatively massive scale of agriculture in the plan area and greater San Joaquin Valley.

Local food hubs are local businesses that aggregate and distribute local agricultural produce to customers in the local economy. Although an analogous "food hub" industry sector does not exist in the IMPLAN sectoring scheme, the USDA guide outlines an approach for collecting the necessary data and constructing an impact activity within the IMPLAN modelling shell in order to estimate the economic impacts of marginal changes in local food hub sales. In addition to employing IMPLAN impact modelling procedures, the approach relies heavily on extensive primary data collection from three different sources: (1) the food hubs themselves, (2) farms and local processors that sell to the food hubs, and (3) customers that purchase from the food hubs. In addition, the document describes tabulation of the collected data, and procedures to convert purchaser prices to producer prices for constructing the impact activity scenario within IMPLAN.

While the USDA guide may provide a map of an approach to modelling the effects of other types of activities that involve downstream use of locally-produced agricultural commodities (e.g., livestock or dairy fed with local crops, or agriculture processing), the main takeaway is that extensive primary data collection from the three sources mentioned above (i.e., local operators, producers who supply commodities to the operators, and customers who purchase from the operators) is required. In some cases, some of the relevant data elements may be obtainable via informal interviews with "key informants" (industry experts or others with intimate knowledge of aspects of the business). However, a researcher undertaking such an extensive and complex task would need to formally survey and/or interview industry participants to obtain the requisite local economic data well before any relevant IMPLAN modelling could even be conducted.

Commenters' Regional Economic Analyses

In response to the economic analysis in the SED a few commenters produced their own economic analyses. Of the analyses discussed in this section, the first analysis was performed by Stratecon, Inc, a strategic planning and economic consulting firm specializing in water, and commissioned by the Merced, Stanislaus, and San Joaquin Counties. The second analysis was performed by Cardno, a professional infrastructure and environmental services company, and Highland Economics, an economic consulting firm, commissioned by Merced Irrigation District (Merced ID). The third analysis was also performed by Cardno and Highland Economics and was commissioned by the Modesto and Turlock Irrigation Districts.

Economic Analysis Performed by Stratecon, Inc.

Many commenters submitted the same 174-page economic report prepared by Stratecon, LLC and EcoGlobal Natural Resources (herein after referred to as Stratecon), which the State Water Board considered.[6] This report asserted that the annual local and regional economic effects associated with LSJR Alternative 3 (referred to as "SED40" by Stratecon) could be as high as $607 million (or $688 million with the SGMA) and that "peak year" total economic output and employment could fall "as much as… $2.75 billion." Responses to claims made in the report regarding effects on agricultural sectors or the larger regional economy are presented in this section. To the extent the report made claims regarding potential effects of the LSJR alternatives outside of the agriculture sector (e.g., potential recreational and hydropower economic effects), responses are provided in Master Response 8.4, *Non-Agricultural Economic Considerations*.

The groundwater and economic analyses performed by Stratecon included several assumptions that are different from the assumptions made by the State Water Board. As explained below, in reaching its conclusions, Stratecon developed impact estimates that are focused on worst-case scenarios; construed commonly-understood terms in an unusual manner; and presented results in unconventional ways. Furthermore, Stratecon assumed a groundwater response by farmers that is inconsistent with observed behavior, exacerbates the impact calculations, and requires an extreme application of SGMA's eventual requirements. Finally, Stratecon evaluated the impacts to dairies and livestock based on unrealistic assumptions. Inevitably, the differences in assumptions and analysis methods between the SED and Stratecon report led to differences in modeling results and conclusions.

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[6] Counties of Merced, San Joaquin, and Stanislaus. 2017. *The Economic Consequences of the Proposed Flow Objective for the Lower San Joaquin River in Merced, San Joaquin, and Stanislaus Counties*. Prepared by Stratecon, Inc. and EcoGlobal Natural Resources. January.

Use of Averages and Data Presentation in the SED

As part of its report, Stratecon suggested that the SED provides an incomplete characterization of the potential effects of the LSJR flow objectives because the SED focuses on average annual impacts, which, Stratecon claims, masks volatility of impacts, and does not account for reduced surface water supply reliability. However, this is not true. Annual average values of potential impacts are presented in the SED for clarity and ease of understanding and to highlight important impact trends. Presenting average values is a common practice in scientific literature. The SED would be impossibly long and difficult to comprehend if all model results for the entire 82-year modeling period were presented. When looking at the average values, readers understand that there are values that higher and lower than that, and can easily figure the total by multiplying the average by the total number of years in the modeling period. In addition, the SED uses many different methods to present data. The methods chosen were specific to each resource area being assessed and done so in a manner to disclose all potential effects and impacts.

The SED uses this variety of data presentation methods to fully describe the range of possible effects for the full range of climatological differences. This includes using cumulative distributions, time series, and exceedance charts to show all data resulting from modeling runs. Exceedance charts are presented throughout the document to capture inter-annual variability in the results. For example, Figures F.1.3-3C, F.1.3-4C through F.1.3-5C of Appendix F.1, *Hydrologic and Water Quality Modeling*, show exceedance charts of surface water diversion on each of the eastside tributaries. These exceedance charts indicate the annual variability in surface water diversions under baseline and each of the LSJR alternatives and inform how diversion reliability could be affected. In many instances the full set of data is presented alongside the average conditions, and can be found in appendices or model files if a reader is interested. For further discussion of exceedance charts and other ways the SED presents results, please see Master Response 2.3, *Presentation of Data and Results in SED and Responses to Comments*.

Surface Water Supply Volatility and Reliability

To support its economic conclusions with regard to the LSJR plan amendments, Stratecon attempted to estimate the economic cost of reduced water supply reliability; however, the analysis suffers from several deficiencies. As part of its analysis, Stratecon referenced terms used by the California Department of Water Resources (DWR) for assessing the likelihood of contractual deliveries from the State Water Project (SWP), but applied them in an unusual way. The SWP is not in the plan area, and DWR's assessment is not an economic assessment, but one of probabilities for planning purposes. DWR simply defines *water delivery reliability* as "the likelihood (probability) that a certain amount of water will be delivered by the SWP in a year." Stratecon used this planning definition as the basis for creating a novel concept called, "the reliable supply of surface water rights" that attempts to monetize water rights as if they are an entitlement. However, in California, there is no such concept in law as water belongs to the people. An appropriative water right is legal permission granted by the State Water Board to a water user to use *up to* a specified amount of water for a specified beneficial purpose such as swimming, fishing, farming or industry, subject first to other requirements such as the public trust. It is not a guarantee that the water is available and *will be delivered*. Unlike DWR, the State Water Board is not an operator or a provider of a water delivery project; and a water right is not a contractual agreement or a guarantee of a certain amount of water delivered to the user. In fact, even DWR's water contracts are not a guarantee and there is no compensation or "lost value" assigned to receiving less than the contractual amount. DWR's SWP long-term contracts state that deliveries may be reduced in the event that "there is drought or any other cause whatsoever" (DWR 1960).

