

Appendix D

Statewide Agricultural Production Model Documentation

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Appendix D

Statewide Agricultural Production Model Documentation

D.1 Introduction

This technical appendix describes the agricultural economic model used in the analysis of Central Valley Project (CVP) Municipal and Industrial Water Shortage Policy (M&I WSP) alternatives. The scenarios evaluated for the Environmental Impact Statement (EIS) include Existing Conditions, the No Action Alternative, and action alternatives provided from CalSim II model output that were designed to cover the range of potential CVP allocation procedures. The Statewide Agricultural Production (SWAP) model was used to evaluate the effects on agricultural production for each alternative. The SWAP model results for each alternative were compared to the results of the No Action Alternative to quantify changes in agricultural production, irrigated acreage, and gross farm revenues.

D.2 SWAP Model Overview

The SWAP model is a regional agricultural production and economic optimization model that simulates the decisions of farmers across 93 percent of agricultural land in California. It is the most current in a series of California agricultural production models, originally developed by researchers at the University of California at Davis in collaboration with the California Department of Water Resources (DWR) with additional funding provided by the Bureau of Reclamation (Reclamation).

The SWAP model has been subject to peer-review (Howitt et al. 2012). The SWAP model, and its predecessor the Central Valley Production Model (CVPM), have been used for numerous policy analyses and impact studies over the past 15 years, including the impacts of the Central Valley Project Improvement Act (Reclamation and United State Fish and Wildlife Service [USFWS] 1999), Upper San Joaquin Basin Storage Investigation (Reclamation 2008), the State Water Project (SWP) drought impact analysis (Howitt et al. 2009a), and the economic implications of Sacramento-San Joaquin River Delta (Delta) conveyance options (Lund et al. 2007).

D.2.1 SWAP Model Mechanics

The SWAP model data coverage is most detailed in the Central Valley, but it also includes production regions in the Central Coast, South Coast, and desert areas. The model assumes that farmers maximize profit subject to resource, technical, and market constraints. Farmers sell and buy in competitive markets, and no one farmer can affect or control the price of any commodity. The model selects those crops, water supplies, and other inputs that maximize profit subject to constraints on water and land, and subject to economic conditions regarding prices, yields, and costs. The competitive market is simulated by maximizing the sum of consumer and producer surplus subject to the following characteristics of production, market conditions, and available resources:

- Constant Elasticity of Substitution (CES) production functions for every crop in every region. CES has four inputs: land, labor, water, and other supplies. CES production functions allow for limited substitution between inputs which allows the model to estimate both total input use and input use intensity. Parameters are calculated using a combination of prior information and the method of Positive Mathematical Programming (PMP) (Howitt 1995).
- Groundwater pumping cost including depth to groundwater.
- California statewide commodity demand functions.
- Resource constraints on land, labor, water, and other input availability by region.

The SWAP model incorporates project water supplies (SWP and CVP), other local water supplies, and groundwater. As conditions change within a SWAP region (e.g., the quantity of available project water supply increases or the cost of groundwater pumping increases), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. It also follows land when that appears to be the most cost-effective response to resource conditions.

The SWAP model is used to compare the long-run response of agriculture to potential changes in SWP and CVP irrigation water delivery, other surface or groundwater conditions, or other economic values or restrictions.

Results from Reclamation's and DWR's operations planning model CalSim II model are used as inputs into SWAP through a standardized data linkage tool. CalSim II output for the four alternative scenarios and Existing Conditions were used as inputs into the SWAP model. The CalSim II data file for each scenario includes nine water year types of which five were included in the SWAP model inputs. The water year types included: wet, above normal, below normal, dry, and critical conditions. For each scenario and water year type, the CalSim II model provides the SWAP model with CVP and SWP deliveries for each SWAP model

region. For more information on the CalSim II model, please see Appendix B, Water Operations Model Documentation.

Alternative 4, Updated M&I WSP, was not explicitly modeled in SWAP as the CVP deliveries as simulated in the CalSim II model were the same as the No Action Alternative. See Appendix B for more information.

D.2.2 SWAP Model Theory

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

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

PMP is fundamentally a three-step procedure for model calibration that assumes farmers optimize input use for maximization of profits. In the first step a linear profit-maximization program is solved. In addition to basic resource availability and non-negativity constraints, a set of calibration constraints is added to restrict land use to observed values. In the second step, the dual (shadow) values from the calibration and resource constraints are used to derive the parameters for the exponential PMP cost function and CES production function. In the third step, the calibrated CES and PMP cost function are combined into a full profit maximization program. The exponential PMP cost function captures the marginal decisions of farmers through the increasing cost of bringing additional land into production (e.g., through decreasing quality). Other input costs, (supplies, land, and labor) enter linearly into the objective function in both the first and third step.

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

D.2.3 Constant Elasticity of Substitution Production Function

Crop production in the SWAP model is represented by a CES production function for each region and crop. In general, a production function is a mathematical specification used to capture the relationship between inputs and output. For example, land, labor, water, and other inputs are combined to produce output of any crop. CES production functions in the SWAP model are specific to each region, thus regional input use is combined to determine regional production for each crop. The calibration routine in SWAP guarantees that both input use and output exactly match a base year of observed data.

The generalized CES production function allows for limited substitution among inputs (Beattie and Taylor 1985). This is consistent with observed farmer production practices (farmers are able to substitute among inputs in order to achieve the same level of production). For example, farmers may substitute labor for chemicals by reducing herbicide application and increasing manual weed control. Or, farmers can substitute labor for water by managing an existing irrigation system more intensively in order to increase efficiency. The CES function used in version 6 of the SWAP model is non-nested, thus the elasticity of substitution is the same between all inputs.

D.2.4 Crop Demand Functions

The SWAP model is specified with downward-sloping California statewide demand functions. The demand curve represents willingness-to-pay for a given level of crop production. All else constant, as production of a crop increases the price of that crop is expected to fall. The extent of the price decrease depends on the elasticity of demand or, equivalently, the price flexibility. The latter refers to the percentage change in crop price due to a percent change in production. The SWAP model is specified with linear demand functions.

D.2.4.1 Demand Shifts

The nature of the demand function for specific commodities can change over time due to tastes and preferences, population growth, changes in income, and other factors. The SWAP model incorporates linear shifts in the demand functions over time due to growth in population and changes in real income per capita. Changes in consumer tastes and preferences are difficult to predict and will have an indeterminate effect on demand and are consequently not considered in the model.

D.3 SWAP Model Data

The SWAP model requires a wide range of data to simulate the supply and demand for statewide agricultural production. The necessary data are not available from a single source and are instead compiled from various publically available sources, including state and federal agencies, academic publications, and water district reports. The last SWAP model data update was completed between 2009 and 2011 under contract with Reclamation, and the model data and code is currently being updated under contract with the California Department of Food and Agriculture. The model update completed in 2011 is known as SWAP version 6 and this version was used for analysis of the M&I WSP alternatives. The update in progress will be known as SWAP version 7, and is not expected to be complete until early 2015.

D.3.1 SWAP Regions and Crop Definitions

The SWAP model has 27 base regions in the Central Valley. The current SWAP model covers agriculture in the original 21 CVPM regions, the Central Coast, the Colorado River region that includes Coachella, Palo Verde and the Imperial Valley and San Diego, Santa Ana and Ventura and the South Coast. Only the 27 regions in the Central Valley are included in the analysis of M&I WSP alternatives.

The SWAP model regions with CVP agricultural water service contractors were included in the summary of the M&I WSP alternatives. CVP agricultural water service contractor regions include regions 2, 3a, 3b, 4, 5, 6, 9, 10, 13, 14a, 15a, 17, 18, and 20. These 14 regions were further aggregated into the Sacramento Valley (2, 3a, 3b, 4, 5, 6), San Joaquin River (9, 10, 13), and Tulare Lake (14a, 15a, 17, 18, 20) regions. Table D-1 summarizes some of the major water users in each of the regions.

Table D-1. SWAP Model Region Summary

Region	Major Surface Water Users
1	CVP Users: Anderson Cottonwood Irrigation District (ID), Clear Creek Community Services District (CSD), Bella Vista Water District (WD), and miscellaneous Sacramento River water users.
2	CVP Users: Corning Canal, Kirkwood WD, Tehama, and miscellaneous Sacramento River water users.
3a	CVP Users: Glenn Colusa ID, Provident ID, Princeton-Codora ID, Maxwell ID, and Colusa Basin Drain Mutual Water Company (MWC)
3b	Tehama Colusa Canal Service Area. CVP Users: Orland-Artois WD and Westside WD.
4	CVP Users: Princeton-Codora-Glenn ID, Colusa Irrigation Co., and miscellaneous Sacramento River water users.
5	Most Feather River Region riparian and appropriative users.
6	Yolo and Solano Counties. CVP Users: Conaway Ranch and miscellaneous Sacramento River water users.

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Region	Major Surface Water Users
7	Sacramento County north of American River. CVP Users: Natomas Central MWC., miscellaneous Sacramento River water users, Pleasant Grove-Verona WMC., and Placer County Water Agency.
8	Sacramento County south of American River and northern San Joaquin County.
9	Direct diverters within the Delta region. CVP Users: Banta Carbona ID, West Side WD, and Plainview.
10	Delta Mendota service area. CVP Users: Panoche WD, Pacheco WD, Del Puerto WD, Hospital WD, Sunflower WD, San Joaquin River Exchange Contractors.
11	Stanislaus River water rights: Modesto ID, Oakdale ID, and South San Joaquin ID.
12	Turlock ID.
13	Merced ID. CVP Users: Madera ID, Chowchilla WD, and Gravely Ford.
14a	CVP Users: Westlands WD.
14b	Southwest corner of Kings County
15a	Tulare Lake Bed. CVP Users: Fresno Slough WD, James ID, Tranquility ID, Traction Ranch, Laguna WD, and Reclamation District 1606.
15b	Dudley Ridge WD and Devils Den (Castaic Lake)
16	Eastern Fresno County. CVP Users: Friant-Kern Canal, Fresno ID, Garfield WD, and International WD.
17	CVP Users: Friant-Kern Canal, Hills Valley ID, Tri-Valley WD, and Orange Cove.
18	CVP Users: Friant-Kern Canal, County of Fresno, Lower Tule River ID, Pixley ID, and Tulare ID.
19a	SWP Service Area, including Belridge Water Storage District (WSD), Berrenda Mesa WD.
19b	SWP Service Area, including Semitropic WSD
20	CVP Users: Friant-Kern Canal. Shafter-Wasco, and South San Joaquin ID.
21a	CVP Users: Cross Valley Canal and Friant-Kern Canal
21b	Arvin Edison WD.
21c	SWP service area: Wheeler Ridge-Maricopa WSD.
23-30	Central Coast, Desert, and Southern California

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

Crops are aggregated into 20 crop groups which are the same across all regions. Each crop group represents a number of individual crops, but many are dominated by a single crop. Irrigated acres represent acreage of all crops within the group, production costs and returns are represented by a single proxy crop for each group. The current 20 crop groups were defined in collaboration with DWR and were last updated in March 2011. Crop group definitions and the corresponding proxy crop are shown in Table D-2.

Table D-2. SWAP Model Crop Groups

SWAP Definition	Proxy Crop	Other Crops
Almonds and Pistachios	Almonds	Pistachios
Alfalfa	Alfalfa Hay	
Corn	Grain Corn	Corn Silage
Cotton	Pima Cotton	Upland Cotton
Cucurbits	Summer Squash	Melons, Cucumbers, Pumpkins
Dry Beans	Dry Beans	Lima Beans

SWAP Definition	Proxy Crop	Other Crops
Fresh Tomatoes	Fresh Tomatoes	
Grain	Wheat	Oats, Sorghum, Barley
Onions and Garlic	Dry Onions	Fresh Onions, Garlic
Other Deciduous	Walnuts	Peaches, Plums, Apples
Other Field	Sudan Grass Hay	Other Silage
Other Truck	Broccoli	Carrots, Peppers, Lettuce, Other Vegetables
Pasture	Irrigated Pasture	
Potatoes	White Potatoes	
Processing Tomatoes	Processing Tomatoes	
Rice	Rice	
Safflower	Safflower	
Sugar Beet	Sugar Beets	
Subtropical	Oranges	Lemons, Miscellaneous Citrus, Olives
Vine	Wine Grapes	Table Grapes, Raisins

D.3.2 Crop Prices and Yields

The SWAP model is designed to calibrate to the actual conditions growers faced in 2005. Growers make current planting decisions based on expectations of prices. The SWAP model does not attempt to model how growers form their price expectations; as an approximation, SWAP uses a three-year simple average of county-level crop prices. Three year 2005 to 2007 averages of crop prices are calculated using the counties in the Central Valley regions within SWAP. Crop prices for each of the SWAP regions within the Central Valley correspond to one of these three areas. Data for county-level crop prices are obtained from the respective County Agricultural Commissioners' annual crop reports.

D.3.3 Crop Yields

Crop yields for each crop group in the SWAP model correspond to the proxy crops listed in Table D-2 and are based on best management practices. The corresponding costs of production, discussed in a subsequent section, are based on cost studies that also reflect best management practices. Thus, crop yields in SWAP are slightly higher than those estimated by calculating county averages, but are more consistent with the production costs. Crop yield data are compiled from the University of California Cooperative Extension (UCCE) production cost budgets prepared by University of California at Davis and UCCE researchers. Yields for each region are based on the most recent proxy crop cost study available in the closest region. For example, if a cost study is not available for a particular crop in the Sacramento Valley, the North San Joaquin Valley study may be used.

D.3.4 Crop Cost of Production Budgets

Land, labor, and other supply costs of production are obtained from the same UCCE crop budgets used to estimate crop yields. Each UCCE budget uses interest rates for capital recovery and interest on operating capital specific to the year of the study. These range from four percent to over eight percent and, as

such, require adjustment to a common base year interest rate. Since the SWAP model is designed to replicate base 2005 conditions, interest rates are adjusted to reflect conditions in 2005.

Land costs are derived from the respective UCCE crop budget and include land-related cash overhead plus rent and land capital recovery costs. Where appropriate, interest rates are adjusted as described above.

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

The supply cost category in the SWAP model includes all inputs not explicitly included in the other three input categories (land, labor, and water), including fertilizers, herbicides, insecticide, fungicide, rodenticide, seed, fuel, and custom costs. Additionally, machinery, establishment costs, buildings, and irrigation system capital recovery costs are included. Each sub-category of supply costs is broken down in detail in the respective crop budget. For example, safflower in the Sacramento Valley requires pre-plant Nitrogen as aqua ammonia at 100 lb per acre in fertilizer costs. Application of Roundup in February and Treflan in March account for herbicide costs. The sum of these individual components, on a per acre basis, is used as base supply input cost data in the SWAP model.

D.3.5 Surface and Groundwater

The SWAP model includes five types of surface water: SWP delivery; three categories of CVP delivery; and local surface water delivery or direct diversion (LOC). The three categories of CVP deliveries are: water service contract, including Friant Class 1 (CVP1); Friant Class 2 (CL2); and water rights settlement and exchange delivery (CVPS)¹. The SWAP model calibrates to a base year 2005 of land and water use. Water supply data in the base year of 2005 is derived from various sources, described below. CVP and SWP deliveries for the M&I WSP alternatives are from the CalSim II model, described in Appendix D.2.1.

The volume of deliveries for each water source in the base year of 2005 is estimated using data from DWR, Reclamation, and water district reports. CVP

¹ CVP Settlement water is delivered to districts and individuals in the Sacramento Valley based on their pre-CVP water rights on the Sacramento River, and San Joaquin River Exchange water is pumped from the Delta and delivered to four districts in the San Joaquin Valley in exchange for water rights diversion eliminated when Friant Dam was constructed. These two delivery categories are geographically distinct but for convenience are combined into one water supply category in SWAP.

water deliveries were derived from Reclamation operations data. Contract deliveries were obtained from Reclamation, the difference between total and contract deliveries indicates deliveries for water rights settlements. SWP water deliveries are obtained from DWR Bulletin 132 (DWR 2008). Kern County Water Agency provides additional details on SWP deliveries to member agencies by region. Local surface water deliveries were obtained from individual district records and reports, DWR water balance estimates prepared for the California Water Plan Update (DWR 2009), and where needed, data from the CVPM model. CVPM data were, in turn, provided by the Central Valley Ground-Surface Water Model.

A key source of irrigation water, and often the most costly, is groundwater pumping. Groundwater pumping capacity estimates are from a 2009 analysis by DWR in consultation with individual districts. Groundwater pumping capacity is intended to represent the maximum that a region can pump in a year given the aquifer characteristics and existing well capacities.

Groundwater pumping costs are broken out into fixed, energy, and operations and maintenance (O&M) components in the SWAP model. Energy and O&M components are variable. Energy costs depend on the price of electricity. The SWAP model version 6 uses the same unit cost of electricity per kilowatt-hour across all regions. Base electricity costs are derived from PG&E rate books and consultation with power officials at the Fresno, California office. Energy cost in 2005 dollars is 18.9 cents per kilowatt-hour, which is an average of PG&E's AG-1B and AG-4B rates (PG&E various years). Overall well efficiency is assumed to be 70 percent.

D.3.6 Crop Water Requirements

Applied water is the amount of water applied by the irrigation system to an acre of a given crop for production in a typical year. Variation in rainfall and other climate effects will alter this requirement. Additionally, farmers may stress irrigate crops or substitute other inputs in order to reduce applied water. The latter effect is handled endogenously by the SWAP model through the respective CES production functions. Applied water per acre (base) requirements for crops in the SWAP model are derived from DWR estimates. DWR estimates are based on Detailed Analysis Units (DAU). An average of DAUs within a SWAP region is used to generate a SWAP region specific estimate of applied water per acre for SWAP crops.

D.3.7 Elasticities

SWAP uses a number of economic response parameters, called elasticities, to estimate rates of change in variables. An elasticity is the percent change in a variable, per unit of percent change in another variable or parameter. Acreage response elasticity is one component of supply response. It is the percentage change in acreage of a crop from a one percent change in that crop's price. The SWAP model contains both long run and short run estimates, and the analyst

decides which of the elasticities to use. Long run acreage response elasticities are used for this analysis.

D.3.8 SWAP Model Data Sources

The SWAP model uses a base year of 2005. DWR is now developing more detailed annual time series data on agricultural land use, but the current version of the SWAP model calibrates to 2005 as a relatively normal base year. 2005 was neither abnormally dry nor wet, and crop markets had been relatively stable. Since 2005, California has experienced drought and unusually high commodity prices, thus more recent base years are not used. All prices and costs in the SWAP model are in constant 2005 dollars for consistency with the land use data. Table D-3 summarizes input data and sources used in the SWAP model.

Table D-3. SWAP Model Input Data Summary

Input	Source	Notes
Land Use	DWR	Base year 2005
Crop Prices	County Agricultural Commissioners'	By proxy crop using 2005—2007 average prices
Crop Yields	UCCE Crop Budgets	By proxy crop for various years (most recent available)
Interest Rates	UCCE Crop Budgets	All interest rates normalized to year 2005 (6.35%)
Land Costs	UCCE Crop Budgets	By proxy crop for various years (most recent available)
Other Supply Costs	UCCE Crop Budgets	By proxy crop for various years (most recent available)
Labor Costs	UCCE Crop Budgets	By proxy crop for various years (most recent available)
Surface Water Costs	Reclamation, DWR, Individual Districts	By SWAP model region
Groundwater Costs	PG&E, Individual Districts	Total cost per acre-foot includes fixed, O&M, and energy cost
Irrigation Water	DWR	Average crop irrigation water requirements in acre-feet per acre
Available Water	CVPM, DWR, Reclamation, Individual Districts	By SWAP model region and water supply source
Elasticities	Green et al. 2006	California estimates

D.3.9 Linkage to Other Models

The SWAP model has important interactions with other models. In particular, CalSim II, Reclamation's and DWR's project operations model for the CVP and the SWP, is used to estimate SWP and CVP supplies which are inputs into SWAP. An existing linkage tool has been developed to translate CalSim II delivery output to a corresponding SWAP input (on-farm applied water) file. Changes in depth to groundwater affect pumping costs and agricultural revenues. Changes in groundwater depth, and resulting changes in groundwater pumping costs can be included from other model, such as CVHM or C2VSim, output, if those models are run concurrently for the project.

D.4 Implementing the SWAP Model for the M&I WSP Alternatives

Scenario analysis using the SWAP model can focus on a single point in time or on several future points. With reasonable interpolation, this approach will create a true time sequence to calculate net present value of a stream of costs or benefits. The alternatives for the M&I WSP were evaluated at a single point in time, also called the level of development.

SWAP is used to compare the long-run agricultural economic responses to changes in CVP irrigation water delivery under the M&I WSP alternatives. Results from the CalSim II model are used as inputs into SWAP through a standardized data linkage tool. As described previously, CalSim II output for the four alternative scenarios and Existing Conditions were used as inputs into the SWAP model. The CalSim II data file for each scenario included nine water year types, of which five were included in the SWAP model inputs. The water year types included: wet, above normal, below normal, dry, and critical conditions. For each scenario and water year type, the CalSim II model provides the SWAP model with CVP and SWP on-farm water deliveries for each SWAP model region.

Additional adjustments relevant to the level of development in the M&I WSP alternatives are described below.

D.4.1 Level of Development and Water Year Type

The No Action Alternative and action alternatives correspond to a 2030 level of development. The Existing Conditions scenario corresponds to the current 2014 level of development.