Stratecon goes on to arbitrarily define a reliable water supply based on the supply of applied surface water "with only a 10% likelihood of interruption" (if looking at an exceedance chart of annual applied surface water, this would equate to the 90 percent exceedance value). The difference between the average annual applied surface water and the "reliable" water supply, Stratecon defines as the "unreliable" water supply. Stratecon then applied these definitions to SED applied surface water results for baseline and LSJR Alternative 3 to estimate how the flow objective could affect the reliability of surface water rights. However, the annual applied surface water volumes, estimated based on the Water Supply Effects (WSE) model results, do not correspond to the amount of surface water rights in the plan area. As described in Appendix G, *Agricultural Economic Effects of Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results*, applied water refers to water that is applied directly to a crop and can come from either groundwater pumping, surface water diversions, or both. Applied surface water is the applied water that was diverted from one of the eastside tributaries, which is estimated by partitioning gross surface water diversions from each river between different types of uses and losses. The reduction in applied surface water due to LSJR Alternative 3 is clearly documented in Appendix G and Chapter 11, *Agricultural Resources*. It is used to estimate potential fallowing, which was then a proxy for the potential conversion of Important Farmland to nonagricultural use for purposes of the environmental analysis (see Appendix B, *State Water Board's Environmental Checklist*, Section II, *Agriculture and Forest Resources*).

Finally, Stratecon coined a new economic variable called the "economic value of surface water rights" and asserted that LSJR Alternative 3 would reduce this value by 50 percent, relative to the baseline value. However, Stratecon does not attempt to estimate the actual economic value of water rights on the eastside tributaries. Instead, Stratecon estimates the reduction in economic value for surface water rights only in a relative sense by assuming that "reliable" water supplies are somewhere between 4 and 5 times more valuable than "unreliable" water supplies. The only support Stratecon provides for this assumption is a "case study" of Westlands Water District (WWD). Based on the case study, Stratecon estimated that WWD paid up to 5 times more for water transfers during 2015 and 2016 than before the drought. However, WWD is a Central Valley Project (CVP) contractor located outside of the plan area on the west side of the San Joaquin Valley in an area of salty soils and poor-quality groundwater with a history of paying extremely high prices for water transfers. WWD does not rely on the Stanislaus, Tuolumne, or Merced Rivers, but is instead a south-of-Delta CVP contractor for export water supplies with one of the lowest priorities for CVP water and therefore one of the first subject to contractual shortages. It is unclear why Stratecon chose WWD in Fresno and Kings Counties for the case study when Stratecon was working for San Joaquin, Merced, and Stanislaus Counties at the time and would be assumed to have access to its clients' relevant data and a wide number of real-world examples within the plan area. Furthermore, it is unclear, in the context of water rights and economics, how this becomes an acceptable evaluation of the potential water supply effects associated with the LSJR plan amendments. No further response will be made related to the "economic value of surface water rights" theory in the Stratecon report.

Groundwater Pumping

One of the major assumptions in the Stratecon report that differs from what was assumed in the SED is the amount of supplemental groundwater pumping that would be performed to replace reduced surface water supplies for agricultural uses. For the SED agricultural analysis, the irrigation districts are generally assumed to fully replace any reduction in their surface water supplies up to their 2009 groundwater pumping capacities. However, in times of severe surface water shortage, the SWAP model assumes the districts can strategically employ existing groundwater pumping capacity up to 2014 pumping levels to preserve permanent crops and corn silage. Once the capacity is reached, and if the additional groundwater pumping still cannot replace all the reduced surface water, then there would be an agricultural water shortage. These assumptions reflect the historic behavior of growers in the plan area that have access to both surface water and groundwater supplies, the investment those growers have in well pumping infrastructure, and the current regulatory climate. Furthermore, it is necessary for the analysis to provide a reasonable representation of both the potential effects on agricultural and groundwater resources. Stated another way, although groundwater pumping lessens agricultural impacts by providing additional water supply, it increases impacts to groundwater resources, which must also be reasonably captured in an environmental analysis.

In contrast, the Stratecon analysis relies exclusive on the experience of WWD in Fresno and Kings Counties in order to assume that additional groundwater pumping in the irrigation districts can only offset up to 50 percent of any reduction in surface water supplies. In this way, Stratecon's estimated land fallowing under SED40 becomes much larger than what is reported in the SED for LSJR Alternative 3, and hence the associated economic impact is much larger than what is reported in the SED. To estimate groundwater pumping, Stratecon plotted the historical groundwater pumping for WWD vs. the percentage of CVP allocation for WWD, and added a linear trend line to fit the scatter plot (Figure A1.4 of the Stratecon report). The trend line shows that for every 119,500 thousand acre-feet (TAF) increase in CVP allocation, there would be 60,000 TAF of decrease in groundwater pumping in WWD. Since 60,000/119,500 ≈ 0.5, Stratecon asserts a generic claim that additional groundwater pumping can only offsets 50 percent of the reduction in surface water supplies. However, Figure A1.4 of the Stratecon report only indicates that WWD pumped a certain amount of groundwater in response to the changes in CVP allocation, which was a decision made by WWD. Nothing in Stratecon's report explains why or how WWD decided how much groundwater should be pumped or how this is analogous to the plan area.

It is speculative to assume that what happened in WWD can be or should be applied in the plan area. Conditions in WWD are very different from those in the plan area irrigation districts, particularly with regards to hydrogeological characteristics of the underlying aquifer, groundwater conditions, irrigation patterns, irrigation drainage, contractual arrangements with respect to surface water delivery, etc., all of which can affect groundwater use. Even as between WWD and other water districts on the west side of the San Joaquin Valley, conditions differ (USCID 2002. It is also important to note that, due to its own unique circumstances, WWD only received more than 75 percent of its CVP contractual entitlement of 1.193 million acre-feet seven times between 1991 and 2016 (CRS 2016). In addition, WWD's groundwater pumping is limited in some areas when the "quality of groundwater below the base of fresh water exceeds 2,000 per million total dissolved solids (TDS) which is too high for irrigating crops" (Westlands 2016). The situation in WWD is unique and different from what occurs in the irrigation districts on the eastside tributaries. Therefore, it is inappropriate to apply WWD's experience to the plan area.

As part of its agricultural analysis, Stratecon took one more step and created a second groundwater use scenario based on its own assumptions regarding future SGMA implementation. In this scenario, it is assumed that "the implementation of measures to meet the SGMA objectives would keep the

Irrigation Districts from responding to surface water supply reductions with any groundwater pumping." That is, there would be no additional groundwater pumping in Stratecon's second scenario. This assumption is unsupported because SGMA is not a moratorium on groundwater pumping or a remedial statute that requires basins to be returned to a pre-SGMA levels. Instead, sustainable groundwater management is defined under SGMA as the "management and use of groundwater in a manner that can be maintained during the [50-year SGMA] planning and implementation horizon without causing undesirable results" (Wat. Code § 10721 (v)). SGMA requires that local public agencies form groundwater sustainability agencies (GSAs) and determine the best approach to sustainably manage their groundwater and surface water resources in order to ensure their basin is operated within its sustainable yield. GSAs will do this by developing and implementing groundwater sustainability plans (GSPs) that outline projects, programs, and enforcement actions. Such actions could be, but are not limited to water conservation and improvements in irrigation efficiency and aquifer storage and recovery. In other words, SGMA contemplates that groundwater substitution could occur, and would likely occur. As stated in the *Overview* to this master response, SGMA allows "overdraft during a period of drought…if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods" (Wat. Code § 10721(x)). Thus, it is reasonable to assume that the strategic use of increased groundwater pumping would also occur in critically dry years under SGMA in a sustainably managed basin.