Each alternative and level of development was evaluated for five water year types, including: wet, above normal, below normal, dry, and critical.

D.4.1.1 Crop Demand Shifts

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

Increases in demand for crops produced in California may be partially offset by other production regions depending on changing export market conditions. For example, today California is the dominant producer of almonds but this may change if other regions in the U.S. or the world increase production. Thus an increase in almond demand could be partially met by other regions. However, additional demand growth from markets like China may offset this effect. The net

effect is indeterminate. In the absence of data or studies demonstrating which effect would dominate, California export share is assumed to remain constant for all crops in the future. This is a key assumption which is consistent with peer-reviewed publications for the California Energy Commission and the academic journal *Climatic Change* in addition to the 2009 DWR Water Plan (Howitt et al. 2009a, Howitt et al. 2009b).

Crop demands are linear in the SWAP model and population and real income changes induce a parallel shift in demand. Demand shifts are included for all of the alternative scenarios evaluated for the M&I WSP, including the No Action Alternative. The exception is the Existing Conditions alternative which includes no shift in demand. Consequently, comparison of the No Action Alternative to each action alternative compares identical future market conditions.

For purposes of the demand shift analysis, a distinction is made between two types of crops grown in California: California specific crops and global commodities. Global commodity crops include grain rice, and corn²; all other crop groups are classified as California crops. Global commodity crops are those for which there is no separate demand for California's production. For these crops, California faces a perfectly elastic demand, and is thus a price taker. For California specific crops, California faces a downward sloping demand for a market that is driven by conditions in the United States and international export markets. A routine in the SWAP model calculates the demand shift for the 2030 level of development for the M&I WSP alternatives.

D.4.1.2 Electricity Costs

Groundwater pumping is typically the most expensive water supply. Real power costs are expected to increase in the future, and groundwater pumping relies heavily on the cost of electricity. Energy pumping costs are escalated according to future marginal power cost estimates for the year 2030.

A marginal power cost escalator is determined for the year 2030 and applied to the energy cost component of groundwater costs. The cost escalator is the ratio of the expected future power cost in 2030 to the base power cost in 2005, in 2005 \$/MWh. Expected future power costs are calculated using the DWR Forward Price Projections (DWR 2011) analysis using wholesale power costs. This calculates an average power cost for each month as the average of the peak (upper bound) and off-peak (lower bound) rates. An average of the monthly costs generates an average yearly cost. This cost is used to generate the power cost escalator by taking the ratio of the future year average to the current year average. The power cost escalator for 2030 is 1.54.

² Rice demand is very elastic but not perfectly elastic. For purposes of the demand shifting analysis, it is assumed to be perfectly elastic.

D.4.1.3 Groundwater Depth

The SWAP model can be linked to a groundwater model to estimate change in depth to groundwater, both static and dynamic, to estimate the additional lift, and therefore energy cost, for water year types. Dry years can result in groundwater levels dropping by several feet in some regions of the Central Valley, depending on local aquifer conditions. The CVHM or C2VSim models were not run for the M&I WSP alternatives. A review of existing studies using the SWAP model linked to CVHM determined that no basis was available to adjust depth to groundwater under the alternative water year types. As such, depth to groundwater is held constant at the baseline levels under all water year types and alternatives.

D.4.1.4 Other Factors

The SWAP model includes a number of sub-routines that are included in studies on a case-by-case basis, but rarely included in evaluation of EIS alternatives. All of these other factors are held constant in the M&I WSP alternatives. Climate change effects are held constant in the analysis of M&I WSP alternatives. The SWAP model has been linked to crop models, such as LAWS, to estimate the change in crop yield and crop evapotranspiration (ET) and therefore applied water requirements. Climate change effects on crop growth remain highly uncertain and are consequently held constant in the analysis.

Crop yields have been increasing for most crops due to technological innovations. Innovations like hybrid seeds, better chemicals and fertilizer, improved pest management, and irrigation and mechanical harvesting advances are some examples. The expected future rate of growth in crop yields remains a contentious topic among researchers. Consequently, yield changes due to technological innovations are held constant in the analysis of M&I WSP alternatives. It is important to note that the SWAP model does allow for some minor yield response to changing market conditions. This effect is referred to as endogenous yield changes. The SWAP model includes full CES production functions for each crop and region which allow for some endogenous yield change in response to changing market conditions, but there is no exogenous technological change included in the analysis.

D.5 Summary of SWAP Results

This section describes the SWAP model results for Existing Conditions and the M&I WSP alternatives. Changes in economic conditions in the Central Valley are summarized in terms of irrigated acreage, gross farm revenues, groundwater use, and groundwater cost. As described previously, agricultural water service contractors in three regions, Sacramento Valley, San Joaquin River, and Tulare Lake, are included in the summary of economic changes. Water year types summarized in this section include wet, below normal, and critical conditions.

D.5.1 Existing Conditions

The Existing Conditions scenario is defined as the baseline conditions for agricultural production in the Central Valley in the current (2014) period. All production conditions including land use, production costs, crop prices, crop yields, and market conditions are representative of the current period. Table D-4 shows the total irrigated acreage and gross farm revenues under Existing Conditions, and the change from the No Action Alternative, which is described in the following section. Table D-5 shows the total groundwater use and groundwater cost under Existing Conditions, and the change from the No Action Alternative.

Many of the differences between Existing Conditions and the policy alternatives are a result of changes that are not related to the M&I WSP. These factors were described in the previous sections and include population growth (crop demand shifts) and real electricity costs.

All of the alternatives are evaluated at a 2030 level of development. Demand for California agriculture is expected to increase between current conditions and 2030 due to population and real income growth. Increasing demand for California crops will increase the real price that growers receive for crop production, all else constant. The Existing Conditions scenario corresponds to the current level of development and consequently does not include the future changes in crop demand. As such, the difference between Existing Conditions and the No Action Alternative shows the effect of the change in real crop prices, which is not attributed to the M&I WSP.

The real cost of electricity is expected to increase between current conditions and the year 2030. The cost of electricity is the largest component of the variable cost of pumping groundwater to irrigate crops. As the cost of electricity increases growers will substitute away from groundwater to minimize the effect of these higher costs. Growers will substitute surface water for groundwater in districts where there is excess capacity to do so and, in areas where there is no available surface water growers will slightly reduce water application and shift the crop mix towards crops that use less water per acre. The difference between Existing Conditions and the No Action Alternative shows the effect of higher groundwater pumping costs, which is not attributable to the M&I WSP.

Table D-4. Existing Conditions Acreage and Value Results

Analysis Metric	Existing Conditions	Change from the No Action Alternative
Wet Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,385.6	-2.7
San Joaquin River	1,401.9	-3.3
Tulare Lake	2,307.7	-7.6
Total Value of Production (million \$)		0.0
Sacramento Valley	3,236.0	-967.0
San Joaquin River	3,188.1	-951.8
Tulare Lake	6,571.3	-1,424.6
Below Normal Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,382.7	-1.8
San Joaquin River	1,401.4	-2.7
Tulare Lake	2,288.2	-20.3
Total Value of Production (million \$)		0.0
Sacramento Valley	3,234.8	-963.5
San Joaquin River	3,192.2	-949.1
Tulare Lake	6,541.9	-1,455.1
Critical Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,347.9	12.8
San Joaquin River	1,400.1	-4.2
Tulare Lake	2,162.1	-0.6
Total Value of Production (million \$)		
Sacramento Valley	3,192.7	-899.0
San Joaquin River	3,206.5	-956.5
Tulare Lake	6,379.0	-1,464.3

Table D-5. Existing Conditions Groundwater Use and Cost Results

Analysis Metric	Existing Conditions	Change from the No Action Alternative
Wet Condition		
Annual Groundwater Pumped (thousand acre-feet [TAF])		
Sacramento Valley	1,316.3	67.8
San Joaquin River	1,044.7	48.5
Tulare Lake	2,453.9	21.5
Annual Cost of Pumping (million \$)		0.0
Sacramento Valley	51.2	-9.4
San Joaquin River	54.8	-10.3
Tulare Lake	199.4	-54.4

Analysis Metric	Existing Conditions	Change from the No Action Alternative
Below Normal Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,335.2	69.4
San Joaquin River	1,254.8	46.2
Tulare Lake	2,879.3	-21.5
Annual Cost of Pumping (million \$)		0.0
Sacramento Valley	53.3	-10.5
San Joaquin River	66.3	-13.3
Tulare Lake	251.5	-80.9
Critical Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,367.2	50.1
San Joaquin River	1,576.4	6.4
Tulare Lake	3,274.3	-10.5
Annual Cost of Pumping (million \$)		
Sacramento Valley	55.3	-11.4
San Joaquin River	83.8	-20.4
Tulare Lake	282.2	-89.7

D.5.2 Alternative 1, No Action Alternative

Alternative 1, the No Action Alternative, represents future (2030) market and production conditions for Central Valley agriculture where an action alternative is not implemented. The No Action Alternative is used to compare the M&I WSP Alternatives 2, 3, and 5. Table D-6 shows the total irrigated acreage and gross value of agricultural production under the No Action Alternative. Table D-7 shows the total groundwater pumping and cost under the No Action Alternative.

On average, in the Central Valley regions with agricultural water service contractors under the No Action Alternative nearly \$16 billion in gross value of production would be generated on about 5.2 million irrigated acres. The wet water year conditions lead to the highest value and largest irrigated footprint. The total irrigated area and gross value decreases in below normal and critical conditions as growers shift the crop mix to lower water use crops and fallow land in response to constrained surface water supplies. For example, the Tulare Lake region irrigates 2.31 million acres in wet years and 2.16 million acres in critically dry years and the corresponding gross value of production decreases from \$7.99 million to \$7.83 million. Growers are able to partially offset reduced surface water supplies by increasing the amount of groundwater pumped. In the Tulare Lake region, groundwater pumping increases from 2.42 million acre-feet (AF) to 3.24 million AF between wet and critically dry years.

Table D-6. No Action Alternative Acreage and Value Results

Analysis Metric	No Action Alternative
	Wet Condition
Total Irrigated Acreage (thousand acres)	
Sacramento Valley	1,388.4
San Joaquin River	1,405.2
Tulare Lake	2,315.2
Total Value of Production (million \$)	
Sacramento Valley	4,203.1
San Joaquin River	4,140.0
Tulare Lake	7,995.9
	Below Normal Condition
Total Irrigated Acreage (thousand acres)	
Sacramento Valley	1,384.5
San Joaquin River	1,404.1
Tulare Lake	2,308.5
Total Value of Production (million \$)	
Sacramento Valley	4,198.3
San Joaquin River	4,141.3
Tulare Lake	7,996.9
	Critical Condition
Total Irrigated Acreage (thousand acres)	
Sacramento Valley	1,335.0
San Joaquin River	1,404.2
Tulare Lake	2,162.7
Total Value of Production (million \$)	
Sacramento Valley	4,091.7
San Joaquin River	4,163.1
Tulare Lake	7,843.2

Table D-7. No Action Alternative Groundwater Use and Cost Results

Analysis Metric	No Action Alternative
	Wet Condition
Annual Groundwater Pumped (TAF)	
Sacramento Valley	1,248.5
San Joaquin River	996.2
Tulare Lake	2,432.4
Annual Cost of Pumping (million \$)	
Sacramento Valley	60.6
San Joaquin River	65.1
Tulare Lake	253.8

Analysis Metric	No Action Alternative
	Below Normal Condition
Annual Groundwater Pumped (TAF)	
Sacramento Valley	1,265.8
San Joaquin River	1,208.7
Tulare Lake	2,900.7
Annual Cost of Pumping (million \$)	
Sacramento Valley	63.9
San Joaquin River	79.6
Tulare Lake	332.4
	Critical Condition
Annual Groundwater Pumped (TAF)	
Sacramento Valley	1,317.1
San Joaquin River	1,570.0
Tulare Lake	3,284.8
Annual Cost of Pumping (million \$)	
Sacramento Valley	66.8
San Joaquin River	104.3
Tulare Lake	371.9

D.5.3 Alternative 2, Equal Agricultural and M&I Allocation

Under Alternative 2, Equal Agricultural and M&I Allocation, agricultural and municipal and industrial (M&I) water service contractors are given equal allocations based on percentage of $\frac{e_{\text{Contract}}}{t_{\text{Total}}}$. Alternative 2 is described in Chapter 2.

Table D-8 shows the total irrigated acreage and gross farm revenues under Alternative 2, and the change from the No Action Alternative. Table D-9 shows the total groundwater use and groundwater cost under Alternative 2, and the change from the No Action Alternative.

Agricultural deliveries are given equal allocation to M&I deliveries, consequently Alternative 2 shows a small increase in irrigated acreage and reduction in groundwater pumping relative to the No Action Alternative. In wet years Alternative 2 has a negligible effect on total irrigated acreage and value. In critically dry years the total value of irrigated crop production would increase by a total of \$74 million on an additional 44 thousand irrigated acres per year. Total groundwater pumping decreases by 51 TAF at a cost savings of \$4 million per year.

The effects of Alternative 2 are not constant across agricultural water service contractor regions in the Central Valley. In all water year conditions, the San Joaquin River region value of production decreases under Alternative 2. This is in contrast to the Sacramento Valley and Tulare Lake regions where the value of production increases. The reason for this difference is that deliveries to the San Joaquin River Exchange Contractors are unchanged under Alternative 2. Sacramento Valley and Tulare Lake regions increase production in response to additional surface water supplies, and this additional production slightly decreases

the statewide price for crops (all else constant). Therefore, the San Joaquin River region then receives a lower price for the crops produced and suffers small economic losses under Alternative 2. The losses in the San Joaquin River region increases with drier water year conditions, with a maximum loss of crop value equal to \$4.8 million per year in critically dry years.

Table D-8. Alternative 2 Acreage and Value Results

Analysis Metric	Alternative 2	Change from the No Action Alternative
Wet Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,388.4	0.0
San Joaquin River	1,405.2	0.1
Tulare Lake	2,315.2	0.0
Total Value of Production (million \$)		
Sacramento Valley	4,203.1	0.0
San Joaquin River	4,140.0	0.0
Tulare Lake	7,995.9	0.0
Below Normal Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,387.6	3.1
San Joaquin River	1,404.1	0.0
Tulare Lake	2,315.3	6.8
Total Value of Production (million \$)		
Sacramento Valley	4,202.0	3.7
San Joaquin River	4,140.7	-0.7
Tulare Lake	7,997.4	0.5
Critical Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,344.7	9.6
San Joaquin River	1,404.2	0.0
Tulare Lake	2,196.9	34.2
Total Value of Production (million \$)		
Sacramento Valley	4,127.4	35.7
San Joaquin River	4,158.2	-4.8
Tulare Lake	7,886.5	43.2

Table D-9. Alternative 2 Groundwater Use and Cost Results

Analysis Metric	Alternative 2	Change from the No Action Alternative
Wet Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,245.5	-3.0
San Joaquin River	986.7	-9.5
Tulare Lake	2,407.3	-25.1
Annual Cost of Pumping (million \$)		
Sacramento Valley	60.3	-0.3
San Joaquin River	64.4	-0.7
Tulare Lake	248.9	-4.9
Below Normal Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,264.5	-1.3
San Joaquin River	1,191.3	-17.4
Tulare Lake	2,875.1	-25.7
Annual Cost of Pumping (million \$)		
Sacramento Valley	63.8	-0.1
San Joaquin River	78.5	-1.2
Tulare Lake	327.6	-4.8
Critical Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,314.0	-3.1
San Joaquin River	1,535.2	-34.8
Tulare Lake	3,271.3	-13.5
Annual Cost of Pumping (million \$)		
Sacramento Valley	66.6	-0.2
San Joaquin River	101.9	-2.4
Tulare Lake	370.4	-1.5

D.5.4 Alternative 3, Full M&I Allocation Preference

Under Alternative 3, Full M&I Allocation Preference, M&I water service contractors are given priority over agricultural water service contractors. Alternative 3 is described in detail in Chapter 2.

Table D-10 shows the total irrigated acreage and gross farm revenues under Alternative 3, and the change from the No Action Alternative. Table D-11 shows the total groundwater use and groundwater cost under Alternative 3, and the change from the No Action Alternative.

In Alternative 3, M&I water service contractors are given priority, consequently Alternative 3 shows a small decrease in irrigated acreage and increase in groundwater pumping relative to the No Action Alternative. In wet years Alternative 3 has a negligible effect on acreage and value. In critically dry years the total value of irrigated crop production would decrease by \$57 million on 27 thousand fewer irrigated acres per year. Total groundwater pumping increases to

offset the decreased surface water, by 27 TAF at an additional cost of \$2.2 million per year.

The effects of Alternative 3 are not constant across agricultural water service contractor regions in the Central Valley. In all water year conditions, the San Joaquin River region value of production increases under Alternative 3. This is in contrast to the Sacramento Valley and Tulare Lake regions where the value of production decreases. The reason for this difference is surface water deliveries to the San Joaquin River Exchange Contractors are unchanged under Alternative 3. Sacramento Valley and Tulare Lake regions decrease production in response to additional reduced surface water supplies, and this drop in production slightly increases the statewide price for crops (all else constant). Therefore, the San Joaquin River region has access to adequate water supplies and receives a higher price for the crops produced. The increase in value in the San Joaquin River region increases with drier water year conditions, with a maximum increase of crop value equal to \$5.2 million per year in critically dry years.

Table D-10. Alternative 3 Acreage and Value Results

Analysis Metric	Alternative 3	Change from the No Action Alternative
Wet Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,388.4	0.0
San Joaquin River	1,405.1	0.0
Tulare Lake	2,315.2	0.0
Total Value of Production (million \$)		
Sacramento Valley	4,203.1	0.0
San Joaquin River	4,140.0	0.0
Tulare Lake	7,995.9	0.0
Below Normal Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,383.1	-1.4
San Joaquin River	1,404.1	0.0
Tulare Lake	2,301.8	-6.7
Total Value of Production (million \$)		
Sacramento Valley	4,195.3	-3.0
San Joaquin River	4,141.8	0.4
Tulare Lake	7,996.1	-0.8

Analysis Metric	Alternative 3	Change from the No Action Alternative
Critical Condition		
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,330.8	-4.2
San Joaquin River	1,404.2	0.0
Tulare Lake	2,139.8	-22.9
Total Value of Production (million \$)		
Sacramento Valley	4,075.6	-16.1
San Joaquin River	4,168.2	5.2
Tulare Lake	7,797.3	-45.9

Table D-11. Alternative 3 Groundwater Use and Cost Results

Analysis Metric	Alternative 3	Change from the No Action Alternative
Wet Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,249.0	0.4
San Joaquin River	999.6	3.4
Tulare Lake	2,443.4	11.0
Annual Cost of Pumping (million \$)		
Sacramento Valley	60.6	0.0
San Joaquin River	65.3	0.2
Tulare Lake	256.0	2.2
Below Normal Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,266.4	0.6
San Joaquin River	1,218.6	9.9
Tulare Lake	2,903.9	3.1
Annual Cost of Pumping (million \$)		
Sacramento Valley	63.9	0.0
San Joaquin River	80.3	0.7
Tulare Lake	332.7	0.3
Critical Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,318.3	1.2
San Joaquin River	1,588.8	18.7
Tulare Lake	3,291.9	7.0
Annual Cost of Pumping (million \$)		
Sacramento Valley	66.8	0.1
San Joaquin River	105.6	1.3
Tulare Lake	372.6	0.8

D.5.5 Alternative 5, M&I Contractor Suggested WSP

Under Alternative 5, M&I Contractor Suggested WSP, there are negligible differences in SWAP results compared to the No Action Alternative. Alternative 5 is described in detail in Chapter 2.

Table D-12 shows the total irrigated acreage and gross farm revenues under Alternative 5, and the change from the No Action Alternative. Table D-13 shows the total groundwater use and groundwater cost under Alternative 5, and the change from the No Action Alternative.

Alternative 5 has a negligible effect on irrigated acreage, gross value, and groundwater under all water year conditions. The Tulare Lake region in critically dry conditions shows a small decrease in gross value due to a shift in the crop mix and increase in groundwater pumping to offset reduced surface water supplies.

Table D-12. Alternative 5 Acreage and Value Results

Analysis Metric	Alternative 5	Change from the No Action Alternative
	Wet Condition	
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,388.4	0.0
San Joaquin River	1,405.2	0.0
Tulare Lake	2,315.2	0.0
Total Value of Production (million \$)		
Sacramento Valley	4,203.1	0.0
San Joaquin River	4,140.0	0.0
Tulare Lake	7,995.9	0.0
	Below Normal Condition	
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,384.5	0.0
San Joaquin River	1,404.1	0.0
Tulare Lake	2,308.5	0.0
Total Value of Production (million \$)		
Sacramento Valley	4,198.3	0.0
San Joaquin River	4,141.3	0.0
Tulare Lake	7,996.9	0.0
	Critical Condition	
Total Irrigated Acreage (thousand acres)		
Sacramento Valley	1,335.0	0.0
San Joaquin River	1,404.2	0.0
Tulare Lake	2,162.7	0.0
Total Value of Production (million \$)		
Sacramento Valley	4,091.7	0.0
San Joaquin River	4,163.1	0.0
Tulare Lake	7,843.2	-0.1

Table D-13. Alternative 5 Groundwater Use and Cost Results

Analysis Metric	Alternative 5	Change from the No Action Alternative
Wet Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,248.5	0.0
San Joaquin River	996.3	0.0
Tulare Lake	2,432.6	0.2
Annual Cost of Pumping (million \$)		
Sacramento Valley	60.6	0.0
San Joaquin River	65.1	0.0
Tulare Lake	253.8	0.0
Below Normal Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,265.8	0.0
San Joaquin River	1,208.7	0.0
Tulare Lake	2,900.8	0.1
Annual Cost of Pumping (million \$)		
Sacramento Valley	63.9	0.0
San Joaquin River	79.6	0.0
Tulare Lake	332.4	0.0
Critical Condition		
Annual Groundwater Pumped (TAF)		
Sacramento Valley	1,317.1	0.0
San Joaquin River	1,570.1	0.1
Tulare Lake	3,284.9	0.0
Annual Cost of Pumping (million \$)		
Sacramento Valley	66.8	0.0
San Joaquin River	104.3	0.0
Tulare Lake	371.9	0.0

D.6 SWAP Model Limitations

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

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

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

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

Similar to other DWR water models including Least Cost Planning Simulation Model, SWAP currently does not differentiate between water delivered under the Table A, Article 21, or Article 56 provisions of the SWP water contracts, treating the supplies as equally valuable for crop production.

D.7 References

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Appendix E

Air Quality Emission Calculations

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General Conformity Applicability Evaluation for Sacramento Valley Air Basin

Table 1. Groundwater Pumping Emissions in Sacramento Metro 8-Hour Ozone Nonattainment Area

Year Type	Groundwater Pumping by SWAP Model Region (TAF/year)							Annual Emissions (tons per year)					
	V03B	V04	V05	V06	V09	Total	Change	VOC	NOx	CO	SOx	PM10	PM2.5
Alternative 1 (No Action)/Alternative 4													
Wet	8.1	18.5	290.0	478.9	100.0	895.4	n/a						
Above Normal	13.6	11.9	290.0	477.9	100.0	893.3	n/a						
Below Normal	74.7	0.0	290.0	473.7	101.0	939.5	n/a						
Dry	74.7	0.0	290.0	474.5	102.9	942.1	n/a						
Critical	74.7	2.0	290.0	473.8	107.5	948.0	n/a						
Alternative 2													
Wet	5.4	18.5	290.0	478.9	100.0	892.7	(2.7)	(0.2)	(3.0)	(3.9)	(1.0)	(0.2)	(0.2)
Above Normal	9.5	11.9	290.0	477.9	100.0	889.2	(4.1)	(0.2)	(4.5)	(5.9)	(1.5)	(0.4)	(0.4)
Below Normal	74.7	0.0	290.0	473.6	100.3	938.6	(0.9)	(0.0)	(0.9)	(1.2)	(0.3)	(0.1)	(0.1)
Dry	74.7	0.0	290.0	474.5	101.6	940.8	(1.3)	(0.1)	(1.4)	(1.9)	(0.5)	(0.1)	(0.1)
Critical	74.7	1.9	290.0	473.7	105.8	946.3	(1.7)	(0.1)	(1.9)	(2.4)	(0.6)	(0.1)	(0.1)
Alternative 3													
Wet	8.5	18.5	290.0	478.9	100.0	895.8	0.4	0.0	0.4	0.6	0.1	0.0	0.0
Above Normal	15.3	11.9	290.0	477.9	100.0	895.1	1.8	0.1	1.9	2.5	0.6	0.2	0.1
Below Normal	74.7	0.0	290.0	473.8	101.4	940.0	0.5	0.0	0.6	0.8	0.2	0.0	0.0
Dry	74.7	0.0	290.0	474.5	103.8	943.1	0.9	0.1	1.0	1.3	0.3	0.1	0.1
Critical	74.7	2.0	290.0	473.8	108.3	948.9	0.9	0.1	1.0	1.3	0.3	0.1	0.1
Alternative 5													
Wet	8.1	18.5	290.0	478.9	100.0	895.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	13.6	11.9	290.0	477.9	100.0	893.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	74.7	0.0	290.0	473.7	101.0	939.5	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Dry	74.7	0.0	290.0	474.5	102.9	942.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Critical	74.7	2.0	290.0	473.8	107.5	948.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note:

Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)

Although the PM2.5 nonattainment region is different than the 8-hour O3 nonattainment region, the affected SWAP regions are the same.

Key:

CO = carbon monoxide

PM2.5 = fine particulate matter

TAF = thousand acre-feet

NOx = nitrogen oxides

SOx = sulfur oxides

VOC = volatile organic compounds

PM10 = inhalable particulate matter

SWAP = Statewide Agricultural Production

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Table 2. Groundwater Pumping Emissions in Sacramento PM10 Maintenance Area

Year Type	SWAP Model Region (TAF/year)		Annual Emissions (tons per year)					
	V09	Change	VOC	NOx	CO	SOx	PM10	PM2.5
Alternative 1 (No Action)/Alternative 4								
Wet	100.0	n/a						
Above Normal	100.0	n/a						
Below Normal	101.0	n/a						
Dry	102.9	n/a						
Critical	107.5	n/a						
Alternative 2								
Wet	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	100.3	(0.7)	(0.0)	(0.8)	(1.0)	(0.3)	(0.1)	(0.1)
Dry	101.6	(1.3)	(0.1)	(1.4)	(1.9)	(0.5)	(0.1)	(0.1)
Critical	105.8	(1.7)	(0.1)	(1.8)	(2.4)	(0.6)	(0.1)	(0.1)
Alternative 3								
Wet	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	101.4	0.4	0.0	0.5	0.6	0.1	0.0	0.0
Dry	103.8	0.9	0.1	1.0	1.3	0.3	0.1	0.1
Critical	108.3	0.9	0.0	0.9	1.2	0.3	0.1	0.1
Alternative 5								
Wet	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	101.0	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Dry	102.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Critical	107.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note:

Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)

PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.

Key:

CO = carbon monoxide

NOx = nitrogen oxides

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

SOx = sulfur oxides

SWAP = Statewide Agricultural Production

TAF = thousand acre-feet

VOC = volatile organic compounds

Table 3. Fugitive Dust Emissions in Sacramento PM10 Maintenance Area

Year Type	SWAP Model Region (TAF/year)		Annual PM10 Emissions (tpy)			
	V09	Change	Land Prep	Harvesting	Windblown Dust	Total
Alternative 1 (No Action)/Alternative 4						
Wet	406.0	n/a				
Above Normal	405.3	n/a				
Below Normal	404.9	n/a				
Dry	404.9	n/a				
Critical	404.9	n/a				
Alternative 2						
Wet	406.1	0.1	7.97E-04	6.70E-05	-5.26E-05	8.12E-04
Above Normal	405.4	0.1	9.64E-04	8.10E-05	-6.36E-05	9.82E-04
Below Normal	404.9	0.0	1.39E-04	1.16E-05	-9.14E-06	1.41E-04
Dry	404.8	(0.0)	-4.16E-05	-3.49E-06	2.74E-06	-4.23E-05
Critical	404.9	0.0	2.09E-05	1.75E-06	-1.38E-06	2.13E-05
Alternative 3						
Wet	406.0	(0.0)	-2.87E-04	-2.41E-05	1.90E-05	-2.93E-04
Above Normal	405.2	(0.0)	-3.39E-04	-2.85E-05	2.24E-05	-3.45E-04
Below Normal	404.8	(0.0)	-9.03E-05	-7.59E-06	5.96E-06	-9.19E-05
Dry	404.9	0.0	2.30E-08	1.93E-09	-1.52E-09	2.34E-08
Critical	404.9	(0.0)	-1.50E-06	-1.26E-07	9.88E-08	-1.52E-06
Alternative 5						
Wet	406.0	(0.0)	-3.10E-06	-2.60E-07	2.04E-07	-3.15E-06
Above Normal	405.3	(0.0)	-6.67E-06	-5.60E-07	4.40E-07	-6.79E-06
Below Normal	404.9	(0.0)	-8.85E-08	-7.43E-09	5.84E-09	-9.01E-08
Dry	404.9	(0.0)	-4.84E-08	-4.06E-09	3.19E-09	-4.92E-08
Critical	404.9	(0.0)	-1.52E-08	-1.27E-09	1.00E-09	-1.54E-08

Note:

Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)
PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.

Key:

PM10 = inhalable particulate matter

TAF = thousand acre-feet

SWAP = Statewide Agricultural Production

tpy = tons per year

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Table 4. Fugitive Dust Emissions in Sacramento PM2.5 Nonattainment Area

Year Type	Total Irrigated Acreage by SWAP Model Region (thousand acres)							Annual PM2.5 Emissions (tpy)			
	V03B	V04	V05	V06	V09	Total	Delta	Land Prep	Harvesting	Windblown Dust	Total
Alternative 1 (No Action)/Alternative 4											
Wet	91.0	259.4	363.5	238.5	406.0	1,358.4	n/a				
Above Normal	91.0	259.4	363.5	238.5	405.3	1,357.6	n/a				
Below Normal	84.4	262.1	363.5	238.5	404.9	1,353.3	n/a				
Dry	67.0	262.8	363.5	238.5	404.9	1,336.7	n/a				
Critical	37.4	259.3	363.5	238.6	404.9	1,303.7	n/a				
Alternative 2											
Wet	91.0	259.4	363.5	238.5	406.1	1,358.5	0.1	1.21E-04	1.01E-05	-1.06E-05	1.20E-04
Above Normal	91.0	259.4	363.5	238.5	405.4	1,357.7	0.1	1.46E-04	1.22E-05	-1.28E-05	1.45E-04
Below Normal	87.5	262.1	363.5	238.5	404.9	1,356.5	3.2	4.73E-03	3.97E-04	-4.16E-04	4.71E-03
Dry	72.3	262.8	363.5	238.5	404.8	1,342.0	5.3	7.98E-03	6.70E-04	-7.02E-04	7.95E-03
Critical	47.1	259.3	363.5	238.6	404.9	1,313.3	9.6	1.45E-02	1.21E-03	-1.27E-03	1.44E-02
Alternative 3											
Wet	91.0	259.4	363.5	238.5	406.0	1,358.4	(0.0)	-4.35E-05	-3.65E-06	3.83E-06	-4.33E-05
Above Normal	91.0	259.4	363.5	238.5	405.2	1,357.6	(0.0)	-5.17E-05	-4.34E-06	4.55E-06	-5.15E-05
Below Normal	82.9	262.1	363.5	238.5	404.8	1,351.9	(1.5)	-2.20E-03	-1.85E-04	1.94E-04	-2.19E-03
Dry	63.9	262.8	363.5	238.5	404.9	1,333.6	(3.1)	-4.63E-03	-3.89E-04	4.08E-04	-4.61E-03
Critical	33.3	259.3	363.5	238.6	404.9	1,299.5	(4.2)	-6.32E-03	-5.31E-04	5.57E-04	-6.30E-03
Alternative 5											
Wet	91.0	259.4	363.5	238.5	406.0	1,358.4	(0.0)	-4.68E-07	-3.94E-08	4.12E-08	-4.67E-07
Above Normal	91.0	259.4	363.5	238.5	405.3	1,357.6	(0.0)	-1.01E-06	-8.46E-08	8.87E-08	-1.00E-06
Below Normal	84.4	262.1	363.5	238.5	404.9	1,353.3	0.0	1.75E-06	1.47E-07	-1.54E-07	1.74E-06
Dry	67.0	262.8	363.5	238.5	404.9	1,336.7	(0.0)	-1.97E-05	-1.65E-06	1.73E-06	-1.96E-05
Critical	37.4	259.3	363.5	238.6	404.9	1,303.7	(0.0)	-7.23E-06	-6.07E-07	6.37E-07	-7.20E-06

Note:

Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)

PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.

Although the PM2.5 nonattainment region is different than the 8-hour O3 nonattainment region, the affected SWAP regions are the same.

Key:

PM2.5 = fine particulate matter

tpy = tons per year

SWAP = Statewide Agricultural Production

Table 5. Total PM Emissions in Sacramento Region

Year Type	Annual PM10 Emissions (tpy)			Annual PM2.5 Emissions (tpy)		
	Exhaust	Dust	Total	Exhaust	Dust	Total
Alternative 2						
Wet	0.0	0.0	0.0	(0.2)	0.0	(0.2)
Above Normal	0.0	0.0	0.0	(0.4)	0.0	(0.4)
Below Normal	(0.1)	0.0	(0.1)	(0.1)	0.0	(0.1)
Dry	(0.1)	(0.0)	(0.1)	(0.1)	0.0	(0.1)
Critical	(0.1)	0.0	(0.1)	(0.1)	0.0	(0.1)
Alternative 3						
Wet	0.0	(0.0)	(0.0)	0.0	(0.0)	0.0
Above Normal	0.0	(0.0)	(0.0)	0.1	(0.0)	0.1
Below Normal	0.0	(0.0)	0.0	0.0	(0.0)	0.0
Dry	0.1	0.0	0.1	0.1	(0.0)	0.1
Critical	0.1	(0.0)	0.1	0.1	(0.0)	0.1
Alternative 5						
Wet	0.0	(0.0)	(0.0)	0.0	(0.0)	0.0
Above Normal	0.0	(0.0)	(0.0)	0.0	(0.0)	0.0
Below Normal	(0.0)	(0.0)	(0.0)	(0.0)	0.0	(0.0)
Dry	0.0	(0.0)	0.0	0.0	(0.0)	0.0
Critical	0.0	(0.0)	0.0	0.0	(0.0)	0.0

Note:

Delta equal to change between action alternative and the No Action Alternative (e.g., Alternative 2 minus Alternative 1)

PM10 maintenance area only located in Sacramento County and is assumed to be equivalent to Region V09 emissions.

Although the PM2.5 nonattainment region is different than the 8-hour ozone nonattainment region, the affected SWAP regions are the same.

Key:

PM = particulate matter

PM2.5 = fine particulate matter

PM10 = inhalable particulate matter

tpy = tons per year

Average Pump Rate: 2,500 gallons per minute
(estimated from Long-Term Water Transfers data)

Average Engine Rating: 160 horsepower
(estimated from Long-Term Water Transfers data)

Conversions

1 TAF = 1,000 acre feet

1 acre-foot = 325,851 gallons

http://www.water.ca.gov/pubs/dwrnews/california_water_facts_card/waterfactscard.pdf

1 hour = 60 minutes

1 pound = 453.6 grams

1 ton = 2,000 pounds

Size Fractions

Description	PM10	PM2.5	Ratio
PM Profile ID No. 411, Windblown Dust - Agricultural	0.5	0.1	0.2
PM Profile ID No. 417, Agricultural Tilling Dust	0.4543	0.0681	0.1499

Note:

Fraction of PM10 (FRPM10) from wind erosion: 0.50

(PM10 Emissions = PM x FRPM10)

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Summary of Results by Watershed

Table 6. Alternative 1: Change in Emissions from Existing Conditions (tons per year)

Year Type	VOC	NOx	CO	SOx	PM10			PM2.5		
					Exhaust	Fugitive	Total	Exhaust	Fugitive	Total
Sacramento River										
Wet	-3.9	-73.7	-96.9	-24.2	-5.8	226.7	220.9	-5.8	33.9	28.1
Above Normal	-4.0	-76.6	-100.7	-25.1	-6.0	221.3	215.3	-6.0	33.1	27.1
Below Normal	-4.0	-75.4	-99.2	-24.7	-6.0	232.7	226.7	-5.9	34.8	28.9
Dry	-3.5	-67.4	-88.7	-22.1	-5.3	195.2	189.9	-5.3	29.3	24.0
Critical	-2.9	-54.5	-71.7	-17.9	-4.3	163.5	159.2	-4.3	24.9	20.7
San Joaquin River										
Wet	-2.8	-52.7	-69.4	-17.3	-4.2	40.1	35.9	-4.1	5.2	1.1
Above Normal	-2.9	-54.2	-71.3	-17.8	-4.3	41.1	36.8	-4.2	5.4	1.2
Below Normal	-2.6	-50.2	-66.0	-16.4	-4.0	41.4	37.4	-3.9	5.5	1.6
Dry	-1.9	-35.9	-47.2	-11.8	-2.8	42.4	39.5	-2.8	5.8	3.0
Critical	-0.4	-6.9	-9.1	-2.3	-0.5	38.6	38.1	-0.5	4.8	4.2
Tulare Lake										
Wet	-1.2	-23.3	-30.7	-7.7	-1.8	-6.8	-8.6	-1.8	-3.0	-4.9
Above Normal	-1.7	-32.7	-43.0	-10.7	-2.6	-7.0	-9.6	-2.6	-3.1	-5.6
Below Normal	1.2	23.3	30.7	7.7	1.8	-15.8	-14.0	1.8	-7.8	-6.0
Dry	-0.2	-4.1	-5.4	-1.3	-0.3	-15.5	-15.9	-0.3	-5.3	-5.6
Critical	0.6	11.4	15.1	3.8	0.9	-6.4	-5.5	0.9	-1.1	-0.2

Key:

CO = carbon monoxide

PM10 = inhalable particulate matter

SOx = sulfur oxides

NOx = nitrogen oxides

PM2.5 = fine particulate matter

VOC = volatile organic compounds

Table 7. Alternative 2: Change in Emissions from Alternative 1 (tons per year)

Year Type	VOC	NOx	CO	SOx	PM10			PM2.5		
					Exhaust	Fugitive	Total	Exhaust	Fugitive	Total
Sacramento River										
Wet	-0.2	-3.3	-4.3	-1.1	-0.3	0.0	-0.3	-0.3	0.0	-0.3
Above Normal	-0.3	-5.0	-6.5	-1.6	-0.4	0.0	-0.4	-0.4	0.0	-0.4
Below Normal	-0.1	-1.4	-1.8	-0.5	-0.1	4.9	4.8	-0.1	0.6	0.5
Dry	-0.1	-1.5	-1.9	-0.5	-0.1	40.7	40.6	-0.1	5.9	5.8
Critical	-0.2	-3.4	-4.5	-1.1	-0.3	27.4	27.2	-0.3	3.8	3.5
San Joaquin River										
Wet	-0.5	-10.3	-13.6	-3.4	-0.8	-0.2	-1.0	-0.8	0.0	-0.9
Above Normal	-0.7	-13.0	-17.1	-4.3	-1.0	-0.2	-1.3	-1.0	-0.1	-1.1
Below Normal	-1.0	-18.9	-24.9	-6.2	-1.5	0.3	-1.2	-1.5	0.0	-1.4
Dry	-1.7	-32.8	-43.2	-10.8	-2.6	0.0	-2.6	-2.6	0.0	-2.6
Critical	-2.0	-37.8	-49.7	-12.4	-3.0	0.1	-2.9	-3.0	0.0	-2.9
Tulare Lake										
Wet	-1.4	-27.2	-35.8	-8.9	-2.1	0.0	-2.1	-2.1	0.0	-2.1
Above Normal	-2.2	-41.3	-54.3	-13.5	-3.3	0.0	-3.2	-3.2	0.0	-3.2
Below Normal	-1.5	-27.9	-36.7	-9.2	-2.2	-16.5	-18.7	-2.2	-4.3	-6.5
Dry	-0.7	-13.0	-17.1	-4.3	-1.0	-30.6	-31.7	-1.0	-12.2	-13.3
Critical	-0.8	-14.7	-19.4	-4.8	-1.2	-36.1	-37.3	-1.2	-14.6	-15.7

Key:

CO = carbon monoxide

PM10 = inhalable particulate matter

SOx = sulfur oxides

NOx = nitrogen oxides

PM2.5 = fine particulate matter

VOC = volatile organic compounds

Table 8. Alternative 3: Change in Emissions from Alternative 1 (tons per year)

Year Type	VOC	NOx	CO	SOx	PM10			PM2.5		
					Exhaust	Fugitive	Total	Exhaust	Fugitive	Total
Sacramento River										
Wet	0.0	0.5	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.1	2.1	2.8	0.7	0.2	0.0	0.2	0.2	0.0	0.2
Below Normal	0.0	0.7	0.9	0.2	0.1	-6.3	-6.3	0.1	-0.9	-0.8
Dry	0.0	-0.4	-0.5	-0.1	0.0	-25.9	-26.0	0.0	-3.8	-3.8
Critical	0.1	1.3	1.7	0.4	0.1	-4.5	-4.4	0.1	-0.5	-0.4
San Joaquin River										
Wet	0.2	3.7	4.9	1.2	0.3	0.1	0.4	0.3	0.0	0.3
Above Normal	0.2	4.7	6.1	1.5	0.4	0.1	0.5	0.4	0.0	0.4
Below Normal	0.6	10.7	14.1	3.5	0.8	-0.2	0.6	0.8	0.0	0.8
Dry	1.2	22.4	29.5	7.4	1.8	0.0	1.8	1.8	0.0	1.8
Critical	1.1	20.4	26.8	6.7	1.6	-0.1	1.5	1.6	0.0	1.6
Tulare Lake										
Wet	0.6	11.9	15.7	3.9	0.9	0.0	0.9	0.9	0.0	0.9
Above Normal	0.8	15.8	20.8	5.2	1.2	0.0	1.2	1.2	0.0	1.2
Below Normal	0.2	3.4	4.4	1.1	0.3	17.5	17.8	0.3	4.4	4.7
Dry	0.5	9.2	12.1	3.0	0.7	19.2	19.9	0.7	7.7	8.4
Critical	0.4	7.6	10.0	2.5	0.6	26.1	26.7	0.6	10.0	10.6