Furthermore, no GSPs have yet to be developed as of the writing of this master response; any level of groundwater pumping or recharge resulting from implementation of a hypothetical GSP would be speculative conjecture at this point. In addition, a GSP which completely prohibits groundwater pumping would be highly unlikely and is not consistent with observed behavior. For more information regarding SGMA and groundwater modeling, including a discussion of why a "with SGMA" baseline was not appropriate for the purposes of the State Water Board SED analyses, please see Master Response 3.4, *Groundwater and the Sustainable Groundwater Management Act*. Because the Stratecon analyses are based on underlying assumptions that appear unreasonable, no further response is provided.

Groundwater Elevation and Groundwater Pumping Cost

To estimate the potential reduction in groundwater elevation that could occur if the irrigation districts in the plan area responded to the reduction in surface water supply by pumping more groundwater, Stratecon also did a regression analysis using data from what they identify as a "natural experiment." This regression uses historical well elevation data from four wells in San Joaquin County as the independent variable, and surface water deliveries, annual change in well elevation and rainfall in Stockton as predictor variables, in order to estimate the impact of surface water deliveries on well elevations. The wells are all located in a small area in the southeast corner of the county. The results of the regression analysis showed that surface water deliveries increased well elevations significantly for three of the four wells. The regression coefficients of surface water deliveries variable that Stratecon computed for those three wells are 0.6, 1.0 and 1.5, that is for each TAF of surface water delivered, there would be a 0.6 (low), 1.0 (middle), 1.5 (high) feet of increase in elevation in those three wells, respectively. For the Central San Joaquin Water Conservation District (CSJWCD), those three coefficients were multiplied by the potential reduction in surface water supply under SED40 to calculate the potential range of decrease in well elevations (from 0.6 feet/TAF as low estimate to 1.5 feet/TAF as high estimate) due to SED40. To obtain the potential range of decrease in well elevations in other irrigation districts, those three coefficients were adjusted (multiplied by the ratio of the irrigated area in CSJWCD to the irrigated area in the respected district) and then multiplied by the potential reduction in surface water supply under SED40. Such decrease in well elevation, that is, the additional lift needed to pump groundwater, became the basis for calculating the higher pumping costs as groundwater elevation decreases later in Stratecon's report.

However, the regression model has problems, including the following. First, unsustainable groundwater pumping is the direct cause of decline in groundwater elevation. Reduction in surface water is not the direct cause. It is true that reduction in surface water supply can prompt water users to pump more groundwater in order to meet the same demand, but water users can also respond by adopting more efficient irrigation method, changing crop patterns, and other actions. On the other hand, groundwater pumping can increase even when surface water supply is not reduced-for example, if growers decide to plant more crops. Therefore, the regression model does not reflect a credible cause-and-effect relationship between the dependent variable and the predictor variable to begin with.

Second, this regression can only reflect how groundwater elevation will change in response to groundwater pumping in the specific location or within a small area. The SED is a programmatic review, which assess the impact of LSJR alternatives on a subbasin scale. Therefore, such regression analyses are not suitable for the scope of the SED. However, if a regression analysis is applied, it is inappropriate to use the results from three wells that are concentrated in one area to represent the groundwater conditions and hydrogeological characteristic of the entire plan area. Once again, given that Stratecon was under contract July 2016 (Stanislaus 2016) to prepare the economic analysis dated January 6, 2017, it is unclear why a wider sample of plan-area specific data from its client agencies was not incorporated.

Agricultural Production

Stratecon attempted to estimate the reduction in agricultural production (in dollars) that would result from LSJR Alternative 3 after applying their lower levels of supplemental groundwater pumping. For this analysis, "Stratecon extrapolated directly from the SWRCB's estimates for each Irrigation District of the relative impacts on crop production by crop type as a result of SWRCB's estimates of water supply changes by matching the proportionality of impacts between crop groups modeled by the SWRCB each year of the Study Period." No further detail is given on the methods for extrapolating their results. In other words, rather than perform an actual analysis of how the reduced water deliveries would affect agricultural production using physical models, Stratecon merely extrapolated how crop production would change based on the water delivery and crop production results presented in the SED.

For the SED, changes in agricultural production are determined using the SWAP model, a widely-used regional economic model for agricultural production in California. The SWAP model estimates how changes in surface water diversions and groundwater pumping will affect agricultural production and related revenues in the irrigation districts by allocating available water supplies among different crop types in order to optimize (maximize) net revenues. When water supplies are not enough to meet all crop demands the model applies deficit irrigation and fallows lower net revenue acres to optimally use the available supplies. Inputs to the SWAP model are specific to the region of interest. For a description of the SWAP model, please see Appendix G, *Agricultural*

Economic Effects of Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results, and Master Response 8.1 *Local Agricultural Economic Effects and the SWAP Model*.

Impacts on the Dairy and Livestock Industries

The analysis prepared by Stratecon focused on a perceived lack of a quantitative analysis in the SED of impacts on dairies from reduced feed production as a result of the plan amendments (p. 68). The authors acknowledge the complexity in developing an estimate but suggest that an "order of magnitude" estimate could be prepared, under a certain set of assumptions: (1) that no feed substitutes are available for locally produced hay and grain, and (2) that a certain percentage (e.g., 15 percent) decrease in grain, hay, and pasture would result in a comparable percentage (e.g., 15 percent) contraction in the dairy and livestock sectors. However, neither assumption is a reasonable or realistic representation of the circumstances facing dairies in the San Joaquin Valley, and the outcome of applying these assumptions would substantially overstate the impacts on dairies and livestock.

First, dairies in California are known to be very adaptable at determining the ration of feeds from many sources, including alfalfa hay, corn silage, corn grain, soy and canola meals, small grain forage, and byproducts such as almond hulls (Silva-del-Rio et al. 2011; Putnam et al. 2016; Asmus 2015). During the drought, and even outside of drought conditions, dairy operators responded to some reduction in corn silage production by instead purchasing sudan silage, buying more grain corn, incorporating more almond hulls, or stockpiling more alfalfa (Lee 2014). In addition to adjusting rations, some growers traveled further for corn silage, even with (1) increased cost of transport, and (2) prices that were nearly double that of a few years earlier (Lee 2014; CDFA 2018). In short, feed substitutes are very likely to be available for diaries even in very dry years.

Second, there is no supporting evidence that a certain percentage decrease in grain, hay, or pasture would translate to a similar percentage reduction in the dairy or livestock sectors. Feed costs represent approximately 59 percent of total costs for dairy operations, but "wet feed & wet roughage," which includes corn silage, represent only about 14 percent of total costs (CDFA 2016, p. 7). Grain and pasture are an even smaller share of costs. During the recent drought, from 2011 through 2015, feed costs ranged from 59 to 66 percent of total costs (CDFA 2016, p. 9). Nevertheless, dairy output remained high, despite significantly lower production of silage and grain. A much more significant factor in the magnitude or profitability of dairies is the price of milk: when milk prices are relatively high (as they were in 2014), dairies are willing to pursue and obtain feed substitutes to maintain high production levels.

Finally, California has historically drawn "much of the alfalfa hay produced in neighboring states, particularly Nevada and Utah, but also Oregon, Arizona, and sometimes Idaho" (Klonsky et al. 2007; Knapp 1990). Ten years ago it was estimated that 8 to 12 percent of alfalfa utilized in California was imported from other states. Recent estimates indicate that "California also attracts between 600,000 and 1 million tons of hay from neighboring states" (Putnam et al. 2016). It is quite possible that a decrease in local hay production in the three-county area may lead to greater imports of hay from elsewhere, including counties adjoining the plan area, more distant counties, and neighboring states, as discussed previously in this master response under *Cost Role of Silage in Dairy Operations, Substitution and Alternative Feedstock Options to Corn Silage*.