Key:

CO = carbon monoxide PM10 = inhalable particulate matter SOx = sulfur oxides
NOx = nitrogen oxides PM2.5 = fine particulate matter VOC = volatile organic compounds

Table 9. Alternative 5: Change in Emissions from Alternative 1 (tons per year)

Year Type	VOC	NOx	CO	SOx	PM10			PM2.5		
					Exhaust	Fugitive	Total	Exhaust	Fugitive	Total
Sacramento River										
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry	0.0	0.1	0.2	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0
Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
San Joaquin River										
Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Critical	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tulare Lake										
Wet	0.0	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Above Normal	0.0	0.6	0.8	0.2	0.1	0.0	0.1	0.1	0.0	0.1
Below Normal	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0

Key:

CO = carbon monoxide PM10 = inhalable particulate matter SOx = sulfur oxides
NOx = nitrogen oxides PM2.5 = fine particulate matter VOC = volatile organic compounds

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Groundwater Pumping Emissions

Table 10. Alternative 1: Diesel Exhaust Emissions

SWAP Region	Change from Existing Conditions (TAF)	Annual Emissions (tons per year)					
		VOC	NOx	CO	SOx	PM10	PM2.5
Wet Condition							
Sacramento River	-67.8	-3.88	-73.67	-96.93	-24.16	-5.82	-5.76
San Joaquin River	-48.5	-2.77	-52.72	-69.37	-17.29	-4.16	-4.12
Tulare Lake	-21.5	-1.23	-23.35	-30.72	-7.66	-1.84	-1.83
Above Normal Condition							
Sacramento River	-70.5	-4.03	-76.56	-100.74	-25.11	-6.04	-5.99
San Joaquin River	-49.9	-2.85	-54.17	-71.28	-17.76	-4.28	-4.24
Tulare Lake	-30.1	-1.72	-32.67	-42.98	-10.71	-2.58	-2.56
Below Normal Condition							
Sacramento River	-69.4	-3.97	-75.38	-99.18	-24.72	-5.95	-5.90
San Joaquin River	-46.2	-2.64	-50.16	-66.00	-16.45	-3.96	-3.92
Tulare Lake	21.5	1.23	23.34	30.71	7.65	1.84	1.83
Dry Condition							
Sacramento River	-62.1	-3.55	-67.43	-88.72	-22.11	-5.32	-5.27
San Joaquin River	-33.0	-1.89	-35.87	-47.20	-11.76	-2.83	-2.81
Tulare Lake	-3.7	-0.21	-4.07	-5.35	-1.33	-0.32	-0.32
Critical Condition							
Sacramento River	-50.1	-2.87	-54.48	-71.68	-17.86	-4.30	-4.26
San Joaquin River	-6.4	-0.36	-6.93	-9.12	-2.27	-0.55	-0.54
Tulare Lake	10.5	0.60	11.44	15.06	3.75	0.90	0.90

Key:

CO = carbon monoxide

NOx = nitrogen oxides

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

SOx = sulfur oxides

SWAP = Statewide Agricultural Production

TAF = thousand acre-feet

VOC = volatile organic compounds

Table 11. Alternative 2: Diesel Exhaust Emissions

SWAP Region	Change from Alternative 1 (TAF)	Annual Emissions (tons per year)					
		VOC	NOx	CO	SOx	PM10	PM2.5
Wet Condition							
Sacramento River	-3.0	-0.17	-3.27	-4.30	-1.07	-0.26	-0.26
San Joaquin River	-9.5	-0.54	-10.34	-13.60	-3.39	-0.82	-0.81
Tulare Lake	-25.1	-1.43	-27.22	-35.81	-8.92	-2.15	-2.13
Above Normal Condition							
Sacramento River	-4.6	-0.26	-4.98	-6.55	-1.63	-0.39	-0.39
San Joaquin River	-11.9	-0.68	-12.97	-17.07	-4.25	-1.02	-1.01
Tulare Lake	-38.0	-2.17	-41.30	-54.35	-13.54	-3.26	-3.23
Below Normal Condition							
Sacramento River	-1.3	-0.07	-1.39	-1.83	-0.46	-0.11	-0.11
San Joaquin River	-17.4	-1.00	-18.93	-24.91	-6.21	-1.49	-1.48
Tulare Lake	-25.7	-1.47	-27.91	-36.73	-9.15	-2.20	-2.18
Dry Condition							
Sacramento River	-1.4	-0.08	-1.47	-1.94	-0.48	-0.12	-0.12
San Joaquin River	-30.2	-1.73	-32.81	-43.17	-10.76	-2.59	-2.57
Tulare Lake	-12.0	-0.68	-13.00	-17.11	-4.26	-1.03	-1.02
Critical Condition							
Sacramento River	-3.1	-0.18	-3.40	-4.47	-1.11	-0.27	-0.27
San Joaquin River	-34.8	-1.99	-37.79	-49.72	-12.39	-2.98	-2.96
Tulare Lake	-13.5	-0.77	-14.72	-19.36	-4.83	-1.16	-1.15

Key:

CO = carbon monoxide

NOx = nitrogen oxides

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

SOx = sulfur oxides

SWAP = Statewide Agricultural Production

TAF = thousand acre-feet

VOC = volatile organic compounds

Table 12. Alternative 3: Diesel Exhaust Emissions

SWAP Region	Change from Alternative 1 (TAF)	Annual Emissions (tons per year)					
		VOC	NOx	CO	SOx	PM10	PM2.5
Wet Condition							
Sacramento River	0.4	0.02	0.46	0.61	0.15	0.04	0.04
San Joaquin River	3.4	0.19	3.70	4.87	1.21	0.29	0.29
Tulare Lake	11.0	0.63	11.93	15.70	3.91	0.94	0.93
Above Normal Condition							
Sacramento River	2.0	0.11	2.14	2.81	0.70	0.17	0.17
San Joaquin River	4.3	0.25	4.66	6.13	1.53	0.37	0.36
Tulare Lake	14.5	0.83	15.77	20.75	5.17	1.25	1.23
Below Normal Condition							
Sacramento River	0.6	0.03	0.65	0.86	0.21	0.05	0.05
San Joaquin River	9.9	0.57	10.74	14.13	3.52	0.85	0.84
Tulare Lake	3.1	0.18	3.37	4.44	1.11	0.27	0.26
Dry Condition							
Sacramento River	-0.3	-0.02	-0.35	-0.47	-0.12	-0.03	-0.03
San Joaquin River	20.6	1.18	22.42	29.50	7.35	1.77	1.75
Tulare Lake	8.5	0.49	9.22	12.13	3.02	0.73	0.72
Critical Condition							
Sacramento River	1.2	0.07	1.31	1.73	0.43	0.10	0.10
San Joaquin River	18.7	1.07	20.36	26.79	6.68	1.61	1.59
Tulare Lake	7.0	0.40	7.61	10.02	2.50	0.60	0.60

Key:

CO = carbon monoxide

NOx = nitrogen oxides

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

SOx = sulfur oxides

SWAP = Statewide Agricultural Production

TAF = thousand acre-feet

VOC = volatile organic compounds

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Table 13. Alternative 5: Diesel Exhaust Emissions

SWAP Region	Change from Alternative 1 (TAF)	Annual Emissions (tons per year)					
		VOC	NOx	CO	SOx	PM10	PM2.5
Wet Condition							
Sacramento River	-0.002	0.00	0.00	0.00	0.00	0.00	0.00
San Joaquin River	0.03	0.00	0.04	0.05	0.01	0.00	0.00
Tulare Lake	0.2	0.01	0.19	0.25	0.06	0.02	0.02
Above Normal Condition							
Sacramento River	0.02	0.00	0.02	0.03	0.01	0.00	0.00
San Joaquin River	0.07	0.00	0.08	0.10	0.02	0.01	0.01
Tulare Lake	0.6	0.03	0.64	0.85	0.21	0.05	0.05
Below Normal Condition							
Sacramento River	-0.002	0.00	0.00	0.00	0.00	0.00	0.00
San Joaquin River	-0.007	0.00	-0.01	-0.01	0.00	0.00	0.00
Tulare Lake	0.08	0.00	0.09	0.12	0.03	0.01	0.01
Dry Condition							
Sacramento River	0.1	0.01	0.12	0.15	0.04	0.01	0.01
San Joaquin River	0.08	0.00	0.09	0.12	0.03	0.01	0.01
Tulare Lake	0.03	0.00	0.03	0.04	0.01	0.00	0.00
Critical Condition							
Sacramento River	0.006	0.00	0.01	0.01	0.00	0.00	0.00
San Joaquin River	0.06	0.00	0.06	0.08	0.02	0.00	0.00
Tulare Lake	0.01	0.00	0.01	0.02	0.00	0.00	0.00

Key:

CO = carbon monoxide

NOx = nitrogen oxides

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

SOx = sulfur oxides

SWAP = Statewide Agricultural Production

TAF = thousand acre-feet

VOC = volatile organic compounds

Average Pump Rate: 2,500 gallons per minute
(estimated from Long-Term Water Transfers data)

Average Engine Rating: 160 horsepower
(estimated from Long-Term Water Transfers data)

Conversions

1 TAF = 1,000 acre feet
1 acre-foot = 325,851 gallons

http://www.water.ca.gov/pubs/dwrnews/california_water_facts_card/waterfactscard.pdf

1 hour = 60 minutes
1 pound = 453.6 grams
1 ton = 2,000 pounds

Fugitive Dust

Table 14. Alternative 1: Detailed Fugitive Dust Emission Calculations

SWAP Region	SWAP Crop Type	Representative Crop	Irrigated Acreage (Change from Ex. Con.) (acres)	Emission Factor (lbs/acre/year)			Annual PM10 Emissions (tpy)				Annual PM2.5 Emissions (tpy)			
				Land Prep	Harvesting	Windblown Dust	Land Prep	Harvesting	Windblown Dust	Total	Land Prep	Harvesting	Windblown Dust	Total
Wet Condition														
Sacramento River	Grain	Rice	25,089.4	20	1.68	1.32	2.51E+02	2.11E+01	-1.66E+01	2.55E+02	3.76E+01	3.16E+00	-3.31E+00	3.75E+01
	Field	Corn	-10,577.7	6.9	1.68	1.32	-3.65E+01	-8.89E+00	6.98E+00	-3.84E+01	-5.47E+00	-1.33E+00	1.40E+00	-5.41E+00
	Forage	Alfalfa	-24,305.3	4	0	1.32	-4.86E+01	0.00E+00	1.60E+01	-3.26E+01	-7.29E+00	0.00E+00	3.21E+00	-4.08E+00
	Vegetable/Truck Crops	Vegetables	11,151.0	8.5	0.17	1.32	4.74E+01	9.48E-01	-7.36E+00	4.10E+01	7.10E+00	1.42E-01	-1.47E+00	5.77E+00
	Orchards and Vineyards	Almonds	1,380.4	3.13	0.08	1.32	2.16E+00	5.52E-02	-9.11E-01	1.30E+00	3.24E-01	8.28E-03	-1.82E-01	1.50E-01
	Sacramento River Subtotal		2,737.8	n/a	n/a	n/a	2.15E+02	1.32E+01	-1.81E+00	2.27E+02	3.23E+01	1.98E+00	-3.61E-01	3.39E+01
San Joaquin River	Grain	Wheat	2,162.7	3.7	5.8	9.75	4.00E+00	6.27E+00	-1.05E+01	-2.67E-01	6.00E-01	9.40E-01	-2.11E+00	-5.68E-01
	Field	Corn	-2,517.0	6.9	1.68	9.75	-8.68E+00	-2.11E+00	1.23E+01	1.47E+00	-1.30E+00	-3.17E-01	2.45E+00	8.35E-01
	Forage	Alfalfa	-24,116.4	4	0	9.75	-4.82E+01	0.00E+00	1.18E+02	6.93E+01	-7.23E+00	0.00E+00	2.35E+01	1.63E+01
	Vegetable/Truck Crops	Vegetables	22,074.7	8.5	0.17	9.75	9.38E+01	1.88E+00	-1.08E+02	-1.19E+01	1.41E+01	2.81E-01	-2.15E+01	-7.17E+00
	Orchards and Vineyards	Almonds	5,676.4	3.13	0.08	9.75	8.88E+00	2.27E-01	-2.77E+01	-1.86E+01	1.33E+00	3.40E-02	-5.53E+00	-4.17E+00
	San Joaquin River Subtotal		3,280.4	n/a	n/a	n/a	4.98E+01	6.26E+00	-1.60E+01	4.01E+01	7.46E+00	9.39E-01	-3.20E+00	5.20E+00
Tulare Lake	Grain	Wheat	2,855.7	3.7	5.8	10.70	5.28E+00	8.28E+00	-1.53E+01	-1.71E+00	7.92E-01	1.24E+00	-3.06E+00	-1.02E+00
	Field	Corn	-19,151.0	6.9	1.68	10.70	-6.61E+01	-1.61E+01	1.02E+02	2.03E+01	-9.90E+00	-2.41E+00	2.05E+01	8.18E+00
	Forage	Alfalfa	-14,422.1	4	0	10.70	-2.88E+01	0.00E+00	7.72E+01	4.83E+01	-4.32E+00	0.00E+00	1.54E+01	1.11E+01
	Vegetable/Truck Crops	Vegetables	25,522.0	8.5	0.17	10.70	1.08E+02	2.17E+00	-1.37E+02	-2.59E+01	1.63E+01	3.25E-01	-2.73E+01	-1.07E+01
	Orchards and Vineyards	Almonds	12,761.4	3.13	0.08	10.70	2.00E+01	5.10E-01	-6.83E+01	-4.78E+01	2.99E+00	7.65E-02	-1.37E+01	-1.06E+01
	Tulare Lake Subtotal		7,566.1	n/a	n/a	n/a	3.88E+01	-5.13E+00	-4.05E+01	-6.80E+00	5.82E+00	-7.68E-01	-8.10E+00	-3.05E+00
Above Normal Condition														
Sacramento River	Grain	Rice	24,649.3	20	1.68	1.32	2.46E+02	2.07E+01	-1.63E+01	2.51E+02	3.69E+01	3.10E+00	-3.25E+00	3.68E+01
	Field	Corn	-10,714.3	6.9	1.68	1.32	-3.70E+01	-9.00E+00	7.07E+00	-3.89E+01	-5.54E+00	-1.35E+00	1.41E+00	-5.48E+00
	Forage	Alfalfa	-24,359.3	4	0	1.32	-4.87E+01	0.00E+00	1.61E+01	-3.26E+01	-7.30E+00	0.00E+00	3.21E+00	-4.09E+00
	Vegetable/Truck Crops	Vegetables	11,072.0	8.5	0.17	1.32	4.71E+01	9.41E-01	-7.31E+00	4.07E+01	7.05E+00	1.41E-01	-1.46E+00	5.73E+00
	Orchards and Vineyards	Almonds	1,326.3	3.13	0.08	1.32	2.08E+00	5.31E-02	-8.75E-01	1.25E+00	3.11E-01	7.95E-03	-1.75E-01	1.44E-01
	Sacramento River Subtotal		1,974.0	n/a	n/a	n/a	2.10E+02	1.27E+01	-1.30E+00	2.21E+02	3.15E+01	1.90E+00	-2.60E-01	3.31E+01
San Joaquin River	Grain	Wheat	2,171.4	3.7	5.8	9.75	4.02E+00	6.30E+00	-1.06E+01	-2.68E-01	6.02E-01	9.44E-01	-2.12E+00	-5.70E-01
	Field	Corn	-2,508.2	6.9	1.68	9.75	-8.65E+00	-2.11E+00	1.22E+01	1.46E+00	-1.30E+00	-3.16E-01	2.44E+00	8.32E-01
	Forage	Alfalfa	-24,456.9	4	0	9.75	-4.89E+01	0.00E+00	1.19E+02	7.03E+01	-7.33E+00	0.00E+00	2.38E+01	1.65E+01
	Vegetable/Truck Crops	Vegetables	22,094.5	8.5	0.17	9.75	9.39E+01	1.88E+00	-1.08E+02	-1.19E+01	1.41E+01	2.82E-01	-2.15E+01	-7.18E+00
	Orchards and Vineyards	Almonds	5,648.5	3.13	0.08	9.75	8.84E+00	2.26E-01	-2.75E+01	-1.85E+01	1.33E+00	3.39E-02	-5.51E+00	-4.15E+00
	San Joaquin River Subtotal		2,949.3	n/a	n/a	n/a	4.92E+01	6.29E+00	-1.44E+01	4.11E+01	7.37E+00	9.44E-01	-2.87E+00	5.44E+00
Tulare Lake	Grain	Wheat	2,855.9	3.7	5.8	10.70	5.28E+00	8.28E+00	-1.53E+01	-1.71E+00	7.92E-01	1.24E+00	-3.06E+00	-1.02E+00
	Field	Corn	-19,169.0	6.9	1.68	10.70	-6.61E+01	-1.61E+01	1.03E+02	2.03E+01	-9.91E+00	-2.41E+00	2.05E+01	8.18E+00
	Forage	Alfalfa	-14,275.4	4	0	10.70	-2.86E+01	0.00E+00	7.64E+01	4.78E+01	-4.28E+00	0.00E+00	1.53E+01	1.10E+01
	Vegetable/Truck Crops	Vegetables	25,497.1	8.5	0.17	10.70	1.08E+02	2.17E+00	-1.36E+02	-2.59E+01	1.62E+01	3.25E-01	-2.73E+01	-1.07E+01
	Orchards and Vineyards	Almonds	12,691.2	3.13	0.08	10.70	1.99E+01	5.08E-01	-6.79E+01	-4.75E+01	2.98E+00	7.61E-02	-1.36E+01	-1.05E+01
	Tulare Lake Subtotal		7,599.7	n/a	n/a	n/a	3.88E+01	-5.14E+00	-4.07E+01	-6.98E+00	5.82E+00	-7.71E-01	-8.13E+00	-3.08E+00

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Below Normal Condition														
Sacramento River	Grain	Rice	25,588.6	20	1.68	1.32	2.56E+02	2.15E+01	-1.69E+01	2.60E+02	3.84E+01	3.22E+00	-3.38E+00	3.82E+01
	Field	Corn	-9,424.6	6.9	1.68	1.32	-3.25E+01	-7.92E+00	6.22E+00	-3.42E+01	-4.87E+00	-1.19E+00	1.24E+00	-4.82E+01
	Forage	Alfalfa	-26,840.2	4	0	1.32	-5.37E+01	0.00E+00	1.77E+01	-3.60E+01	-8.05E+00	0.00E+00	3.54E+00	-4.50E+00
	Vegetable/Truck Crops	Vegetables	11,194.3	8.5	0.17	1.32	4.76E+01	9.52E-01	-7.39E+00	4.11E+01	7.13E+00	1.43E-01	-1.48E+00	5.80E+00
	Orchards and Vineyards	Almonds	1,301.9	3.13	0.08	1.32	2.04E+00	5.21E-02	-8.59E-01	1.23E+00	3.05E-01	7.81E-03	-1.72E-01	1.41E-01
	Sacramento River Subtotal		1,820.1	n/a	n/a	n/a	2.19E+02	1.46E+01	-1.20E+00	2.33E+02	3.29E+01	2.19E+00	-2.40E-01	3.48E+01
San Joaquin River	Grain	Wheat	2,175.5	3.7	5.8	9.75	4.02E+00	6.31E+00	-1.06E+01	-2.69E-01	6.03E-01	9.46E-01	-2.12E+00	-5.71E-01
	Field	Corn	-2,605.1	6.9	1.68	9.75	-8.99E+00	-2.19E+00	1.27E+01	1.52E+00	-1.35E+00	-3.28E-01	2.54E+00	8.64E-01
	Forage	Alfalfa	-24,510.5	4	0	9.75	-4.90E+01	0.00E+00	1.19E+02	7.04E+01	-7.35E+00	0.00E+00	2.39E+01	1.65E+01
	Vegetable/Truck Crops	Vegetables	22,022.9	8.5	0.17	9.75	9.36E+01	1.87E+00	-1.07E+02	-1.19E+01	1.40E+01	2.81E-01	-2.15E+01	-7.15E+00
	Orchards and Vineyards	Almonds	5,635.1	3.13	0.08	9.75	8.82E+00	2.25E-01	-2.75E+01	-1.84E+01	1.32E+00	3.38E-02	-5.49E+00	-4.14E+00
	San Joaquin River Subtotal		2,717.8	n/a	n/a	n/a	4.84E+01	6.22E+00	-1.32E+01	4.14E+01	7.26E+00	9.32E-01	-2.65E+00	5.54E+00
Tulare Lake	Grain	Wheat	4,171.3	3.7	5.8	10.70	7.72E+00	1.21E+01	-2.23E+01	-2.50E+00	1.16E+00	1.81E+00	-4.46E+00	-1.49E+00
	Field	Corn	-9,159.0	6.9	1.68	10.70	-3.16E+01	-7.69E+00	4.90E+01	9.71E+00	-4.74E+00	-1.15E+00	9.80E+00	3.91E+00
	Forage	Alfalfa	-16,359.5	4	0	10.70	-3.27E+01	0.00E+00	8.75E+01	5.48E+01	-4.90E+00	0.00E+00	1.75E+01	1.26E+01
	Vegetable/Truck Crops	Vegetables	28,555.9	8.5	0.17	10.70	1.21E+02	2.43E+00	-1.53E+02	-2.90E+01	1.82E+01	3.64E-01	-3.06E+01	-1.20E+01
	Orchards and Vineyards	Almonds	13,047.9	3.13	0.08	10.70	2.04E+01	5.22E-01	-6.98E+01	-4.89E+01	3.06E+00	7.82E-02	-1.40E+01	-1.08E+01
	Tulare Lake Subtotal		20,256.6	n/a	n/a	n/a	8.52E+01	7.35E+00	-1.08E+02	-1.58E+01	1.28E+01	1.10E+00	-2.17E+01	-7.80E+00
Dry Condition														
Sacramento River	Grain	Rice	22,555.8	20	1.68	1.32	2.26E+02	1.89E+01	-1.49E+01	2.30E+02	3.38E+01	2.84E+00	-2.98E+00	3.37E+01
	Field	Corn	-12,367.8	6.9	1.68	1.32	-4.27E+01	-1.04E+01	8.16E+00	-4.49E+01	-6.40E+00	-1.56E+00	1.63E+00	-6.32E+00
	Forage	Alfalfa	-21,846.4	4	0	1.32	-4.37E+01	0.00E+00	1.44E+01	-2.93E+01	-6.55E+00	0.00E+00	2.88E+00	-3.67E+00
	Vegetable/Truck Crops	Vegetables	10,689.6	8.5	0.17	1.32	4.54E+01	9.09E-01	-7.05E+00	3.93E+01	6.81E+00	1.36E-01	-1.41E+00	5.54E+00
	Orchards and Vineyards	Almonds	494.1	3.13	0.08	1.32	7.73E-01	1.98E-02	-3.26E-01	4.67E-01	1.16E-01	2.96E-03	-6.52E-02	5.37E-02
	Sacramento River Subtotal		-474.8	n/a	n/a	n/a	1.85E+02	9.49E+00	3.13E-01	1.95E+02	2.78E+01	1.42E+00	6.27E-02	2.93E+01
San Joaquin River	Grain	Wheat	2,171.9	3.7	5.8	9.75	4.02E+00	6.30E+00	-1.06E+01	-2.68E-01	6.02E-01	9.44E-01	-2.12E+00	-5.70E-01
	Field	Corn	-2,521.8	6.9	1.68	9.75	-8.70E+00	-2.12E+00	1.23E+01	1.47E+00	-1.30E+00	-3.18E-01	2.46E+00	8.36E-01
	Forage	Alfalfa	-24,849.5	4	0	9.75	-4.97E+01	0.00E+00	1.21E+02	7.14E+01	-7.45E+00	0.00E+00	2.42E+01	1.68E+01
	Vegetable/Truck Crops	Vegetables	21,855.5	8.5	0.17	9.75	9.29E+01	1.86E+00	-1.07E+02	-1.18E+01	1.39E+01	2.78E-01	-2.13E+01	-7.10E+00
	Orchards and Vineyards	Almonds	5,651.0	3.13	0.08	9.75	8.84E+00	2.26E-01	-2.75E+01	-1.85E+01	1.33E+00	3.39E-02	-5.51E+00	-4.15E+00
	San Joaquin River Subtotal		2,307.2	n/a	n/a	n/a	4.73E+01	6.26E+00	-1.12E+01	4.24E+01	7.10E+00	9.39E-01	-2.25E+00	5.79E+00
Tulare Lake	Grain	Wheat	6,362.2	3.7	5.8	10.70	1.18E+01	1.85E+01	-3.40E+01	-3.82E+00	1.76E+00	2.77E+00	-6.81E+00	-2.28E+00
	Field	Corn	-28,576.7	6.9	1.68	10.70	-9.86E+01	-2.40E+01	1.53E+02	3.03E+01	-1.48E+01	-3.60E+00	3.06E+01	1.22E+01
	Forage	Alfalfa	-12,046.3	4	0	10.70	-2.41E+01	0.00E+00	6.45E+01	4.04E+01	-3.61E+00	0.00E+00	1.29E+01	9.28E+00
	Vegetable/Truck Crops	Vegetables	32,100.4	8.5	0.17	10.70	1.36E+02	2.73E+00	-1.72E+02	-3.26E+01	2.05E+01	4.09E-01	-3.43E+01	-1.35E+01
	Orchards and Vineyards	Almonds	13,294.7	3.13	0.08	10.70	2.08E+01	5.32E-01	-7.11E+01	-4.98E+01	3.12E+00	7.97E-02	-1.42E+01	-1.10E+01
	Tulare Lake Subtotal		11,134.3	n/a	n/a	n/a	4.63E+01	-2.29E+00	-5.96E+01	-1.55E+01	6.94E+00	-3.44E-01	-1.19E+01	-5.31E+00
Critical Condition														
Sacramento River	Grain	Rice	20,304.5	20	1.68	1.32	2.03E+02	1.71E+01	-1.34E+01	2.07E+02	3.04E+01	2.56E+00	-2.68E+00	3.03E+01
	Field	Corn	-11,377.3	6.9	1.68	1.32	-3.93E+01	-9.56E+00	7.51E+00	-4.13E+01	-5.88E+00	-1.43E+00	1.50E+00	-5.82E+00
	Forage	Alfalfa	-22,543.4	4	0	1.32	-4.51E+01	0.00E+00	1.49E+01	-3.02E+01	-6.76E+00	0.00E+00	2.97E+00	-3.78E+00
	Vegetable/Truck Crops	Vegetables	10,110.3	8.5	0.17	1.32	4.30E+01	8.59E-01	-6.67E+00	3.72E+01	6.44E+00	1.29E-01	-1.33E+00	5.24E+00
	Orchards and Vineyards	Almonds	-9,338.6	3.13	0.08	1.32	-1.46E+01	-3.74E-01	6.16E+00	-8.83E+00	-2.19E+00	-5.60E-02	1.23E+00	-1.01E+00
	Sacramento River Subtotal		-12,844.5	n/a	n/a	n/a	1.47E+02	7.98E+00	8.48E+00	1.64E+02	2.20E+01	1.20E+00	1.70E+00	2.49E+01
San Joaquin River	Grain	Wheat	2,336.9	3.7	5.8	9.75	4.32E+00	6.78E+00	-1.14E+01	-2.89E-01	6.48E-01	1.02E+00	-2.28E+00	-6.14E-01
	Field	Corn	-1,764.1	6.9	1.68	9.75	-6.09E+00	-1.48E+00	8.60E+00	1.03E+00	-9.12E-01	-2.22E-01	1.72E+00	5.85E-01
	Forage	Alfalfa	-24,270.7	4	0	9.75	-4.85E+01	0.00E+00	1.18E+02	6.97E+01	-7.28E+00	0.00E+00	2.37E+01	1.64E+01
	Vegetable/Truck Crops	Vegetables	21,682.8	8.5	0.17	9.75	9.22E+01	1.84E+00	-1.06E+02	-1.17E+01	1.38E+01	2.76E-01	-2.11E+01	-7.04E+00
	Orchards and Vineyards	Almonds	6,178.5	3.13	0.08	9.75	9.67E+00	2.47E-01	-3.01E+01	-2.02E+01	1.45E+00	3.70E-02	-6.02E+00	-4.54E+00
	San Joaquin River Subtotal		4,163.5	n/a	n/a	n/a	5.15E+01	7.39E+00	-2.03E+01	3.86E+01	7.72E+00	1.11E+00	-4.06E+00	4.77E+00
Tulare Lake	Grain	Wheat	8,148.6	3.7	5.8	10.70	1.51E+01	2.36E+01	-4.36E+01	-4.89E+00	2.26E+00	3.54E+00	-8.72E+00	-2.92E+00
	Field	Corn	-44,256.3	6.9	1.68	10.70	-1.53E+02	-3.72E+01	2.37E+02	4.69E+01	-2.29E+01	-5.57E+00	4.74E+01	1.89E+01
	Forage	Alfalfa	-11,842.1	4	0	10.70	-2.37E+01	0.00E+00	6.34E+01	3.97E+01	-3.55E+00	0.00E+00	1.27E+01	9.12E+00
	Vegetable/Truck Crops	Vegetables	34,379.4	8.5	0.17	10.70	1.46E+02	2.92E+00	-1.84E+02	-3.49E+01	2.19E+01	4.38E-01	-3.68E+01	-1.44E+01
	Orchards and Vineyards	Almonds	14,198.0	3.13	0.08	10.70	2.22E+01	5.68E-01	-7.60E+01	-5.32E+01	3.33E+00	8.51E-02	-1.52E+01	-1.18E+01
	Tulare Lake Subtotal		627.7	n/a	n/a	n/a	7.04E+00	-1.01E+01	-3.36E+00	-6.37E+00	1.06E+00	-1.51E+00	-6.72E-01	-1.12E+00

Key:

SWAP = Statewide Agricultural Production

lbs/acre/year = pounds per acre per year

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

tpy = tons per year

Appendix E
Air Quality Emission Calculations

Table 15. Alternative 2: Detailed Fugitive Dust Emission Calculations

SWAP Region	SWAP Crop Type	Representative Crop	Irrigated Acreage (Change from Alt 1) (acres)	Emission Factor (lbs/acre/year)			Annual PM10 Emissions (tpy)				Annual PM2.5 Emissions (tpy)			
				Land Prep	Harvesting	Windblown Dust	Land Prep	Harvesting	Windblown Dust	Total	Land Prep	Harvesting	Windblown Dust	Total
Wet Condition														
Sacramento River	Grain	Rice	0.4	20	1.68	1.32	3.52E-03	2.96E-04	-2.33E-04	3.59E-03	5.28E-04	4.44E-05	-4.65E-05	5.26E-04
	Field	Corn	1.5	6.9	1.68	1.32	5.25E-03	1.28E-03	-1.00E-03	5.52E-03	7.86E-04	1.91E-04	-2.01E-04	7.77E-04
	Forage	Alfalfa	-1.4	4	0	1.32	-2.90E-03	0.00E+00	9.56E-04	-1.94E-03	-4.34E-04	0.00E+00	1.91E-04	-2.43E-04
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	1.32	3.38E-05	6.76E-07	-5.25E-06	2.92E-05	5.07E-06	1.01E-07	-1.05E-06	4.12E-06
	Orchards and Vineyards	Almonds	0.1	3.13	0.08	1.32	1.63E-04	4.17E-06	-6.88E-05	9.86E-05	2.45E-05	6.25E-07	-1.38E-05	1.13E-05
	Sacramento River Subtotal		0.5	n/a	n/a	n/a	6.07E-03	1.58E-03	-3.54E-04	7.29E-03	9.10E-04	2.37E-04	-7.08E-05	1.08E-03
San Joaquin River	Grain	Wheat	-2.3	3.7	5.8	9.75	-4.24E-03	-6.64E-03	1.12E-02	2.83E-04	-6.35E-04	-9.96E-04	2.23E-03	6.02E-04
	Field	Corn	10.2	6.9	1.68	9.75	3.53E-02	8.59E-03	-4.98E-02	-5.97E-03	5.29E-03	1.29E-03	-9.97E-03	-3.39E-03
	Forage	Alfalfa	66.7	4	0	9.75	1.33E-01	0.00E+00	-3.25E-01	-1.92E-01	2.00E-02	0.00E+00	-6.50E-02	-4.50E-02
	Vegetable/Truck Crops	Vegetables	2.8	8.5	0.17	9.75	1.19E-02	2.39E-04	-1.37E-02	-1.51E-03	1.79E-03	3.58E-05	-2.74E-03	-9.12E-04
	Orchards and Vineyards	Almonds	0.7	3.13	0.08	9.75	1.06E-03	2.72E-05	-3.31E-03	-2.22E-03	1.60E-04	4.08E-06	-6.63E-04	-4.99E-04
	San Joaquin River Subtotal		78.1	n/a	n/a	n/a	1.77E-01	2.21E-03	-3.81E-01	-2.01E-01	2.66E-02	3.32E-04	-7.61E-02	-4.92E-02
Tulare Lake	Grain	Wheat	0.1	3.7	5.8	10.70	2.69E-04	4.22E-04	-7.78E-04	-8.73E-05	4.03E-05	6.32E-05	-1.56E-04	-5.20E-05
	Field	Corn	2.1	6.9	1.68	10.70	7.08E-03	1.72E-03	-1.10E-02	-2.18E-03	1.06E-03	2.58E-04	-2.20E-03	-8.76E-04
	Forage	Alfalfa	-3.5	4	0	10.70	-6.95E-03	0.00E+00	1.86E-02	1.17E-02	-1.04E-03	0.00E+00	3.72E-03	2.68E-03
	Vegetable/Truck Crops	Vegetables	0.1	8.5	0.17	10.70	2.89E-04	5.77E-06	-3.63E-04	-6.90E-05	4.33E-05	8.65E-07	-7.27E-05	-2.85E-05
	Orchards and Vineyards	Almonds	0.2	3.13	0.08	10.70	3.57E-04	9.12E-06	-1.22E-03	-8.54E-04	5.35E-05	1.37E-06	-2.44E-04	-1.89E-04
	Tulare Lake Subtotal		-1.0	n/a	n/a	n/a	1.04E-03	2.16E-03	5.27E-03	8.47E-03	1.56E-04	3.24E-04	1.05E-03	1.53E-03
Above Normal Condition														
Sacramento River	Grain	Rice	0.6	20	1.68	1.32	6.25E-03	5.25E-04	-4.13E-04	6.37E-03	9.37E-04	7.87E-05	-8.25E-05	9.34E-04
	Field	Corn	2.1	6.9	1.68	1.32	7.21E-03	1.76E-03	-1.38E-03	7.59E-03	1.08E-03	2.63E-04	-2.76E-04	1.07E-03
	Forage	Alfalfa	-2.6	4	0	1.32	-5.13E-03	0.00E+00	1.69E-03	-3.44E-03	-7.69E-04	0.00E+00	3.38E-04	-4.31E-04
	Vegetable/Truck Crops	Vegetables	0.1	8.5	0.17	1.32	2.36E-04	4.72E-06	-3.66E-05	2.04E-04	3.54E-05	7.07E-07	-7.32E-06	2.87E-05
	Orchards and Vineyards	Almonds	0.2	3.13	0.08	1.32	2.45E-04	6.25E-06	-1.03E-04	1.48E-04	3.67E-05	9.37E-07	-2.06E-05	1.70E-05
	Sacramento River Subtotal		0.4	n/a	n/a	n/a	8.82E-03	2.29E-03	-2.40E-04	1.09E-02	1.32E-03	3.44E-04	-4.79E-05	1.62E-03
San Joaquin River	Grain	Wheat	-2.9	3.7	5.8	9.75	-5.30E-03	-8.30E-03	1.40E-02	3.54E-04	-7.94E-04	-1.24E-03	2.79E-03	7.52E-04
	Field	Corn	11.2	6.9	1.68	9.75	3.86E-02	9.40E-03	-5.45E-02	-6.53E-03	5.79E-03	1.41E-03	-1.09E-02	-3.71E-03
	Forage	Alfalfa	81.9	4	0	9.75	1.64E-01	0.00E+00	-3.99E-01	-2.35E-01	2.46E-02	0.00E+00	-7.98E-02	-5.53E-02
	Vegetable/Truck Crops	Vegetables	3.1	8.5	0.17	9.75	1.33E-02	2.67E-04	-1.53E-02	-1.69E-03	2.00E-03	4.00E-05	-3.06E-03	-1.02E-03
	Orchards and Vineyards	Almonds	0.8	3.13	0.08	9.75	1.22E-03	3.13E-05	-3.81E-03	-2.56E-03	1.83E-04	4.69E-06	-7.62E-04	-5.74E-04
	San Joaquin River Subtotal		94.2	n/a	n/a	n/a	2.12E-01	1.40E-03	-4.59E-01	-2.46E-01	3.17E-02	2.09E-04	-9.18E-02	-5.98E-02
Tulare Lake	Grain	Wheat	0.4	3.7	5.8	10.70	7.56E-04	1.19E-03	-2.19E-03	-2.45E-04	1.13E-04	1.78E-04	-4.37E-04	-1.46E-04
	Field	Corn	4.6	6.9	1.68	10.70	1.58E-02	3.84E-03	-2.44E-02	-4.84E-03	2.36E-03	5.75E-04	-4.89E-03	-1.95E-03
	Forage	Alfalfa	-9.4	4	0	10.70	-1.87E-02	0.00E+00	5.01E-02	3.14E-02	-2.81E-03	0.00E+00	1.00E-02	7.21E-03
	Vegetable/Truck Crops	Vegetables	0.2	8.5	0.17	10.70	7.97E-04	1.59E-05	-1.00E-03	-1.90E-04	1.19E-04	2.39E-06	-2.01E-04	-7.88E-05
	Orchards and Vineyards	Almonds	0.5	3.13	0.08	10.70	7.53E-04	1.93E-05	-2.58E-03	-1.80E-03	1.13E-04	2.89E-06	-5.15E-04	-3.99E-04
	Tulare Lake Subtotal		-3.7	n/a	n/a	n/a	-6.62E-04	5.06E-03	1.99E-02	2.43E-02	-9.92E-05	7.58E-04	3.98E-03	4.64E-03
Below Normal Condition														
Sacramento River	Grain	Rice	52.4	20	1.68	1.32	5.24E-01	4.40E-02	-3.46E-02	5.34E-01	7.86E-02	6.60E-03	-6.92E-03	7.83E-02
	Field	Corn	80.6	6.9	1.68	1.32	2.78E-01	6.77E-02	-5.32E-02	2.93E-01	4.17E-02	1.02E-02	-1.06E-02	4.12E-02
	Forage	Alfalfa	2,931.5	4	0	1.32	5.86E+00	0.00E+00	-1.93E+00	3.93E+00	8.79E-01	0.00E+00	-3.87E-01	4.92E-01
	Vegetable/Truck Crops	Vegetables	30.2	8.5	0.17	1.32	1.28E-01	2.57E-03	-1.99E-02	1.11E-01	1.92E-02	3.85E-04	-3.98E-03	1.56E-02
	Orchards and Vineyards	Almonds	27.1	3.13	0.08	1.32	4.24E-02	1.08E-03	-1.79E-02	2.56E-02	6.36E-03	1.63E-04	-3.58E-03	2.95E-03
	Sacramento River Subtotal		3,121.8	n/a	n/a	n/a	6.84E+00	1.15E-01	-2.06E+00	4.89E+00	1.02E+00	1.73E-02	-4.12E-01	6.30E-01
San Joaquin River	Grain	Wheat	10.1	3.7	5.8	9.75	1.86E-02	2.92E-02	-4.91E-02	-1.24E-03	2.79E-03	4.38E-03	-9.82E-03	-2.65E-03
	Field	Corn	58.6	6.9	1.68	9.75	2.02E-01	4.92E-02	-2.85E-01	-3.42E-02	3.03E-02	7.38E-03	-5.71E-02	-1.94E-02
	Forage	Alfalfa	-125.8	4	0	9.75	-2.52E-01	0.00E+00	6.13E-01	3.61E-01	-3.77E-02	0.00E+00	1.23E-01	8.49E-02
	Vegetable/Truck Crops	Vegetables	26.5	8.5	0.17	9.75	1.13E-01	2.25E-03	-1.29E-01	-1.43E-02	1.69E-02	3.38E-04	-2.58E-02	-8.61E-03
	Orchards and Vineyards	Almonds	5.9	3.13	0.08	9.75	9.18E-03	2.35E-04	-2.86E-02	-1.92E-02	1.38E-03	3.52E-05	-5.72E-03	-4.30E-03
	San Joaquin River Subtotal		-24.8	n/a	n/a	n/a	9.09E-02	8.09E-02	1.21E-01	2.93E-01	1.36E-02	1.21E-02	2.42E-02	4.99E-02