Stratecon compounds the fallacy of its "order of magnitude" calculation by applying the same two assumptions (no feed substitutes, and one-to-one feed acreage to dairy contraction) to estimating multiplier impacts using the IMPLAN model (pp. 100-109). After making certain aggregation adjustments to the base IMPLAN model to avoid double counting, the authors applied the acreage reductions in grain, silage, and pasture as "direct impact" inputs to IMPLAN. The year-to-year variations shown in the authors' Figures 10.9 through 10.16 lends further support for the contention made in the SED that determining impacts to dairies (and livestock) is too complex to quantify. In particular: dairy operators respond to many different market forces, especially milk prices, but also cost and availability of alternative feed sources. Dairy output levels have not been so directly correlated historically with feed acreage. In addition, even assuming that the high correlation is accurate, dairies are unable to expand and contract (i.e., purchase or sell off cows) from year to year to the degree suggested by the figures in the report.

Conclusion

Stratecon's estimate of the impact on the regional economy is much higher than the SED because the above analyses overestimate impacts on agricultural production, especially by using equivalencies based on the out-of-region and uniquely situated WWD, and then cascade these asserted effects into other sectors. Furthermore, in its analyses, Stratecon generally presented the maximum value of impacts and used that value to calculate the extreme worst-case scenario (rather than a "most likely" outcome). For agricultural impacts, reductions in hay and silage were tied to a direct impact on dairies (i.e.,, no substitution of feedstock), thus resulting in an extreme set of impacts on the region. The Stratecon analysis substantially overstates the impacts on dairies and livestock operations by applying unrealistic assumptions to create "upper bound" scenarios. Furthermore, in presenting the increased cost of groundwater pumping from changes in groundwater depth, Stratecon chose to discuss the result using the maximum decrease in the well elevation seen in their experiment. This is misleading and exaggerates the impact. In contrast, the SED presents a more reasonable scenario of what would happened in response to the LSJR alternatives based on historical observation.

Economic Analysis Presented by Merced Irrigation District

The economic analysis presented by Merced ID (herein after referred to as the Merced ID Report)[7] attempted to estimate the potential economic impacts for Merced County of a 40 percent unimpaired flow requirement from February to June on the Merced River. The State Water Board considered this report, which estimated that the economic impact of the 40 percent unimpaired flow requirement for Merced County would average $0 in wet and above normal years, $132 million in below normal years, $238 million in dry years, and $155 million in critical years. The report applies several modeling tools, including economic models that were also used in the SED economic analysis, but the authors make several significant and unsupported assumptions that are different from those of the State Water Board. Ultimately, these differences cause the estimates of economic impacts to be substantially higher than from those in the SED. The Merced ID Report includes four key components that are the basis of its estimate of impact: crop production losses, animal product losses, processor impacts, and regional impacts. The latter two impact components are directly multiplicative of the first two.

[7] Merced ID. 2016. *Economic Impacts of Reduced Water Availability to Merced Irrigation District*. Prepared by Cardno and Highland Economics. July.

Surface Water Deliveries and Groundwater Use

The Merced ID Report indicates that a hydrologic model was used to estimate canal deliveries, water availability for the Lake Don Pedro Community Services District (LDPCSD), and Merced ID hydropower generation. Results were estimated for two scenarios: a baseline conditions scenario; and, a SED scenario that consisted of a 40 percent unimpaired flow requirement on the Merced River. Then, the results of these two model runs were used as inputs to the various economic analyses described in the report. The modeling period for the hydrologic model was 1922 to 2014, which is 11 years longer than the modeling period used in the SED and WSE model (1922 to 2003). However, the Merced ID Report does not include further description of the hydrologic model and the assumptions used to characterize baseline conditions or the SED scenario. This makes it impossible to examine why hydrologic results presented in the Merced ID Report are different from those estimated by the WSE model.

In the Merced ID Report, it was assumed that no additional groundwater pumping would occur to supplement surface water reduction because SGMA will limit the ability of the district to pump groundwater in the future. However, this assumption is speculative because, as discussed previously in the *Overview* and the discussion of the Stratecon Inc. economic report, SGMA is not a moratorium on groundwater pumping or a remedial statute that requires basins to be returned to a pre-SGMA level. As GSPs have not yet been developed, it is unknown exactly what measures the GSAs would take to comply with SGMA, but it is unlikely that it would completely prohibit groundwater use. Opportunistic groundwater pumping during dry periods would likely still occur, as long as it is balanced out with greater recharge during wetter periods. For more information regarding SGMA and groundwater recharge, please see Master Response 3.4, *Groundwater and the Sustainable Groundwater Management Act*.

To avoid masking potential groundwater impacts and speculating on the implementation of SGMA, it was assumed in the SED that the irrigation districts would respond to surface water reductions by pumping groundwater, as they have in the past. The Merced ID Report itself mentions on page 2-10 that over the recent drought Merced County agriculture increased in value, partially because groundwater was used to mitigate reduced surface water supplies. Ultimately, including supplemental groundwater pumping mitigates the effects of surface water reduction by providing more water for irrigation, which, in turn, will reduce the agricultural impacts. However, it increases impacts on groundwater resources, which is captured in the SED analyses.

Use of the SWAP Model

Similar to the State Water Board SED analyses, Merced ID also used the SWAP model to analyze how changes in irrigation water supplies would affect crop production. However, Merced ID made several modifications to SWAP for this analysis that cause results to diverge from those presented in the SED. The primary modifications made in Merced ID's analysis are as follows.

1. The geographic scope was updated to represent only agricultural production receiving Merced ID surface water deliveries. This includes Class I and II users within the district, Stevinson Irrigation District, and other areas in Merced ID's sphere of influence. Cropping patterns and crop acreages were also updated to represent these areas based on values reported by Merced ID. Individual crops were combined into 11 aggregate crops that represented the majority of crops grown in the district or on other lands that received surface water from the district. For each aggregate crop, University of California Cooperative Extension (UCCE) studies were used to

update production costs and applied water rates. Average crop yields and revenues for the aggregate crops were estimated based on data from Merced County Agricultural Commissioner's annual reports. Water prices were updated to the price of water charged by Merced ID in 2013.

2. Because of the importance of the dairy and cattle industries, fallowing of animal feed crops (corn silage, alfalfa, and irrigated pasture) was restricted to no more than 50 percent of the baseline acres. This constraint was added to balance reduction of different crop-types, assuming that 50 percent of the animal feed crops would remain in production even if it would impact higher net revenue vegetables or perennial crops.

3. For permanent crops, any reduction in fruit and nut production was modeled as a reduction in yield, rather than a reduction in acreage planted, by using deficit irrigation yield curves. These curves were developed based on literature review of the effects of deficit irrigation on almonds, peaches, and grapes. In other words, it was assumed that permanent crops would not be fallowed even under reduced water supply, but would receive less applied water per acre, which would result in less yield per acre.