Central Valley Project Municipal & Industrial Water Shortage Policy
Final EIS

Tulare Lake	Grain	Wheat	-280.4	3.7	5.8	10.70	-5.19E-01	-8.13E-01	1.50E+00	1.68E-01	-7.78E-02	-1.22E-01	3.00E-01	1.00E-01
	Field	Corn	3,168.5	6.9	1.68	10.70	1.09E+01	2.66E+00	-1.70E+01	-3.36E+00	1.64E+00	3.99E-01	-3.39E+00	-1.35E+00
	Forage	Alfalfa	3,903.1	4	0	10.70	7.81E+00	0.00E+00	-2.09E+01	-1.31E+01	1.17E+00	0.00E+00	-4.18E+00	-3.01E+00
	Vegetable/Truck Crops	Vegetables	-126.7	8.5	0.17	10.70	-5.38E-01	-1.08E-02	6.78E-01	1.29E-01	-8.07E-02	-1.61E-03	1.36E-01	5.32E-02
	Orchards and Vineyards	Almonds	97.4	3.13	0.08	10.70	1.52E-01	3.90E-03	-5.21E-01	-3.65E-01	2.29E-02	5.84E-04	-1.04E-01	-8.08E-02
	Tulare Lake Subtotal		6,762.0	n/a	n/a	n/a	1.78E+01	1.84E+00	-3.62E+01	-1.65E+01	2.67E+00	2.76E-01	-7.24E+00	-4.29E+00
Dry Condition														
Sacramento River	Grain	Rice	3,351.1	20	1.68	1.32	3.35E+01	2.81E+00	-2.21E+00	3.41E+01	5.02E+00	4.22E-01	-4.42E-01	5.00E+00
	Field	Corn	1,556.8	6.9	1.68	1.32	5.37E+00	1.31E+00	-1.03E+00	5.65E+00	8.05E-01	1.96E-01	-2.05E-01	7.96E-01
	Forage	Alfalfa	24.4	4	0	1.32	4.88E-02	0.00E+00	-1.61E-02	3.27E-02	7.31E-03	0.00E+00	-3.22E-03	4.09E-03
	Vegetable/Truck Crops	Vegetables	209.8	8.5	0.17	1.32	8.92E-01	1.78E-02	-1.38E-01	7.71E-01	1.34E-01	2.67E-03	-2.77E-02	1.09E-01
	Orchards and Vineyards	Almonds	168.6	3.13	0.08	1.32	2.64E-01	6.74E-03	-1.11E-01	1.59E-01	3.96E-02	1.01E-03	-2.22E-02	1.83E-02
	Sacramento River Subtotal		5,310.7	n/a	n/a	n/a	4.01E+01	4.15E+00	-3.50E+00	4.07E+01	6.01E+00	6.22E-01	-7.01E-01	5.93E+00
San Joaquin River	Grain	Wheat	6.5	3.7	5.8	9.75	1.20E-02	1.88E-02	-3.16E-02	-8.00E-04	1.80E-03	2.81E-03	-6.31E-03	-1.70E-03
	Field	Corn	-80.5	6.9	1.68	9.75	-2.78E-01	-6.76E-02	3.92E-01	4.70E-02	-4.16E-02	-1.01E-02	7.84E-02	2.67E-02
	Forage	Alfalfa	28.2	4	0	9.75	5.64E-02	0.00E+00	-1.38E-01	-8.11E-02	8.46E-03	0.00E+00	-2.75E-02	-1.90E-02
	Vegetable/Truck Crops	Vegetables	4.6	8.5	0.17	9.75	1.97E-02	3.94E-04	-2.26E-02	-2.50E-03	2.96E-03	5.91E-05	-4.52E-03	-1.51E-03
	Orchards and Vineyards	Almonds	-6.6	3.13	0.08	9.75	-1.04E-02	-2.66E-04	3.24E-02	2.17E-02	-1.56E-03	-3.99E-05	6.48E-03	4.88E-03
	San Joaquin River Subtotal		-47.8	n/a	n/a	n/a	-2.00E-01	-4.87E-02	2.33E-01	-1.57E-02	-3.00E-02	-7.30E-03	4.66E-02	9.31E-03
Tulare Lake	Grain	Wheat	118.6	3.7	5.8	10.70	2.19E-01	3.44E-01	-6.34E-01	-7.12E-02	3.29E-02	5.15E-02	-1.27E-01	-4.25E-02
	Field	Corn	27,966.8	6.9	1.68	10.70	9.65E+01	2.35E+01	-1.50E+02	-2.97E+01	1.45E+01	3.52E+00	-2.99E+01	-1.19E+01
	Forage	Alfalfa	92.1	4	0	10.70	1.84E-01	0.00E+00	-4.93E-01	-3.09E-01	2.76E-02	0.00E+00	-9.85E-02	-7.09E-02
	Vegetable/Truck Crops	Vegetables	275.0	8.5	0.17	10.70	1.17E+00	2.34E-02	-1.47E+00	-2.79E-01	1.75E-01	3.50E-03	-2.94E-01	-1.16E-01
	Orchards and Vineyards	Almonds	86.2	3.13	0.08	10.70	1.35E-01	3.45E-03	-4.61E-01	-3.23E-01	2.02E-02	5.17E-04	-9.22E-02	-7.15E-02
	Tulare Lake Subtotal		28,538.7	n/a	n/a	n/a	9.82E+01	2.39E+01	-1.53E+02	-3.06E+01	1.47E+01	3.58E+00	-3.05E+01	-1.22E+01
Critical Condition														
Sacramento River	Grain	Rice	1,959.3	20	1.68	1.32	1.96E+01	1.65E+00	-1.29E+00	1.99E+01	2.94E+00	2.47E-01	-2.59E-01	2.93E+00
	Field	Corn	20.1	6.9	1.68	1.32	6.93E-02	1.69E-02	-1.33E-02	7.30E-02	1.04E-02	2.53E-03	-2.65E-03	1.03E-02
	Forage	Alfalfa	49.7	4	0	1.32	9.95E-02	0.00E+00	-3.28E-02	6.67E-02	1.49E-02	0.00E+00	-6.56E-03	8.35E-03
	Vegetable/Truck Crops	Vegetables	56.9	8.5	0.17	1.32	2.42E-01	4.83E-03	-3.75E-02	2.09E-01	3.62E-02	7.25E-04	-7.50E-03	2.94E-02
	Orchards and Vineyards	Almonds	7,541.6	3.13	0.08	1.32	1.18E+01	3.02E-01	-4.98E+00	7.13E+00	1.77E+00	4.52E-02	-9.95E-01	8.19E-01
	Sacramento River Subtotal		9,627.6	n/a	n/a	n/a	3.18E+01	1.97E+00	-6.35E+00	2.74E+01	4.77E+00	2.95E-01	-1.27E+00	3.79E+00
San Joaquin River	Grain	Wheat	11.5	3.7	5.8	9.75	2.13E-02	3.34E-02	-5.62E-02	-1.42E-03	3.20E-03	5.01E-03	-1.12E-02	-3.03E-03
	Field	Corn	6.3	6.9	1.68	9.75	2.16E-02	5.25E-03	-3.05E-02	-3.65E-03	3.23E-03	7.87E-04	-6.09E-03	-2.07E-03
	Forage	Alfalfa	107.5	4	0	9.75	2.15E-01	0.00E+00	-5.24E-01	-3.09E-01	3.22E-02	0.00E+00	-1.05E-01	-7.26E-02
	Vegetable/Truck Crops	Vegetables	9.8	8.5	0.17	9.75	4.17E-02	8.34E-04	-4.78E-02	-5.28E-03	6.25E-03	1.25E-04	-9.56E-03	-3.19E-03
	Orchards and Vineyards	Almonds	-138.0	3.13	0.08	9.75	-2.16E-01	-5.52E-03	6.73E-01	4.51E-01	-3.24E-02	-8.28E-04	1.35E-01	1.01E-01
	San Joaquin River Subtotal		-2.9	n/a	n/a	n/a	8.36E-02	3.40E-02	1.44E-02	1.32E-01	1.25E-02	5.10E-03	2.87E-03	2.05E-02
Tulare Lake	Grain	Wheat	39.7	3.7	5.8	10.70	7.35E-02	1.15E-01	-2.13E-01	-2.39E-02	1.10E-02	1.73E-02	-4.25E-02	-1.42E-02
	Field	Corn	34,116.9	6.9	1.68	10.70	1.18E+02	2.87E+01	-1.83E+02	-3.62E+01	1.76E+01	4.30E+00	-3.65E+01	-1.46E+01
	Forage	Alfalfa	113.9	4	0	10.70	2.28E-01	0.00E+00	-6.09E-01	-3.82E-01	3.41E-02	0.00E+00	-1.22E-01	-8.77E-02
	Vegetable/Truck Crops	Vegetables	38.9	8.5	0.17	10.70	1.65E-01	3.31E-03	-2.08E-01	-3.95E-02	2.48E-02	4.96E-04	-4.16E-02	-1.64E-02
	Orchards and Vineyards	Almonds	-138.6	3.13	0.08	10.70	-2.17E-01	-5.54E-03	7.42E-01	5.19E-01	-3.25E-02	-8.31E-04	1.48E-01	1.15E-01
	Tulare Lake Subtotal		34,170.9	n/a	n/a	n/a	1.18E+02	2.88E+01	-1.83E+02	-3.61E+01	1.77E+01	4.31E+00	-3.66E+01	-1.46E+01

Key:

SWAP = Statewide Agricultural Production

lbs/acre/year = pounds per acre per year

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

tpy = tons per year

Table 16. Alternative 3: Detailed Fugitive Dust Emission Calculations

SWAP Region	SWAP Crop Type	Representative Crop	Irrigated Acreage (Change from Alt 1) (acres)	Emission Factor (lbs/acre/year)			Annual PM10 Emissions (tpy)				Annual PM10 Emissions (tpy)			
				Land Prep	Harvesting	Windblown Dust	Land Prep	Harvesting	Windblown Dust	Total	Land Prep	Harvesting	Windblown Dust	Total
Wet Condition														
Sacramento River	Grain	Rice	-0.1	20	1.68	1.32	-1.28E-03	-1.07E-04	8.42E-05	-1.30E-03	-1.91E-04	-1.61E-05	1.68E-05	-1.90E-04
	Field	Corn	-0.5	6.9	1.68	1.32	-1.90E-03	-4.62E-04	3.63E-04	-2.00E-03	-2.84E-04	-6.92E-05	7.25E-05	-2.81E-04
	Forage	Alfalfa	0.5	4	0	1.32	1.05E-03	0.00E+00	-3.46E-04	7.02E-04	1.57E-04	0.00E+00	-6.91E-05	8.79E-05
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	1.32	-1.24E-05	-2.48E-07	1.92E-06	-1.07E-05	-1.86E-06	-3.72E-08	3.85E-07	-1.51E-06
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	1.32	-5.91E-05	-1.51E-06	2.49E-05	-3.57E-05	-8.86E-06	-2.27E-07	4.99E-06	-4.10E-06
	Sacramento River Subtotal		-0.2	n/a	n/a	n/a	-2.20E-03	-5.71E-04	1.28E-04	-2.64E-03	-3.29E-04	-8.55E-05	2.56E-05	-3.89E-04
San Joaquin River	Grain	Wheat	0.8	3.7	5.8	9.75	1.53E-03	2.41E-03	-4.04E-03	-1.02E-04	2.30E-04	3.61E-04	-8.08E-04	-2.18E-04
	Field	Corn	-3.7	6.9	1.68	9.75	-1.26E-02	-3.07E-03	1.78E-02	2.13E-03	-1.89E-03	-4.60E-04	3.56E-03	1.21E-03
	Forage	Alfalfa	-24.1	4	0	9.75	-4.82E-02	0.00E+00	1.17E-01	6.92E-02	-7.22E-03	0.00E+00	2.35E-02	1.63E-02
	Vegetable/Truck Crops	Vegetables	-1.0	8.5	0.17	9.75	-4.27E-03	-8.54E-05	4.90E-03	5.41E-04	-6.40E-04	-1.28E-05	9.80E-04	3.27E-04
	Orchards and Vineyards	Almonds	-0.2	3.13	0.08	9.75	-3.81E-04	-9.74E-06	1.19E-03	7.96E-04	-5.71E-05	-1.46E-06	2.37E-04	1.79E-04
	San Joaquin River Subtotal		-28.2	n/a	n/a	n/a	-6.39E-02	-7.58E-04	1.37E-01	7.26E-02	-9.58E-03	-1.14E-04	2.74E-02	1.78E-02
Tulare Lake	Grain	Wheat	-0.1	3.7	5.8	10.70	-9.70E-05	-1.52E-04	2.81E-04	3.15E-05	-1.45E-05	-2.28E-05	5.61E-05	1.88E-05
	Field	Corn	-0.7	6.9	1.68	10.70	-2.56E-03	-6.23E-04	3.97E-03	7.86E-04	-3.83E-04	-9.34E-05	7.93E-04	3.17E-04
	Forage	Alfalfa	1.3	4	0	10.70	2.51E-03	0.00E+00	-6.72E-03	-4.21E-03	3.77E-04	0.00E+00	-1.34E-03	-9.68E-04
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	10.70	-1.05E-04	-2.09E-06	1.32E-04	2.50E-05	-1.57E-05	-3.13E-07	2.63E-05	1.03E-05
	Orchards and Vineyards	Almonds	-0.1	3.13	0.08	10.70	-1.29E-04	-3.29E-06	4.41E-04	3.08E-04	-1.93E-05	-4.94E-07	8.81E-05	6.83E-05
	Tulare Lake Subtotal		0.4	n/a	n/a	n/a	-3.75E-04	-7.80E-04	-1.90E-03	-3.06E-03	-5.63E-05	-1.17E-04	-3.81E-04	-5.54E-04
Above Normal Condition														
Sacramento River	Grain	Rice	0.1	20	1.68	1.32	1.16E-03	9.73E-05	-7.64E-05	1.18E-03	1.74E-04	1.46E-05	-1.53E-05	1.73E-04
	Field	Corn	-0.4	6.9	1.68	1.32	-1.44E-03	-3.50E-04	2.75E-04	-1.51E-03	-2.16E-04	-5.25E-05	5.50E-05	-2.13E-04
	Forage	Alfalfa	-0.4	4	0	1.32	-8.83E-04	0.00E+00	2.91E-04	-5.92E-04	-1.32E-04	0.00E+00	5.83E-05	-7.41E-05
	Vegetable/Truck Crops	Vegetables	0.1	8.5	0.17	1.32	2.40E-04	4.80E-06	-3.73E-05	2.08E-04	3.60E-05	7.20E-07	-7.45E-06	2.93E-05
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	1.32	-1.47E-05	-3.76E-07	6.19E-06	-8.87E-06	-2.20E-06	-5.63E-08	1.24E-06	-1.02E-06
	Sacramento River Subtotal		-0.7	n/a	n/a	n/a	-9.39E-04	-2.49E-04	4.59E-04	-7.28E-04	-1.41E-04	-3.73E-05	9.18E-05	-8.62E-05
San Joaquin River	Grain	Wheat	1.2	3.7	5.8	9.75	2.14E-03	3.36E-03	-5.64E-03	-1.43E-04	3.21E-04	5.03E-04	-1.13E-03	-3.04E-04
	Field	Corn	-3.0	6.9	1.68	9.75	-1.04E-02	-2.54E-03	1.48E-02	1.77E-03	-1.57E-03	-3.81E-04	2.95E-03	1.00E-03
	Forage	Alfalfa	-30.5	4	0	9.75	-6.11E-02	0.00E+00	1.49E-01	8.77E-02	-9.15E-03	0.00E+00	2.98E-02	2.06E-02
	Vegetable/Truck Crops	Vegetables	-0.9	8.5	0.17	9.75	-3.98E-03	-7.96E-05	4.56E-03	5.04E-04	-5.97E-04	-1.19E-05	9.13E-04	3.04E-04
	Orchards and Vineyards	Almonds	-0.2	3.13	0.08	9.75	-3.02E-04	-7.71E-06	9.40E-04	6.30E-04	-4.52E-05	-1.16E-06	1.88E-04	1.42E-04
	San Joaquin River Subtotal		-33.5	n/a	n/a	n/a	-7.37E-02	7.27E-04	1.63E-01	9.05E-02	-1.10E-02	1.09E-04	3.27E-02	2.18E-02
Tulare Lake	Grain	Wheat	0.2	3.7	5.8	10.70	4.11E-04	6.44E-04	-1.19E-03	-1.33E-04	6.15E-05	9.65E-05	-2.37E-04	-7.95E-05
	Field	Corn	1.9	6.9	1.68	10.70	6.63E-03	1.61E-03	-1.03E-02	-2.04E-03	9.94E-04	2.42E-04	-2.06E-03	-8.21E-04
	Forage	Alfalfa	-1.5	4	0	10.70	-3.06E-03	0.00E+00	8.18E-03	5.12E-03	-4.58E-04	0.00E+00	1.64E-03	1.18E-03
	Vegetable/Truck Crops	Vegetables	0.1	8.5	0.17	10.70	4.38E-04	8.75E-06	-5.51E-04	-1.05E-04	6.56E-05	1.31E-06	-1.10E-04	-4.33E-05
	Orchards and Vineyards	Almonds	0.2	3.13	0.08	10.70	2.86E-04	7.30E-06	-9.77E-04	-6.84E-04	4.28E-05	1.09E-06	-1.95E-04	-1.51E-04
	Tulare Lake Subtotal		0.9	n/a	n/a	n/a	4.71E-03	2.27E-03	-4.82E-03	2.16E-03	7.06E-04	3.41E-04	-9.64E-04	8.27E-05
Below Normal Condition														
Sacramento River	Grain	Rice	-262.9	20	1.68	1.32	-2.63E+00	-2.21E-01	1.73E-01	-2.68E+00	-3.94E-01	-3.31E-02	3.47E-02	-3.92E-01
	Field	Corn	-788.5	6.9	1.68	1.32	-2.72E+00	-6.62E-01	5.20E-01	-2.86E+00	-4.08E-01	-9.93E-02	1.04E-01	-4.03E-01
	Forage	Alfalfa	-49.6	4	0	1.32	-9.92E-02	0.00E+00	3.27E-02	-6.64E-02	-1.49E-02	0.00E+00	6.54E-03	-8.32E-03
	Vegetable/Truck Crops	Vegetables	-137.3	8.5	0.17	1.32	-5.83E-01	-1.17E-02	9.06E-02	-5.04E-01	-8.74E-02	-1.75E-03	1.81E-02	-7.11E-02
	Orchards and Vineyards	Almonds	-204.6	3.13	0.08	1.32	-3.20E-01	-8.18E-03	1.35E-01	-1.93E-01	-4.80E-02	-1.23E-03	2.70E-02	-2.22E-02
	Sacramento River Subtotal		-1,442.8	n/a	n/a	n/a	-6.35E+00	-9.03E-01	9.52E-01	-6.30E+00	-9.52E-01	-1.35E-01	1.90E-01	-8.97E-01
San Joaquin River	Grain	Wheat	-7.1	3.7	5.8	9.75	-1.31E-02	-2.05E-02	3.45E-02	8.74E-04	-1.96E-03	-3.08E-03	6.90E-03	1.86E-03
	Field	Corn	-31.8	6.9	1.68	9.75	-1.10E-01	-2.67E-02	1.55E-01	1.86E-02	-1.65E-02	-4.01E-03	3.10E-02	1.05E-02
	Forage	Alfalfa	81.4	4	0	9.75	1.63E-01	0.00E+00	-3.97E-01	-2.34E-01	2.44E-02	0.00E+00	-7.94E-02	-5.50E-02
	Vegetable/Truck Crops	Vegetables	-22.3	8.5	0.17	9.75	-9.49E-02	-1.90E-03	1.09E-01	1.20E-02	-1.42E-02	-2.84E-04	2.18E-02	7.25E-03
	Orchards and Vineyards	Almonds	-1.0	3.13	0.08	9.75	-1.58E-03	-4.05E-05	4.93E-03	3.31E-03	-2.38E-04	-6.07E-06	9.87E-04	7.43E-04
	San Joaquin River Subtotal		19.2	n/a	n/a	n/a	-5.64E-02	-4.92E-02	-9.37E-02	-1.99E-01	-8.45E-03	-7.37E-03	-1.87E-02	-3.46E-02