Please see Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results,* and Master Response 8.1, *Local Agricultural Economic Analysis and the SWAP Model*, for discussion of the revised SWAP model run and how it was used in the SED analysis. For the SED, the geographic scope of SWAP was also updated to represent Merced ID (as well as the other irrigation districts diverting water from the eastside tributaries). However, only the areas receiving surface water within Merced ID's boundaries were represented in the revised SWAP analysis (any surface water reduction from Merced ID for Stevinson Irrigation District and the areas in Merced ID's sphere of influence is assumed to be replaced with groundwater, therefore there is no agricultural impact in these areas). Relative cropping patterns and crop applied water rates were defined based on 2010 DWR Detailed Analysis Unit (DAU) data. The DWR DAU data is divided into 20 aggregate crops. 2010 DWR DAU data was used in the analysis because it corresponds to the baseline period for the SED and because it is part of a statewide, consistent database supported by a sister agency. Please see Master Response 2.5, *Baseline and No Project*, for information regarding the data used in the analysis. Crop production costs, crop yields, water prices, and crop prices are based on the CVPM data that was already in the SWAP model database corresponding to the area of Merced ID and were not changed for the SED.

Please also see Master Response 8.1 for discussion of the assumptions used in the revised SWAP model run, including constraints on corn silage, deficit irrigation, and fallowing of permanent crops. In the revised SWAP analysis, SWAP models two options that growers of permanent crops can apply in response to reductions in water delivery, deficit irrigation and early retirement of older plants already near the end of their productive lifespan. Though yield was not reported in the SWAP model output for the SED, gross revenue results can be used as a proxy for yield to observe the effect of deficit irrigation on crop production. During periods of deficit irrigation, the gross revenue per acre will be reduced from periods of full water supply.

With regards to dairy feed crops, it was also assumed in the SED that substitute feed crops could be imported from other areas to mitigate reduction in animal feed crops in the plan area. However, corn silage is difficult and expensive to transport because it is wet and heavy. Therefore, a constraint was included in the SED revised SWAP analysis to limit fallowing so that 70 percent of the baseline acres of corn silage would stay in production even if higher net revenue vegetable crops would be fallowed or deficit irrigation would be applied to perennial crops.

Effects on Dairy and Cattle Industries

Merced ID estimated impacts to the dairy and cattle industries by assuming a linear relationship between the number of acres of feed crops grown with surface water from Merced ID and the volume of animal production in the county. In other words, every acre of feed crop grown was assumed to support a certain number of cows and, in turn, a certain amount of milk and beef production. The linear relationship between feed acres and dairy and cattle production assumes that finding replacement feed supplies is not economical. For dairies, a 1-acre reduction of alfalfa or corn silage was estimated to cost $3,617 in milk production, based on the Merced County Agricultural Commissioner's annual estimate of milk production value multiplied by the percentage of the counties corn silage grown on surface water deliveries from Merced ID. For cattle, a 1-acre reduction of irrigated pasture was estimated to cost $9,931 in beef production, based on statistics from the Merced County Agricultural Commissioner's annual reports for the average price of beef, average beef yield per cow, and the ratio of cattle to irrigated pasture in Merced County.

However, this analysis presents an oversimplification of how the agricultural economy operates and ignores the adaptability of the dairy and livestock industries, thus overestimating potential impacts. These impact estimates assume 1:1 relative relationships between the acreage of specific feed crops and production in the downstream industries (silage corn for dairies and irrigated pasture for beef). In other words, a 1 percent reduction in corn silage acreage will result in a 1 percent reduction in the revenue generated from milk production. For this assumption to hold, historical data should show that herd size fluctuates with feed acreage, something that was not observed during the most recent drought, or more broadly in the past 25 years of dramatic growth in the dairy industry in the San Joaquin Valley.

This assumption ignores the many other factors that will affect production in the dairy and livestock industries, such as the ability to import feed supplies from other areas, the potential to modify food rations with substitute feed crops, and changes in the prices for both milk and beef.

The report argues that feed crops will not be imported because of the following reasons.

1. Corn silage is wet and heavy and, thus, expensive to transport.
2. The unimpaired flow requirements will reduce water supply for agricultural areas throughout Merced, Tuolumne, and Stanislaus counties, impacting the ability to import feed crops from those nearby areas.
3. SGMA will impact groundwater use and feed crop production across California.

It is true that corn silage can be expensive to transport (though it still could be economical depending on the distance and the price of milk), but there are alternative sources of roughage, which are cheaper to transport, that could be used as substitutes. Dairies in California are very adaptable, as evidenced during the recent drought, and could modify their feed rations in response to changes in feed availability. The ration chosen will depend upon relative prices of each commodity, availability of sources, and nutritional requirements of the cows. The economics of whether shipping replacement or substitute feed crops will depend on several factors, in particular the price of milk and beef. Higher prices will incentivize dairy owners and ranchers to find ways to increase production, even if it means paying higher feed transportation costs. Furthermore, even with unimpaired flow requirements on the eastside tributaries, feed crops could still be moved around from other areas within the counties not affected by the flow requirements or from other nearby counties in the San Joaquin Valley. It is also common for feed crops such as alfalfa to be imported from other states. Please see the section above regarding the potential economic effects on existing dairies and livestock operations. Finally, it is unknown how SGMA will be implemented and it is speculative to assume it would cause widespread shortage of feed crops across California.

For the SED, it was assumed that dairies and livestock operations would be able to adapt to reductions in feed crop production in the area of potential effects, as these industries have in the past. The first part of this assumption is that feed crops, such as alfalfa, would be imported from other parts of the state or from other states to maintain production levels. Silage, because it is expensive to transport, would be maintained to some degree even under reduced water supplies (hence the constraint on fallowing of corn silage represented in the revised SWAP model run). However, to the extent that there is some reduction in corn silage acreage, dairy rations could be modified and alternative sources of roughage could be imported that would be less costly to transport. Any additional feed imports for dairies and livestock operations would increase costs for the operations; however, these costs will depend on many unknown variables, such the distance feed would need to be transported. Increasing milk and beef prices could also offset the increased feed transportation costs. Please see Master Response 3.5, *Agricultural Resources*, for discussion of the potential effects on dairies and livestock operations.

Effects on the Food Processing Industry

Merced ID also estimated the forward-linkage impacts on food and beverage processing industries based on the changes in local crop production (as determined by SWAP) of crops that are used as inputs by processors, such as peaches, tomatoes, grapes, and nuts. In addition, effects on beef and dairy processors were also analyzed, based on changes in dairy and beef production calculated as described in the previous section. Impacts were determined for eight processing sectors from the IMPLAN model, with each sector represented by a single agricultural commodity (see Table 4-6 of the Merced ID Report). Changes in processor output value for Merced County were calculated using: (1) the proportion and dollar value of local crop production (or dairy/beef production) that is processed locally for each processing sector, and (2) the value of processing output per dollar of crop input. This information was estimated based data from various sources, including IMPLAN and interviews with growers and processors.

Like in the assessment of impacts on dairies and beef, this analysis also overestimates impacts because it assumes a linear relationship between changes in crop production and processor output. In the Merced ID Report, every dollar lost in crop production is translated into a reduction in processed product value (after being multiplied by the proportion of local crop production that is processed locally). For example, in the Merced ID Report it is assumed that 90 percent of local peach production is also processed locally and for every $1 lost from reductions in peach production $2.78 are lost in processing output; in other words, every $1 lost in local peach production is multiplied by $2.50 (90%*$2.78) to determine the impact to local processors. However, a linear relationship ignores the adaptability of the industry and the potential to import processing inputs from neighboring areas of the San Joaquin Valley. Furthermore, it is unclear how the two variables (the proportion of local crop production processed locally and the value of processing output per dollar of crop input) were determined for each processing sector. The report simply states that several data sources were used in their development, but does not actually describe how the data from these sources was used to determine the numbers.