Central Valley Project Municipal & Industrial Water Shortage Policy
Final EIS

Tulare Lake	Grain	Wheat	300.4	3.7	5.8	10.70	5.56E-01	8.71E-01	-1.61E+00	-1.80E-01	8.33E-02	1.31E-01	-3.21E-01	-1.08E-01
	Field	Corn	-2,661.5	6.9	1.68	10.70	-9.18E+00	-2.24E+00	1.42E+01	2.82E+00	-1.38E+00	-3.35E-01	2.85E+00	1.14E+00
	Forage	Alfalfa	-4,407.8	4	0	10.70	-8.82E+00	0.00E+00	2.36E+01	1.48E+01	-1.32E+00	0.00E+00	4.72E+00	3.40E+00
	Vegetable/Truck Crops	Vegetables	171.3	8.5	0.17	10.70	7.28E-01	1.46E-02	-9.17E-01	-1.74E-01	1.09E-01	2.18E-03	-1.83E-01	-7.20E-02
	Orchards and Vineyards	Almonds	-71.8	3.13	0.08	10.70	-1.12E-01	-2.87E-03	3.84E-01	2.69E-01	-1.68E-02	-4.30E-04	7.68E-02	5.95E-02
	Tulare Lake Subtotal		-6,669.3	n/a	n/a	n/a	-1.68E+01	-1.35E+00	3.57E+01	1.75E+01	-2.52E+00	-2.03E-01	7.14E+00	4.41E+00
Dry Condition														
Sacramento River	Grain	Rice	-2,255.0	20	1.68	1.32	-2.25E+01	-1.89E+00	1.49E+00	-2.30E+01	-3.38E+00	-2.84E-01	2.98E-01	-3.37E+00
	Field	Corn	-806.4	6.9	1.68	1.32	-2.78E+00	-6.77E-01	5.32E-01	-2.93E+00	-4.17E-01	-1.02E-01	1.06E-01	-4.12E-01
	Forage	Alfalfa	-4.6	4	0	1.32	-9.29E-03	0.00E+00	3.07E-03	-6.23E-03	-1.39E-03	0.00E+00	6.13E-04	-7.80E-04
	Vegetable/Truck Crops	Vegetables	-12.6	8.5	0.17	1.32	-5.37E-02	-1.07E-03	8.33E-03	-4.64E-02	-8.04E-03	-1.61E-04	1.67E-03	-6.54E-03
	Orchards and Vineyards	Almonds	-6.6	3.13	0.08	1.32	-1.03E-02	-2.64E-04	4.36E-03	-6.25E-03	-1.55E-03	-3.96E-05	8.72E-04	-7.18E-04
	Sacramento River Subtotal		-3,085.2	n/a	n/a	n/a	-2.54E+01	-2.57E+00	2.04E+00	-2.59E+01	-3.81E+00	-3.86E-01	4.07E-01	-3.79E+00
San Joaquin River	Grain	Wheat	-1.8	3.7	5.8	9.75	-3.42E-03	-5.36E-03	9.00E-03	2.28E-04	-5.12E-04	-8.03E-04	1.80E-03	4.85E-04
	Field	Corn	26.6	6.9	1.68	9.75	9.19E-02	2.24E-02	-1.30E-01	-1.55E-02	1.38E-02	3.36E-03	-2.60E-02	-8.84E-03
	Forage	Alfalfa	-10.0	4	0	9.75	-1.99E-02	0.00E+00	4.86E-02	2.86E-02	-2.99E-03	0.00E+00	9.72E-03	6.73E-03
	Vegetable/Truck Crops	Vegetables	-1.8	8.5	0.17	9.75	-7.69E-03	-1.54E-04	8.81E-03	9.74E-04	-1.15E-03	-2.30E-05	1.76E-03	5.87E-04
	Orchards and Vineyards	Almonds	1.1	3.13	0.08	9.75	1.73E-03	4.42E-05	-5.38E-03	-3.61E-03	2.59E-04	6.62E-06	-1.08E-03	-8.10E-04
	San Joaquin River Subtotal		14.1	n/a	n/a	n/a	6.26E-02	1.69E-02	-6.88E-02	1.07E-02	9.39E-03	2.54E-03	-1.38E-02	-1.85E-03
Tulare Lake	Grain	Wheat	-43.4	3.7	5.8	10.70	-8.03E-02	-1.26E-01	2.32E-01	2.61E-02	-1.20E-02	-1.89E-02	4.65E-02	1.55E-02
	Field	Corn	-17,820.4	6.9	1.68	10.70	-6.15E+01	-1.50E+01	9.53E+01	1.89E+01	-9.22E+00	-2.24E+00	1.91E+01	7.61E+00
	Forage	Alfalfa	-44.8	4	0	10.70	-8.96E-02	0.00E+00	2.40E-01	1.50E-01	-1.34E-02	0.00E+00	4.79E-02	3.45E-02
	Vegetable/Truck Crops	Vegetables	-73.8	8.5	0.17	10.70	-3.14E-01	-6.27E-03	3.95E-01	7.49E-02	-4.70E-02	-9.40E-04	7.90E-02	3.10E-02
	Orchards and Vineyards	Almonds	-15.2	3.13	0.08	10.70	-2.38E-02	-6.09E-04	8.14E-02	5.70E-02	-3.57E-03	-9.13E-05	1.63E-02	1.26E-02
	Tulare Lake Subtotal		-17,997.7	n/a	n/a	n/a	-6.20E+01	-1.51E+01	9.63E+01	1.92E+01	-9.29E+00	-2.26E+00	1.93E+01	7.70E+00
Critical Condition														
Sacramento River	Grain	Rice	-47.7	20	1.68	1.32	-4.77E-01	-4.01E-02	3.15E-02	-4.86E-01	-7.15E-02	-6.01E-03	6.30E-03	-7.12E-02
	Field	Corn	-83.0	6.9	1.68	1.32	-2.86E-01	-6.97E-02	5.48E-02	-3.01E-01	-4.29E-02	-1.04E-02	1.10E-02	-4.24E-02
	Forage	Alfalfa	-58.0	4	0	1.32	-1.16E-01	0.00E+00	3.83E-02	-7.77E-02	-1.74E-02	0.00E+00	7.65E-03	-9.74E-03
	Vegetable/Truck Crops	Vegetables	48.2	8.5	0.17	1.32	2.05E-01	4.10E-03	-3.18E-02	1.77E-01	3.07E-02	6.14E-04	-6.36E-03	2.50E-02
	Orchards and Vineyards	Almonds	-4,066.7	3.13	0.08	1.32	-6.36E+00	-1.63E-01	2.68E+00	-3.84E+00	-9.54E-01	-2.44E-02	5.37E-01	-4.42E-01
	Sacramento River Subtotal		-4,207.2	n/a	n/a	n/a	-7.04E+00	-2.68E-01	2.78E+00	-4.53E+00	-1.06E+00	-4.02E-02	5.55E-01	-5.40E-01
San Joaquin River	Grain	Wheat	-14.5	3.7	5.8	9.75	-2.69E-02	-4.22E-02	7.09E-02	1.80E-03	-4.03E-03	-6.32E-03	1.42E-02	3.82E-03
	Field	Corn	-96.4	6.9	1.68	9.75	-3.33E-01	-8.10E-02	4.70E-01	5.62E-02	-4.99E-02	-1.21E-02	9.40E-02	3.20E-02
	Forage	Alfalfa	-99.9	4	0	9.75	-2.00E-01	0.00E+00	4.87E-01	2.87E-01	-2.99E-02	0.00E+00	9.73E-02	6.74E-02
	Vegetable/Truck Crops	Vegetables	82.1	8.5	0.17	9.75	3.49E-01	6.98E-03	-4.00E-01	-4.42E-02	5.23E-02	1.05E-03	-8.00E-02	-2.67E-02
	Orchards and Vineyards	Almonds	113.9	3.13	0.08	9.75	1.78E-01	4.56E-03	-5.55E-01	-3.72E-01	2.67E-02	6.83E-04	-1.11E-01	-8.36E-02
	San Joaquin River Subtotal		-14.8	n/a	n/a	n/a	-3.21E-02	-1.12E-01	7.22E-02	-7.15E-02	-4.82E-03	-1.67E-02	1.44E-02	-7.10E-03
Tulare Lake	Grain	Wheat	-5,465.4	3.7	5.8	10.70	-1.01E+01	-1.58E+01	2.92E+01	3.28E+00	-1.52E+00	-2.38E+00	5.85E+00	1.96E+00
	Field	Corn	-9,336.6	6.9	1.68	10.70	-3.22E+01	-7.84E+00	5.00E+01	9.90E+00	-4.83E+00	-1.18E+00	9.99E+00	3.99E+00
	Forage	Alfalfa	-61.3	4	0	10.70	-1.23E-01	0.00E+00	3.28E-01	2.06E-01	-1.84E-02	0.00E+00	6.56E-02	4.72E-02
	Vegetable/Truck Crops	Vegetables	-6,331.1	8.5	0.17	10.70	-2.69E+01	-5.38E-01	3.39E+01	6.43E+00	-4.03E+00	-8.07E-02	6.77E+00	2.66E+00
	Orchards and Vineyards	Almonds	-1,675.0	3.13	0.08	10.70	-2.62E+00	-6.70E-02	8.96E+00	6.27E+00	-3.93E-01	-1.00E-02	1.79E+00	1.39E+00
	Tulare Lake Subtotal		-22,869.5	n/a	n/a	n/a	-7.20E+01	-2.43E+01	1.22E+02	2.61E+01	-1.08E+01	-3.64E+00	2.45E+01	1.00E+01

Key:

SWAP = Statewide Agricultural Production

lbs/acre/year = pounds per acre per year

PM10 = inhalable particulate matter

PM2.5 = fine particulate matter

tpy = tons per year

Table 17. Alternative 5: Detailed Fugitive Dust Emission Calculations

SWAP Region	SWAP Crop Type	Representative Crop	Irrigated Acreage (Change from Alt 1) (acres)	Emission Factor (lbs/acre/year)			Annual PM10 Emissions (tpy)				Annual PM10 Emissions (tpy)			
				Land Prep	Harvesting	Windblown Dust	Land Prep	Harvesting	Windblown Dust	Total	Land Prep	Harvesting	Windblown Dust	Total
Wet Condition														
Sacramento River	Grain	Rice	0.0	20	1.68	1.32	-1.37E-05	-1.15E-06	9.06E-07	-1.40E-05	-2.06E-06	-1.73E-07	1.81E-07	-2.05E-06
	Field	Corn	0.0	6.9	1.68	1.32	-2.04E-05	-4.97E-06	3.90E-06	-2.15E-05	-3.06E-06	-7.45E-07	7.81E-07	-3.02E-06
	Forage	Alfalfa	0.0	4	0	1.32	1.13E-05	0.00E+00	-3.72E-06	7.56E-06	1.69E-06	0.00E+00	-7.44E-07	9.46E-07
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	1.32	-1.33E-07	-2.66E-09	2.06E-08	-1.15E-07	-1.99E-08	-3.99E-10	4.13E-09	-1.62E-08
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	1.32	-6.36E-07	-1.63E-08	2.68E-07	-3.84E-07	-9.54E-08	-2.44E-09	5.36E-08	-4.42E-08
	Sacramento River Subtotal		0.0	n/a	n/a	n/a	-2.36E-05	-6.14E-06	1.38E-06	-2.84E-05	-3.54E-06	-9.21E-07	2.75E-07	-4.19E-06
San Joaquin River	Grain	Wheat	0.0	3.7	5.8	9.75	1.65E-05	2.59E-05	-4.35E-05	-1.10E-06	2.47E-06	3.88E-06	-8.70E-06	-2.34E-06
	Field	Corn	0.0	6.9	1.68	9.75	-1.36E-04	-3.31E-05	1.92E-04	2.30E-05	-2.04E-05	-4.97E-06	3.84E-05	1.31E-05
	Forage	Alfalfa	-0.3	4	0	9.75	-5.19E-04	0.00E+00	1.26E-03	7.45E-04	-7.77E-05	0.00E+00	2.53E-04	1.75E-04
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	9.75	-4.61E-05	-9.22E-07	5.29E-05	5.84E-06	-6.91E-06	-1.38E-07	1.06E-05	3.52E-06
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	9.75	-4.11E-06	-1.05E-07	1.28E-05	8.59E-06	-6.16E-07	-1.58E-08	2.56E-06	1.93E-06
	San Joaquin River Subtotal		-0.3	n/a	n/a	n/a	-6.88E-04	-8.28E-06	1.48E-03	7.81E-04	-1.03E-04	-1.24E-06	2.96E-04	1.91E-04
Tulare Lake	Grain	Wheat	0.0	3.7	5.8	10.70	-1.04E-06	-1.64E-06	3.02E-06	3.39E-07	-1.57E-07	-2.45E-07	6.04E-07	2.02E-07
	Field	Corn	0.0	6.9	1.68	10.70	-2.75E-05	-6.70E-06	4.27E-05	8.46E-06	-4.13E-06	-1.01E-06	8.54E-06	3.41E-06
	Forage	Alfalfa	0.0	4	0	10.70	2.71E-05	0.00E+00	-7.24E-05	-4.53E-05	4.06E-06	0.00E+00	-1.45E-05	-1.04E-05
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	10.70	-1.12E-06	-2.25E-08	1.42E-06	2.69E-07	-1.69E-07	-3.37E-09	2.83E-07	1.11E-07
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	10.70	-1.39E-06	-3.55E-08	4.74E-06	3.32E-06	-2.08E-07	-5.32E-09	9.49E-07	7.35E-07
	Tulare Lake Subtotal		0.0	n/a	n/a	n/a	-4.04E-06	-8.40E-06	-2.05E-05	-3.29E-05	-6.05E-07	-1.26E-06	-4.10E-06	-5.96E-06
Above Normal Condition														
Sacramento River	Grain	Rice	0.0	20	1.68	1.32	-5.02E-05	-4.22E-06	3.31E-06	-5.11E-05	-7.53E-06	-6.32E-07	6.63E-07	-7.50E-06
	Field	Corn	0.0	6.9	1.68	1.32	-5.23E-05	-1.27E-05	1.00E-05	-5.50E-05	-7.84E-06	-1.91E-06	2.00E-06	-7.75E-06
	Forage	Alfalfa	0.0	4	0	1.32	4.11E-05	0.00E+00	-1.35E-05	2.75E-05	6.15E-06	0.00E+00	-2.71E-06	3.45E-06
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	1.32	-2.30E-06	-4.59E-08	3.56E-07	-1.98E-06	-3.44E-07	-6.88E-09	7.13E-08	-2.80E-07
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	1.32	-1.85E-06	-4.72E-08	7.78E-07	-1.11E-06	-2.77E-07	-7.07E-09	1.56E-07	-1.28E-07
	Sacramento River Subtotal		0.0	n/a	n/a	n/a	-6.56E-05	-1.70E-05	9.03E-07	-8.17E-05	-9.83E-06	-2.55E-06	1.81E-07	-1.22E-05
San Joaquin River	Grain	Wheat	0.0	3.7	5.8	9.75	3.62E-05	5.68E-05	-9.55E-05	-2.42E-06	5.43E-06	8.52E-06	-1.91E-05	-5.15E-06
	Field	Corn	-0.1	6.9	1.68	9.75	-2.71E-04	-6.59E-05	3.82E-04	4.58E-05	-4.06E-05	-9.88E-06	7.65E-05	2.60E-05
	Forage	Alfalfa	-0.6	4	0	9.75	-1.13E-03	0.00E+00	2.75E-03	1.62E-03	-1.69E-04	0.00E+00	5.50E-04	3.81E-04
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	9.75	-9.30E-05	-1.86E-06	1.07E-04	1.18E-05	-1.39E-05	-2.79E-07	2.13E-05	7.11E-06
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	9.75	-8.67E-06	-2.22E-07	2.70E-05	1.81E-05	-1.30E-06	-3.32E-08	5.40E-06	4.07E-06
	San Joaquin River Subtotal		-0.7	n/a	n/a	n/a	-1.46E-03	-1.12E-05	3.17E-03	1.69E-03	-2.20E-04	-1.68E-06	6.34E-04	4.13E-04
Tulare Lake	Grain	Wheat	0.0	3.7	5.8	10.70	-6.61E-06	-1.04E-05	1.91E-05	2.15E-06	-9.91E-07	-1.55E-06	3.82E-06	1.28E-06
	Field	Corn	0.0	6.9	1.68	10.70	-1.34E-04	-3.26E-05	2.08E-04	4.12E-05	-2.01E-05	-4.89E-06	4.15E-05	1.66E-05
	Forage	Alfalfa	0.1	4	0	10.70	1.49E-04	0.00E+00	-4.00E-04	-2.50E-04	2.24E-05	0.00E+00	-8.00E-05	-5.76E-05
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	10.70	-6.99E-06	-1.40E-07	8.80E-06	1.67E-06	-1.05E-06	-2.09E-08	1.76E-06	6.91E-07
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	10.70	-6.34E-06	-1.62E-07	2.17E-05	1.52E-05	-9.51E-07	-2.43E-08	4.34E-06	3.36E-06
	Tulare Lake Subtotal		0.0	n/a	n/a	n/a	-4.42E-06	-4.33E-05	-1.43E-04	-1.90E-04	-6.63E-07	-6.49E-06	-2.85E-05	-3.57E-05
Below Normal Condition														
Sacramento River	Grain	Rice	0.0	20	1.68	1.32	-2.36E-04	-1.98E-05	1.56E-05	-2.40E-04	-3.53E-05	-2.97E-06	3.11E-06	-3.52E-05
	Field	Corn	0.0	6.9	1.68	1.32	-7.16E-05	-1.74E-05	1.37E-05	-7.54E-05	-1.07E-05	-2.61E-06	2.74E-06	-1.06E-05
	Forage	Alfalfa	1.2	4	0	1.32	2.50E-03	0.00E+00	-8.24E-04	1.67E-03	3.74E-04	0.00E+00	-1.65E-04	2.10E-04
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	1.32	-5.59E-05	-1.12E-06	8.68E-06	-4.83E-05	-8.38E-06	-1.68E-07	1.74E-06	-6.81E-06
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	1.32	1.12E-06	2.86E-08	-4.72E-07	6.75E-07	1.68E-07	4.29E-09	-9.43E-08	7.76E-08
	Sacramento River Subtotal		1.2	n/a	n/a	n/a	2.13E-03	-3.83E-05	-7.86E-04	1.31E-03	3.20E-04	-5.74E-06	-1.57E-04	1.57E-04
San Joaquin River	Grain	Wheat	0.0	3.7	5.8	9.75	-1.45E-05	-2.27E-05	3.82E-05	9.68E-07	-2.17E-06	-3.41E-06	7.64E-06	2.06E-06
	Field	Corn	0.0	6.9	1.68	9.75	-6.22E-05	-1.52E-05	8.79E-05	1.05E-05	-9.33E-06	-2.27E-06	1.76E-05	5.98E-06
	Forage	Alfalfa	0.1	4	0	9.75	1.40E-04	0.00E+00	-3.42E-04	-2.02E-04	2.11E-05	0.00E+00	-6.85E-05	-4.74E-05
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	9.75	-8.61E-05	-1.72E-06	9.87E-05	1.09E-05	-1.29E-05	-2.58E-07	1.97E-05	6.58E-06
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	9.75	2.36E-06	6.04E-08	-7.35E-06	-4.93E-06	3.54E-07	9.05E-09	-1.47E-06	-1.11E-06
	San Joaquin River Subtotal		0.0	n/a	n/a	n/a	-2.00E-05	-3.96E-05	-1.25E-04	-1.84E-04	-2.99E-06	-5.93E-06	-2.50E-05	-3.39E-05