The analysis presented above under the heading, *Potential Economic Effects on the Food Processing Industry*, shows that on average, in critical years, most crops do not have a large change in production relative to the total production over the three counties. The crops that do have relatively large changes are primarily low net revenue animal feed crops, which are not directly processed. Feed crops do support the dairies and cattle operations that, in turn, support milk and beef processors, but, as discussed previously, it is assumed that substitute feed supplies can be imported from other areas. With regards to other crop processing industries, results of the analysis above suggest that changes in processor inputs under LSJR Alternative 3 are relatively small and are likely to fall within normally anticipated annual variation in yields. Furthermore, food processors, like the rest of the agricultural economy, can adapt to small changes in crop production in the area of potential effects. The most likely form of adaptation would be to find alternative suppliers in the local area to replace reductions in processor inputs. This is possible as, for many crops, not all local production is used in the local processing industry. For example, as the Merced ID report indicates, only about 8 percent of local nut production is also processed in Merced County. Additionally, some crops, depending on how well they can be preserved in transit, could be imported from other areas of the San Joaquin Valley.

Regional Economic Effects

Merced ID assessed direct, indirect, and induced regional economic effects on economic output and employment in Merced County using the IMPLAN model. The analysis included the regional effects caused by changes in crop production, beef and milk production, and processor output. This analysis employed the 2013 IMPLAN database for Merced County. Several modifications were made to the IMPLAN model and data to better reflect conditions in Merced County and to avoid double counting of benefits in analyzing the food processing sectors. Unfortunately, since the direct impacts estimated by the SWAP model and the dairy, livestock, and food processing analyses are overestimated, the regional economic impacts will also be overestimated.

The analysis of regional economic effects in the SED used data from the 2010 IMPLAN model database. The 2010 database was used because it corresponds to the time period when the notice of preparation for the SED was released. However, IMPLAN multipliers for indirect and induced effects were extracted from the IMPLAN database and applied to the revised SWAP model direct revenue results for crop production in a postprocessing spreadsheet. This method helps provide more user control, but still operates in the same way the IMPLAN model would have to produce regional economic effects for the agricultural sectors of interest.

Municipal and Industrial Effects

Merced ID also estimated economic impacts to one relatively small municipal diverter from Lake McClure, the LDPCSD. LDPCSD generally diverts less than 1,000 AF/year. The economic impacts in the Merced ID Report are based on the cost to replace lost surface water diversions with groundwater. First, the number of months when surface water delivery to LDPCSD is interrupted is determined as the number of months that Lake McClure storage falls below 115,000 AF (at which point water level falls below LDPCSD's intake). Second, the cost per acre foot to pump groundwater is assumed to be $127.86/AF based on the unit capital and energy costs for a typical municipal well in the City of Modesto (assumes $60.05/AF for capital cost and $67.81/AF for energy cost). Finally, the analysis uses an average monthly demand of 50 AF; this puts the cost to supply LDPCSD with groundwater for one month at $6,393. Every month that LDPCSD's surface water supply is interrupted it is assumed that the district will pay $6,393 to pump groundwater for that month. However, this analysis overestimates the cost impacts to LDPCSD because it assumes they would need to construct new groundwater wells that would incur new capital costs. During the recent drought LDPCSD already developed three new groundwater wells to fully supply their water needs. Furthermore, a significant portion of the cost for building these wells was provided for through grants from the USDA, DWR, and the State Water Board (Kampa 2016).

In the SED the potential effects of the LSJR alternatives on service providers were qualitatively evaluated. This analysis was based on the estimated average annual reductions in tributary water supply calculated in the WSE model and information on the various mechanisms service providers use to obtain water supplies. Specific impacts to individual municipalities were not modeled because each service provider has unique circumstances and it is impossible to predict the actions each would take in response to water supply reduction. For discussion of the methodology and results of the analysis please see Chapter 13, *Service Providers*, and Master Response 3.6, *Service Providers*. Also see Chapter 22, *Integrated Discussion of Potential Municipal and Domestic Water Supply Management Options*, for discussion of management options for municipalities to deal with water shortage.

Hydropower Effects

Merced ID also used a spreadsheet model to evaluate potential economic impacts of reduced hydropower production. After reductions in hydropower generation were determined in the hydrologic model, the reductions were multiplied by an annual estimate of the dollar value per kilowatt-hour (kWh) to calculate the change in revenue. IMPLAN was used again to determine the indirect and induced effects associated with the change in this revenue.

In the SED, effects of the LSJR alternatives on hydropower are estimated in the WSE model for Lake McClure as well as other generating facilities downstream. The methodology and results of this analysis are presented in Appendix J, *Hydropower and Electric Grid Analysis of Lower San Joaquin River Flow Alternatives*. The economic effects of reduced hydropower generation are presented in Chapter 20, *Economic Analyses*. Please see Master Response 8.4, *Non-Agricultural Economic Considerations*, for discussion of potential effects on hydropower generation and results changes in revenues.

Conclusion

Overall, economic effects presented by Merced ID in its comment letter and in the Merced ID Report are overestimated compared to the SED due to several assumptions. The primary differences between the analyses are as follows.

- The assumption that no groundwater pumping will occur to offset surface water reductions.
- The assumption in the Merced ID Report's SWAP analysis that 50 percent of animal feed crops will be maintained.
- The estimated impacts on dairy and livestock industries, assuming that substitute feed crops would not be available.
- The estimated impacts on the food processing industry using IMPLAN, assuming that substitute inputs would not be available.

However, as described above, these assumptions are speculative and ignore historical responses. The impact estimates in the report represent a worst-case scenario ignoring the flexibility and adaptability in the agricultural industry. In contrast, the SED presents a more reasonable scenario of what would happened in response to the LSJR alternatives based on historical observation.

Economic Analysis Presented by Turlock and Modesto Irrigation Districts

The State Water Board also considered the economic analysis presented by the Turlock and Modesto Irrigation Districts (TID and MID).[8] The analysis is based on work performed by *Cardno ENTRIX* and *Highland Economics* and is an extension of the work performed previously for TID and MID as part of the Federal Energy Regulatory Commission (FERC) relicensing for New Don Pedro Reservoir (TID/MID 2014). Although the analysis uses similar modeling tools to those used in the SED to estimate the economic impacts, including the SWAP model, the authors apply them in extreme ways; for example, the analysis focuses only on critical water year types and suggests unlikely and restrictive responses by producers in order to justify a conclusion that economic losses could reach "just under $1.6 billion" annually. In contrast, the economic impact analysis presented in the SED is based on observed grower behavior and adaptation during past water shortages.

Surface Water Deliveries and Groundwater Use

A hydrologic operations model was used to determine the change in surface water available for diversion from the Tuolumne under the 40 percent unimpaired flow requirement. The modeling period for the hydrologic model was 1971 to 2016. The output of the model is the amount of water diverted under the 40 percent unimpaired flow requirement as a percent of the baseline. The resulting reduction in diversions determined in the TID and MID's operations model is lower than what is predicted in the WSE model.

TID and MID assumed that groundwater is not available above historical pumping volumes due to implementation of SGMA. However, this assumption is speculative, as discussed previously in this master response with regards to the analyses performed by Stratecon and Merced ID. Growers in TID and MID have invested substantially in groundwater infrastructure, and SGMA is not a moratorium on groundwater pumping or a remedial statute that requires basins to be returned to a pre-SGMA level. As GSPs have not yet been developed it is unknown exactly what measures the GSAs would take to comply with SGMA, but it is unlikely that they would adopt a blanket prohibition on groundwater use. Opportunistic groundwater pumping during dry periods would likely still occur, even if it creates overdraft, as long as it is balanced out with greater recharge during wetter periods. As discussed in the *Overview* to this master response, SGMA contemplates this strategic use of groundwater. For more information regarding SGMA and groundwater modeling, please see Master Response 3.4, *Groundwater and the Sustainable Groundwater Management Act*. To capture potential impacts to groundwater resources and to avoid speculating on the implementation of SGMA, it was assumed in the SED that the irrigation districts would respond to surface water reduction by pumping groundwater, as they have in the past.

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[8] Appendix C, *Comments on the SWRCBS's SED: Economics, Agriculture, Social and Environmental Justice*, and Appendix I to the joint MID/TID comment letter, *Regional Economic Impact Caused by a Reduction in Irrigation Water Supplied to Turlock Irrigation District and Modesto Irrigation District: Methodology Memorandum.* Based on work by Cardno ENTRIX and Highland Economics.

Use of the SWAP Model

Like in the SED, TID and MID also used the SWAP model to analyze how changes in irrigation water supplies would affect crop production. However, rather than running the model directly with the timeseries of varying canal deliveries, TID and MID ran the SWAP model 16 times, each time reducing the percent of surface water available, compared to baseline, in 5 percent increments, from 95 percent to 20 percent. Each model run produced estimates for the reduction in agricultural revenue output corresponding to the 5-percent incremental reductions in surface water diversions, relative to baseline. Annual surface water diversion results, as a percent of demand, for the 42-year modeling period from the operations model were then rounded to the nearest 5 percent and matched with the corresponding level of delivery in the suite of SWAP model runs. For example, the estimated surface water diversion in1976 was 68.1 percent of baseline, which would then be rounded up to 70 percent, meaning, the corresponding economic impacts would be those from the 70 percent SWAP model run.

In addition, several modifications were made to SWAP for TID and MID's analysis that cause results to diverge from those presented in the SED. The primary modifications are as follows.

1. The geographic scope was set to represent only agricultural production receiving surface water deliveries attributable to the Don Pedro Project. Cropping patterns and crop acreages were also set to represent these areas based on values reported by the districts. Individual crops were combined into nine aggregate crops to represent the majority of crops grown in the districts. For each aggregate crop, University of California Cooperative Extension (UCCE) studies were used for production costs and applied water rates. Average crop yields and revenues for the aggregate crops were estimated based on data from Stanislaus and Merced County Agricultural Commissioner's annual reports. For water prices, the rates charged by TID and MID in 2012 were used.
2. Since TID does not currently have policies that allow short term transfers of water between individual growers, it was assumed in their analysis that growers could not conduct intra-district transfers to transfer water from lower value crops to higher value crops during water shortages. Instead all crops were assumed to receive a uniform reduction in water supply equal to the relative reduction in canal deliveries from the Tuolumne. For example, if canal deliveries were 10 percent less than baseline, then all crops would receive 10 percent less water, regardless of their net-revenue value.
3. For permanent crops, any reduction in fruit and nut production was modeled as a reduction in yield, rather than a reduction in acreage planted, by using deficit irrigation yield curves. These curves were developed based on literature review of the effects of deficit irrigation on almonds, peaches, and grapes. In other words, it was assumed that permanent crops would not be fallowed even under reduced water supply, but would receive less applied water per acre, which would result in less yield per acre.

Please see Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results,* and Master 8.1, *Local Agricultural Economic Analysis and the SWAP Model*, for discussion of the revised SWAP model run and how it was used in the SED analysis. For the SED, the geographic scope of the SWAP model was also updated to represent TID and MID (as well as the other irrigation districts diverting water from the eastside tributaries). However, relative cropping patterns and crop applied water rates were defined based on 2010 DWR DAU data. The DWR DAU data is divided into 20 aggregate crops. 2010 DWR DAU data was used in the analysis because it corresponds to the baseline period for the SED and because it is part of a statewide, consistent database supported by a sister agency. Please see Master Response 2.5, *Baseline and No Project*, for information regarding the data used in the analysis. Furthermore, crop production costs, crop yields, water prices, and crop prices are based on the CVPM data that was already in the SWAP model corresponding to the area of TID and MID and were not changed for the SED.

Please also see Master Response 8.1 for discussion of the assumptions used in the SWAP model, including intra district transfers, deficit irrigation, and fallowing of permanent crops. For the SED, reduced water supplies for permanent crops were modeled in two ways, either with deficit irrigation or with a reduction in acreage to represent early retirement of older plants already near the end of their productive lifespan. Though yield was not reported in the SWAP model output for the SED, gross revenue results can be used as a proxy for yield to observe the effect of deficit irrigation on crop production. During periods of deficit irrigation, the gross revenue per acre will be reduced from periods of full water supply.

Effects on the Dairy and Cattle Industries

TID and MID conducted two analyses to determine the range of possible economic impacts to the dairy and cattle industry. Maximum impacts were estimated by assuming a linear relationship between the acreage of feed crops grown in the districts and the volume of animal production. In other words, every acre of feed crop grown was assumed to support a certain number of cows and, in turn, a certain amount of milk and beef production. The linear relationship between feed acres and dairy and cattle production assumes that finding replacement feed supplies is not economical. Minimum impacts were estimated assuming that it is possible for dairy and cattle operations to fully replace any reduction in feed supplies with imported feed. In this scenario, there are no direct impacts on production of milk or beef and, therefore, there is no reduction in total revenue. However, there is an additional cost of transportation to import feed from other areas. The additional cost reduces the net revenue of the dairy and cattle operation owners and, thus, reduces their spendable income.

For the SED, like in the minimum impact scenario presented by TID and MID, it was assumed that dairies and livestock operations would be able to adapt to reductions in feed crop production in the area of potential effects, as these industries have in the past. The first part of this assumption is that feed crops, such as alfalfa, would be imported from other parts of the state or from other states to maintain production levels. Silage corn, because it is expensive to transport, would be maintained to some degree even under reduced water supplies (hence the constraint on fallowing of corn silage represented in the revised SWAP model run). However, to the extent that there is some reduction in corn silage acreage, diary rations could be modified and alternative sources of roughage could be imported that would be less costly to transport. Any additional feed imports for dairies and livestock operations would increase costs for the operations; however, these costs will depend on many unknown variables, such the distance feed would need to be transported. Increasing milk and beef prices could also offset the increased feed transportation costs. No information is given in Appendix I of TID and MID's comment letter as to how feed transportation costs were estimated. Please see Master Response 3.5, *Agricultural Resources*, for discussion of the potential effects on dairies and livestock operations.

Effects on the Food Processing Industry

Similar to the procedure used for dairies, TID and MID conducted two analyses to determine the range of possible economic impacts to the food processing industry. Maximum impacts for non-animal processing sectors were estimated by assuming a linear relationship between the acreage of input crops grown (as determined by the SWAP model) in the districts and the volume of processor output. In addition, effects on beef and dairy processors were also estimated in the same way based on the maximum impacts to dairy and beef production calculated as described in the previous section. Impacts were determined for 10 processing sectors from the IMPLAN model (5 based on crop production, 4 based on dairy output, and 1 based on beef output), with each sector represented by a single agricultural commodity (see Table 4-6 of the Merced ID Report). The linear relationship assumes that finding replacement processing inputs from nearby areas is not economical. Minimum impacts were estimated assuming that it is possible to import processor production inputs from the surrounding area. Furthermore, no increase in transportation cost is applied as IMPLAN data shows that there are enough crop supplies grown locally to offset reduced crop production under the LSJR alternatives. Under the minimum scenario it is assumed that there is no impact to output from the local dairy and beef industries and thus no effect on associated processors.

The analysis presented above under the heading, *Potential Economic Effects on the Food Processing Industry*, shows that on average, in critical years, most crops do not have a large change in production relative to the total production over the three counties. The crops that do have relatively large changes are primarily low net revenue animal feed crops, which are not directly processed. Feed crops do support the dairies and cattle operations that, in turn, support milk and beef processors, but, as discussed previously, it is assumed that, given the value of the industry, substitute feed supplies can be imported from neighboring areas and other states. With regards to other crop processing industries, results of the analysis above suggest that changes in processor inputs under LSJR Alternative 3 are relatively small and are likely to fall within normally anticipated annual variation in yields. Furthermore, food processors, like the rest of the agricultural economy, can adapt to small changes in crop production in the area of potential effects. The most likely form of adaptation would be to find alternative suppliers in the local area to replace reductions in processor inputs. According to Appendix I of MID and TID's comment letter (page 2-14) "IMPLAN data indicates that, even in 25 percent water years, there may be sufficient local supply to meet local processor demand (i.e. local production still exceeds local demand within aggregated crop categories)." This suggests that even under a very limited water supply for MID and TID processors in the area may still be able to find raw inputs. Additionally, some crops, depending on how well they can be preserved in transit, could be imported from other areas of the San Joaquin Valley.

Regional Economic Effects

TID and MID assessed direct, indirect, and induced regional economic effects on economic output and employment in Stanislaus, Merced, and Tuolumne Counties using the IMPLAN model. The analysis included the regional effects caused by changes in crop production, beef and milk production, and processor output. This analysis employed the 2012 IMPLAN database for Stanislaus, Merced, and Tuolumne Counties. Several modifications were made to the IMPLAN model and data to reflect conditions in the counties and to avoid double counting of benefits in analyzing the food processing sectors.

The analysis of regional economic effects in the SED used data from the 2010 IMPLAN model database. The 2010 database was used because it corresponds to the time period when the notice of preparation for the SED was released. However, IMPLAN multipliers for indirect and induced effects were extracted from the IMPLAN database and applied to the SWAP model direct revenue results for crop production in a post-processing spreadsheet. This method helps provide more user control, but still operates in the same way the IMPLAN model would have to produce regional economic effects for the agricultural sectors of interest.

Breakdown of TID/MID Economic Impact Estimates

As discussed above, the comment authors attempted to estimate both minimum and maximum potential impacts to MID and TID, in order to bound what could occur; however, their comments focus on the maximum (worst case) scenario rather than what is most likely to happen. In particular, the commenters focused on a nearly $1.6 billion per year impact to TID and MID, based on what could have happened in 2015/2016 assuming the maximum impact scenario described above. However, this estimate presents a set of circumstances that reflect conditions from one of the worst critical years in history, as well as modeling scenario that includes assumptions that is inconsistent with grower behavior, responses by dairies and cattle and calf operators that are unrealistic, and effects on processors that are exaggerated.

In contrast, as indicated in Table 8.2-10 in this master response, the revised estimate of average annual regional economic impact is $69 million *for the entire plan area*, with a potential for modest additional, but unquantified, costs to dairy and beef cattle operations. In critical water years, the regional economic impact would be larger, averaging $229 million per year, but this estimate is still a fraction of what was estimated by the commenters. The plan amendment represents a permanent change to the pattern of water supplies, and growers' long-term cropping decisions will certainly be influenced by water availability. Short-term drought response can be instructive, but it is this long-term consequence and the economic factors that affect individual decisions that is intended to be captured by the State Water Board's SWAP modeling.

The major share, or $1.285 billion, of the commenters $1.6 billion per year impact estimate comes from three related secondary components that progressively magnify the economic effect: impacts to animal commodities, processing of crops and animal products, and the tertiary ("ripple effects") resulting from these secondary impacts. First, animal commodities (milk and beef cattle), it is asserted, would be affected by loss of locally-sourced feed when silage, alfalfa, and irrigated pasture acreage would decline in critical years. Without support, the authors suggest that herd sizes would be "permanently reduced" by 15 to 30 percent as a result of critical year acreage shortages, and these would cause $266.2 million in losses. As noted in some detail in this master response, dairies and beef cattle operators have opportunities to obtain replacement feed, and make herd size decisions that relate far more to commodity prices than to feed supplies. Second, reduced processing of animal products (milk and beef), and of other crop commodities, represents $590.6 million of their $1.285 billion total. However, this impact is solely contingent on the assumptions about crop and animal production, discussed above. Finally, tertiary-level ("ripple") impacts caused by reduced economic output from animal commodities and food processing, which the authors estimate to be $428.7 million, are so-called multiplier effects that rely directly upon the validity of the direct effects to the industries.

The remainder of the estimated $1.6 billion impact is from reduced crop production (which accounts for $166.9 million) and the indirect and induced effects (which accounts for about $132.9 million) it would have on the regional economy. The commenters' central argument about crop production impacts is that growers cannot transfer water within districts and that each grower is affected equally by water supply changes, (Although only TID has this policy explicitly, the authors apply the same "rule" to MID.) For the crop-related economic impacts, this means that all crops share proportionally in the impacts (see commenter's Appendix I, Figure 7, p. 2-7). This modeling approach suggests that *all* crops and crop types are affected, rather than it falling largely on lower net-revenue crops. When higher net-revenue crops are reduced, they represent a higher cost and higher proportion of the total impact. However, this assumption runs contrary to observable grower behavior by ignoring economic and market forces. Short-term options, within a critical water year, are certainly limited for growers, but they are also willing to make cropping decisions for a variety of market and other reasons. Figure 8.2-2 in this master response shows cropping patterns do change from year to year. The commenter's estimates are also inflated due to the inclusion of an additional restriction on replacement groundwater as an implied result of SGMA. As discussed in Master Response 3.4, *Groundwater and the Sustainable Groundwater Management Act*, blanket prohibitions are unsupported as SGMA is not a moratorium on groundwater pumping. Finally, in a similar manner as noted above, tertiary-level ("ripple") impacts caused by reduced economic output from crop production, are so-called multiplier effects that rely directly upon the validity of the direct effects on the industry.

Conclusion

Overall, the range of economic impacts predicted by TID and MID is quite large as shows how changing assumptions can drastically change results. For the minimum impact scenario, the districts estimate that the average annual impact to direct output would be $57.7 million per year. For the maximum impact scenario, the districts estimate that the average annual impact to direct output would be $343.3 million per year. These estimates vary from the $69 million annual average economic impact estimated in the SED for the following reasons.

- The SED includes economic impacts to other irrigation districts that could be affected under the LSJR alternatives.
- The SED includes San Joaquin County in it regional economic analysis.
- TID and MID include Tuolumne County in their regional economic analysis.

However, both the minimum and maximum impact scenarios use assumptions that likely overestimate the economic impacts. The minimum impact scenario overestimates economic effects by assuming that no groundwater pumping will occur to mitigate surface water reduction. The maximum impact scenario overestimates economic effects by assuming that no groundwater pumping will occur to mitigate surface water reduction and that the dairy, beef, and food processing cannot adapt and will be unable to find replacement feed and input supplies to continue production.

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