Central Valley Project Municipal & Industrial Water Shortage Policy
Final EIS

Tulare Lake	Grain	Wheat	0.1	3.7	5.8	10.70	2.76E-04	4.32E-04	-7.97E-04	-8.94E-05	4.13E-05	6.48E-05	-1.59E-04	-5.33E-05
	Field	Corn	0.2	6.9	1.68	10.70	5.79E-04	1.41E-04	-8.97E-04	-1.78E-04	8.67E-05	2.11E-05	-1.79E-04	-7.16E-05
	Forage	Alfalfa	-3.3	4	0	10.70	-6.62E-03	0.00E+00	1.77E-02	1.11E-02	-9.92E-04	0.00E+00	3.54E-03	2.55E-03
	Vegetable/Truck Crops	Vegetables	0.1	8.5	0.17	10.70	4.92E-04	9.84E-06	-6.19E-04	-1.18E-04	7.38E-05	1.48E-06	-1.24E-04	-4.87E-05
	Orchards and Vineyards	Almonds	0.0	3.13	0.08	10.70	-3.04E-05	-7.78E-07	1.04E-04	7.28E-05	-4.56E-06	-1.17E-07	2.08E-05	1.61E-05
	Tulare Lake Subtotal		-2.9	n/a	n/a	n/a	-5.30E-03	5.82E-04	1.55E-02	1.08E-02	-7.95E-04	8.72E-05	3.10E-03	2.39E-03
Dry Condition														
Sacramento River	Grain	Rice	-9.1	20	1.68	1.32	-9.12E-02	-7.66E-03	6.02E-03	-9.28E-02	-1.37E-02	-1.15E-03	1.20E-03	-1.36E-02
	Field	Corn	-3.9	6.9	1.68	1.32	-1.35E-02	-3.29E-03	2.58E-03	-1.42E-02	-2.02E-03	-4.92E-04	5.16E-04	-2.00E-03
	Forage	Alfalfa	0.0	4	0	1.32	-7.98E-05	0.00E+00	2.63E-05	-5.35E-05	-1.20E-05	0.00E+00	5.27E-06	-6.70E-06
	Vegetable/Truck Crops	Vegetables	-0.1	8.5	0.17	1.32	-4.76E-04	-9.52E-06	7.39E-05	-4.12E-04	-7.14E-05	-1.43E-06	1.48E-05	-5.80E-05
	Orchards and Vineyards	Almonds	0.1	3.13	0.08	1.32	1.75E-04	4.47E-06	-7.38E-05	1.06E-04	2.62E-05	6.71E-07	-1.48E-05	1.22E-05
	Sacramento River Subtotal		-13.1	n/a	n/a	n/a	-1.05E-01	-1.09E-02	8.62E-03	-1.07E-01	-1.57E-02	-1.64E-03	1.72E-03	-1.57E-02
San Joaquin River	Grain	Wheat	0.0	3.7	5.8	9.75	-4.18E-05	-6.55E-05	1.10E-04	2.79E-06	-6.26E-06	-9.81E-06	2.20E-05	5.93E-06
	Field	Corn	0.1	6.9	1.68	9.75	2.64E-04	6.43E-05	-3.73E-04	-4.46E-05	3.96E-05	9.63E-06	-7.46E-05	-2.54E-05
	Forage	Alfalfa	-0.1	4	0	9.75	-1.36E-04	0.00E+00	3.30E-04	1.95E-04	-2.03E-05	0.00E+00	6.61E-05	4.57E-05
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	9.75	-6.11E-05	-1.22E-06	7.01E-05	7.75E-06	-9.17E-06	-1.83E-07	1.40E-05	4.67E-06
	Orchards and Vineyards	Almonds	0.1	3.13	0.08	9.75	1.88E-04	4.82E-06	-5.87E-04	-3.94E-04	2.82E-05	7.22E-07	-1.17E-04	-8.84E-05
	San Joaquin River Subtotal		0.1	n/a	n/a	n/a	2.14E-04	2.40E-06	-4.49E-04	-2.33E-04	3.21E-05	3.59E-07	-8.98E-05	-5.74E-05
Tulare Lake	Grain	Wheat	-0.4	3.7	5.8	10.70	-7.33E-04	-1.15E-03	2.12E-03	2.38E-04	-1.10E-04	-1.72E-04	4.24E-04	1.42E-04
	Field	Corn	-99.9	6.9	1.68	10.70	-3.45E-01	-8.39E-02	5.35E-01	1.06E-01	-5.17E-02	-1.26E-02	1.07E-01	4.27E-02
	Forage	Alfalfa	-0.5	4	0	10.70	-9.88E-04	0.00E+00	2.64E-03	1.66E-03	-1.48E-04	0.00E+00	5.29E-04	3.81E-04
	Vegetable/Truck Crops	Vegetables	-0.6	8.5	0.17	10.70	-2.71E-03	-5.42E-05	3.41E-03	6.47E-04	-4.06E-04	-8.12E-06	6.82E-04	2.68E-04
	Orchards and Vineyards	Almonds	0.4	3.13	0.08	10.70	5.94E-04	1.52E-05	-2.03E-03	-1.42E-03	8.90E-05	2.28E-06	-4.06E-04	-3.15E-04
	Tulare Lake Subtotal		-101.1	n/a	n/a	n/a	-3.49E-01	-8.51E-02	5.41E-01	1.07E-01	-5.22E-02	-1.28E-02	1.08E-01	4.31E-02
Critical Condition														
Sacramento River	Grain	Rice	0.0	20	1.68	1.32	-4.35E-04	-3.65E-05	2.87E-05	-4.43E-04	-6.52E-05	-5.48E-06	5.74E-06	-6.50E-05
	Field	Corn	0.0	6.9	1.68	1.32	-8.29E-05	-2.02E-05	1.59E-05	-8.73E-05	-1.24E-05	-3.03E-06	3.17E-06	-1.23E-05
	Forage	Alfalfa	-0.1	4	0	1.32	-1.27E-04	0.00E+00	4.18E-05	-8.49E-05	-1.90E-05	0.00E+00	8.36E-06	-1.06E-05
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	1.32	-1.23E-04	-2.46E-06	1.91E-05	-1.06E-04	-1.84E-05	-3.68E-07	3.81E-06	-1.50E-05
	Orchards and Vineyards	Almonds	-4.6	3.13	0.08	1.32	-7.27E-03	-1.86E-04	3.06E-03	-4.39E-03	-1.09E-03	-2.78E-05	6.13E-04	-5.04E-04
	Sacramento River Subtotal		-4.8	n/a	n/a	n/a	-8.03E-03	-2.45E-04	3.17E-03	-5.11E-03	-1.20E-03	-3.67E-05	6.34E-04	-6.07E-04
San Joaquin River	Grain	Wheat	0.0	3.7	5.8	9.75	-3.15E-05	-4.93E-05	8.29E-05	2.10E-06	-4.71E-06	-7.39E-06	1.66E-05	4.47E-06
	Field	Corn	0.0	6.9	1.68	9.75	-2.87E-05	-6.98E-06	4.05E-05	4.85E-06	-4.30E-06	-1.05E-06	8.10E-06	2.76E-06
	Forage	Alfalfa	-0.1	4	0	9.75	-2.89E-04	0.00E+00	7.05E-04	4.16E-04	-4.34E-05	0.00E+00	1.41E-04	9.77E-05
	Vegetable/Truck Crops	Vegetables	0.0	8.5	0.17	9.75	-5.51E-05	-1.10E-06	6.32E-05	6.98E-06	-8.26E-06	-1.65E-07	1.26E-05	4.21E-06
	Orchards and Vineyards	Almonds	0.2	3.13	0.08	9.75	2.98E-04	7.61E-06	-9.28E-04	-6.22E-04	4.46E-05	1.14E-06	-1.86E-04	-1.40E-04
	San Joaquin River Subtotal		0.0	n/a	n/a	n/a	-1.07E-04	-4.98E-05	-3.56E-05	-1.92E-04	-1.60E-05	-7.46E-06	-7.12E-06	-3.06E-05
Tulare Lake	Grain	Wheat	-0.1	3.7	5.8	10.70	-1.09E-04	-1.70E-04	3.14E-04	3.53E-05	-1.63E-05	-2.55E-05	6.29E-05	2.10E-05
	Field	Corn	-46.8	6.9	1.68	10.70	-1.61E-01	-3.93E-02	2.50E-01	4.96E-02	-2.42E-02	-5.89E-03	5.01E-02	2.00E-02
	Forage	Alfalfa	-0.2	4	0	10.70	-3.59E-04	0.00E+00	9.60E-04	6.01E-04	-5.38E-05	0.00E+00	1.92E-04	1.38E-04
	Vegetable/Truck Crops	Vegetables	-0.1	8.5	0.17	10.70	-2.31E-04	-4.62E-06	2.91E-04	5.52E-05	-3.47E-05	-6.93E-07	5.82E-05	2.29E-05
	Orchards and Vineyards	Almonds	0.2	3.13	0.08	10.70	3.39E-04	8.66E-06	-1.16E-03	-8.11E-04	5.08E-05	1.30E-06	-2.32E-04	-1.80E-04
	Tulare Lake Subtotal		-46.9	n/a	n/a	n/a	-1.62E-01	-3.95E-02	2.51E-01	4.95E-02	-2.43E-02	-5.92E-03	5.01E-02	2.00E-02

Key:
SWAP = Statewide Agricultural Production lbs/acre/year = pounds per acre per year PM10 = inhalable particulate matter PM2.5 = fine particulate matter tpy = tons per year

Size Fractions

Description	PM10	PM2.5	Ratio
PM Profile ID No. 411, Windblown Dust - Agricultural	0.5	0.1	0.2
PM Profile ID No. 417, Agricultural Tilling Dust	0.4543	0.0681	0.1499

Note:
Fraction of PM10 (FRPM10) from wind erosion: 0.50
(PM10 Emissions = PM x FRPM10)

Table 18. SWAP Output - Annual Groundwater Pumped

SWAP Region	Annual Groundwater Pumped (TAF)					Alternative 2 - Alt 1	Alternative 3 - Alt 1	Alternative 5 - Alt 1	Alt 1 - Existing
						Change from Alt 1 (TAF)			
	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Existing Conditions	Alternative 2	Alternative 3	Alternative 5	Existing Conditions
Wet Condition									
Sacramento River	1,248.5	1,245.5	1,249.0	1,248.5	1,316.3	-3.0	0.4	-0.002	-67.8
San Joaquin River	996.2	986.7	999.6	996.3	1,044.7	-9.5	3.4	0.03	-48.5
Tulare Lake	2,432.4	2,407.3	2,443.4	2,432.6	2,453.9	-25.1	11.0	0.2	-21.5
Above Normal Conditions									
Sacramento River	1,240.5	1,235.9	1,242.4	1,240.5	1,310.9	-4.6	2.0	0.02	-70.5
San Joaquin River	1,122.3	1,110.3	1,126.6	1,122.4	1,172.1	-11.9	4.3	0.1	-49.9
Tulare Lake	2,771.5	2,733.4	2,786.0	2,772.0	2,801.5	-38.0	14.5	0.6	-30.1
Below Normal Conditions									
Sacramento River	1,265.8	1,264.5	1,266.4	1,265.8	1,335.2	-1.3	0.6	-0.002	-69.4
San Joaquin River	1,208.7	1,191.3	1,218.6	1,208.7	1,254.8	-17.4	9.9	-0.01	-46.2
Tulare Lake	2,900.7	2,875.1	2,903.9	2,900.8	2,879.3	-25.7	3.1	0.1	21.5
Dry Condition									
Sacramento River	1,271.6	1,270.2	1,271.3	1,271.7	1,333.6	-1.4	-0.3	0.1	-62.1
San Joaquin River	1,315.5	1,285.3	1,336.1	1,315.6	1,348.5	-30.2	20.6	0.1	-33.0
Tulare Lake	3,047.0	3,035.1	3,055.5	3,047.1	3,050.8	-12.0	8.5	0.03	-3.7
Critical Condition									
Sacramento River	1,317.1	1,314.0	1,318.3	1,317.1	1,367.2	-3.1	1.2	0.01	-50.1
San Joaquin River	1,570.0	1,535.2	1,588.8	1,570.1	1,576.4	-34.8	18.7	0.1	-6.4
Tulare Lake	3,284.8	3,271.3	3,291.9	3,284.9	3,274.3	-13.5	7.0	0.01	10.5

Key:

SWAP = Statewide Agricultural Production

TAF = thousand acre-feet

Central Valley Project Municipal & Industrial Water Shortage Policy
Final EIS

Table 19. SWAP Output - Irrigated Acreage

								Alternative 2 - Alt 1	Alternative 3 - Alt 1	Alternative 5 - Alt 1	Alt 1 - Existing
		Representative	Total Irrigated Acreage (thousand acres)					Change from Alternative 1 (acres)			
SWAP Region	SWAP Crop Type	Crop	Alternative 1	Alternative 2	Alternative 3	Alternative 5	Existing Conditions	Alternative 2	Alternative 3	Alternative 5	Existing Conditions
Wet Condition											
Sacramento River	Grain	Rice	616	616	616	616	591	0.35	-0.13	-0.00	25,089.44
	Field	Corn	116	116	116	116	127	1.52	-0.55	-0.01	-10,577.72
	Forage	Alfalfa	126	126	126	126	150	-1.45	0.52	0.01	-24,305.28
	Vegetable/Truck Crops	Vegetables	129	129	129	129	118	0.01	-0.00	-0.00	11,150.97
	Orchards and Vineyards	Almonds	401	401	401	401	400	0.10	-0.04	-0.00	1,380.37
	Sacramento River Subtotal		1,388	1,388	1,388	1,388	1,386	0.54	-0.19	-0.00	2,737.77
San Joaquin River	Grain	Wheat	77	77	77	77	75	-2.29	0.83	0.01	2,162.72
	Field	Corn	466	466	466	466	469	10.23	-3.65	-0.04	-2,517.01
	Forage	Alfalfa	275	275	275	275	299	66.69	-24.09	-0.26	-24,116.37
	Vegetable/Truck Crops	Vegetables	224	224	224	224	202	2.81	-1.01	-0.01	22,074.66
	Orchards and Vineyards	Almonds	363	363	363	363	357	0.68	-0.24	-0.00	5,676.38
	San Joaquin River Subtotal		1,405	1,405	1,405	1,405	1,402	78.12	-28.16	-0.30	3,280.39
Tulare Lake	Grain	Wheat	116	116	116	116	113	0.15	-0.05	-0.00	2,855.73
	Field	Corn	897	897	897	897	916	2.05	-0.74	-0.01	-19,150.98
	Forage	Alfalfa	217	217	217	217	232	-3.48	1.26	0.01	-14,422.07
	Vegetable/Truck Crops	Vegetables	271	271	271	271	245	0.07	-0.02	-0.00	25,522.04
	Orchards and Vineyards	Almonds	815	815	815	815	802	0.23	-0.08	-0.00	12,761.36
	Tulare Lake Subtotal		2,315	2,315	2,315	2,315	2,308	-0.98	0.36	0.00	7,566.08
Above Normal Condition											
Sacramento River	Grain	Rice	616	616	616	616	591	0.63	0.12	-0.01	24,649.29
	Field	Corn	116	116	116	116	127	2.09	-0.42	-0.02	-10,714.32
	Forage	Alfalfa	126	126	126	126	150	-2.57	-0.44	0.02	-24,359.26
	Vegetable/Truck Crops	Vegetables	129	129	129	129	118	0.06	0.06	-0.00	11,071.98
	Orchards and Vineyards	Almonds	401	401	401	401	400	0.16	-0.01	-0.00	1,326.31
	Sacramento River Subtotal		1,388	1,388	1,388	1,388	1,386	0.36	-0.70	-0.00	1,974.01
San Joaquin River	Grain	Wheat	77	77	77	77	75	-2.86	1.16	0.02	2,171.42
	Field	Corn	466	466	466	466	469	11.19	-3.03	-0.08	-2,508.19
	Forage	Alfalfa	274	274	274	274	299	81.91	-30.53	-0.56	-24,456.87
	Vegetable/Truck Crops	Vegetables	224	224	224	224	202	3.14	-0.94	-0.02	22,094.48
	Orchards and Vineyards	Almonds	363	363	363	363	357	0.78	-0.19	-0.01	5,648.50
	San Joaquin River Subtotal		1,404	1,405	1,404	1,404	1,401	94.16	-33.53	-0.65	2,949.34
Tulare Lake	Grain	Wheat	116	116	116	116	113	0.41	0.22	-0.00	2,855.90
	Field	Corn	897	897	897	897	916	4.57	1.92	-0.04	-19,169.03
	Forage	Alfalfa	217	217	217	217	232	-9.36	-1.53	0.07	-14,275.45
	Vegetable/Truck Crops	Vegetables	271	271	271	271	245	0.19	0.10	-0.00	25,497.14
	Orchards and Vineyards	Almonds	815	815	815	815	802	0.48	0.18	-0.00	12,691.17
	Tulare Lake Subtotal		2,315	2,315	2,315	2,315	2,308	-3.72	0.90	0.03	7,599.72
Below Normal Condition											
Sacramento River	Grain	Rice	616	616	616	616	591	52.43	-262.90	-0.02	25,588.62
	Field	Corn	117	117	116	117	126	80.63	-788.47	-0.02	-9,424.63
	Forage	Alfalfa	121	124	121	121	148	2,931.46	-49.58	1.25	-26,840.16
	Vegetable/Truck Crops	Vegetables	129	129	129	129	118	30.19	-137.25	-0.01	11,194.29
	Orchards and Vineyards	Almonds	401	401	401	401	399	27.11	-204.62	0.00	1,301.94
	Sacramento River Subtotal		1,385	1,388	1,383	1,385	1,383	3,121.82	-1,442.82	1.19	1,820.05
San Joaquin River	Grain	Wheat	77	77	77	77	75	10.07	-7.07	-0.01	2,175.47
	Field	Corn	466	466	466	466	469	58.58	-31.81	-0.02	-2,605.08
	Forage	Alfalfa	274	274	274	274	298	-125.80	81.44	0.07	-24,510.51
	Vegetable/Truck Crops	Vegetables	224	224	224	224	202	26.50	-22.32	-0.02	22,022.87
	Orchards and Vineyards	Almonds	363	363	363	363	357	5.86	-1.01	0.00	5,635.08
	San Joaquin River Subtotal		1,404	1,404	1,404	1,404	1,401	-24.79	19.22	0.03	2,717.82

Appendix E
Air Quality Emission Calculations

Tulare Lake	Grain	Wheat	116	116	116	116	112	-280.45	300.41	0.15	4,171.33
	Field	Corn	893	896	891	893	902	3,168.52	-2,661.48	0.17	-9,159.04
	Forage	Alfalfa	214	218	209	214	230	3,903.14	-4,407.80	-3.31	-16,359.50
	Vegetable/Truck Crops	Vegetables	271	271	271	271	242	-126.65	171.30	0.12	28,555.87
	Orchards and Vineyards	Almonds	815	815	815	815	802	97.42	-71.76	-0.02	13,047.92
	Tulare Lake Subtotal		2,308	2,315	2,302	2,308	2,288	6,761.99	-6,669.33	-2.90	20,256.58
Dry Condition											
Sacramento River	Grain	Rice	610	614	608	610	588	3,351.13	-2,254.97	-9.12	22,555.75
	Field	Corn	109	110	108	109	121	1,556.79	-806.39	-3.91	-12,367.82
	Forage	Alfalfa	121	122	121	121	143	24.40	-4.65	-0.04	-21,846.41
	Vegetable/Truck Crops	Vegetables	128	128	128	128	117	209.79	-12.63	-0.11	10,689.59
	Orchards and Vineyards	Almonds	399	400	399	399	399	168.60	-6.61	0.11	494.10
	Sacramento River Subtotal		1,368	1,373	1,365	1,368	1,368	5,310.71	-3,085.24	-13.07	-474.79
San Joaquin River	Grain	Wheat	77	77	77	77	75	6.48	-1.85	-0.02	2,171.92
	Field	Corn	466	466	466	466	469	-80.47	26.64	0.08	-2,521.81
	Forage	Alfalfa	274	274	274	274	299	28.22	-9.97	-0.07	-24,849.49
	Vegetable/Truck Crops	Vegetables	224	224	224	224	202	4.64	-1.81	-0.01	21,855.49
	Orchards and Vineyards	Almonds	363	363	363	363	357	-6.65	1.10	0.12	5,651.04
	San Joaquin River Subtotal		1,404	1,404	1,404	1,404	1,402	-47.78	14.12	0.09	2,307.16
Tulare Lake	Grain	Wheat	117	117	117	117	110	118.58	-43.43	-0.40	6,362.20
	Field	Corn	851	879	833	851	879	27,966.79	-17,820.44	-99.91	-28,576.67
	Forage	Alfalfa	209	209	209	209	221	92.09	-44.81	-0.49	-12,046.34
	Vegetable/Truck Crops	Vegetables	271	271	271	271	239	275.05	-73.80	-0.64	32,100.40
	Orchards and Vineyards	Almonds	815	815	815	815	801	86.15	-15.22	0.38	13,294.68
	Tulare Lake Subtotal		2,262	2,291	2,244	2,262	2,251	28,538.67	-17,997.70	-101.06	11,134.26
Critical Condition											
Sacramento River	Grain	Rice	601	603	601	601	581	1,959.30	-47.71	-0.04	20,304.46
	Field	Corn	105	105	104	105	116	20.10	-82.99	-0.02	-11,377.28
	Forage	Alfalfa	121	121	121	121	143	49.74	-58.00	-0.06	-22,543.39
	Vegetable/Truck Crops	Vegetables	120	120	120	120	110	56.86	48.20	-0.03	10,110.30
	Orchards and Vineyards	Almonds	389	397	385	389	398	7,541.63	-4,066.72	-4.64	-9,338.59
	Sacramento River Subtotal		1,335	1,345	1,331	1,335	1,348	9,627.64	-4,207.22	-4.80	-12,844.50
San Joaquin River	Grain	Wheat	77	77	77	77	75	11.53	-14.54	-0.02	2,336.94
	Field	Corn	466	466	466	466	468	6.25	-96.40	-0.01	-1,764.09
	Forage	Alfalfa	274	274	274	274	298	107.50	-99.87	-0.14	-24,270.75
	Vegetable/Truck Crops	Vegetables	224	224	224	224	202	9.81	82.07	-0.01	21,682.81
	Orchards and Vineyards	Almonds	363	363	363	363	357	-138.05	113.92	0.19	6,178.53
	San Joaquin River Subtotal		1,404	1,404	1,404	1,404	1,400	-2.95	-14.82	0.01	4,163.45
Tulare Lake	Grain	Wheat	117	117	111	117	108	39.75	-5,465.42	-0.06	8,148.60
	Field	Corn	751	785	742	751	795	34,116.95	-9,336.57	-46.79	-44,256.28
	Forage	Alfalfa	209	209	209	209	221	113.88	-61.34	-0.18	-11,842.06
	Vegetable/Truck Crops	Vegetables	271	271	264	271	236	38.91	-6,331.11	-0.05	34,379.44
	Orchards and Vineyards	Almonds	815	815	814	815	801	-138.61	-1,675.01	0.22	14,197.97
	Tulare Lake Subtotal		2,163	2,197	2,140	2,163	2,162	34,170.88	-22,869.45	-46.86	627.68

Key:
SWAP = Statewide Agricultural Production

Note:
Change from Alt 1 for Action Alternatives = Action Alternative minus Alternative 1 (No Action)
Change from Alt 1 for Existing Conditions = Alternative 1 (No Action) minus Existing Conditions

If acreage is not irrigated, then fields would be left barren and subject to windblown dust.
Less irrigated acreage (as compared to Alt 1) would equal a decrease in harvest/land preparation emissions.

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Table 20. Annual Groundwater Pumped (TAF) by SWAP Region

SWAP Region		Wet Years					Above Normal					Below Normal					Dry					Critical				
		Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 3	Alt 3	Alt 5
Sacramento River	V01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V02	380.0	318.7	318.4	318.7	318.7	380.0	318.6	318.2	318.9	318.7	380.0	324.7	323.4	325.2	324.7	380.0	331.0	329.0	332.3	331.0	380.0	348.2	346.4	349.0	348.2
	V03A	151.7	134.4	134.4	134.4	134.4	143.9	128.5	128.4	128.5	128.5	120.5	102.7	102.8	102.7	102.7	118.1	101.4	102.0	99.8	101.5	134.5	128.4	127.2	128.8	128.4
	V03B	19.5	8.1	5.4	8.5	8.1	22.8	13.6	9.5	15.3	13.6	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	93.4	74.7	74.7	74.7	74.7
	V04	0.0	18.5	18.5	18.5	18.5	0.0	11.9	11.9	11.9	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.9	2.0	2.0
	V05	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0	290.0
	V06	475.1	478.9	478.9	478.9	478.9	474.2	477.9	477.9	477.9	477.9	470.0	473.7	473.6	473.8	473.7	470.8	474.5	474.5	474.5	474.5	469.3	473.8	473.7	473.8	473.8
San Joaquin River	V07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V09	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.9	101.0	100.3	101.4	101.0	102.2	102.9	101.6	103.8	102.9	106.4	107.5	105.8	108.3	107.5
	V10	170.1	125.6	116.1	129.0	125.6	260.9	211.8	199.9	216.1	211.9	312.9	269.6	253.0	279.0	269.6	352.6	322.5	293.6	342.2	322.6	532.9	529.6	496.2	547.6	529.6
	V11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V13	774.6	770.6	770.6	770.6	770.6	811.3	810.5	810.5	810.5	810.5	841.0	838.0	838.0	838.1	838.0	893.7	890.0	890.1	890.0	890.0	937.0	933.0	933.2	932.8	933.0
Tulare Lake	V14A	222.1	182.3	160.5	192.5	182.4	428.1	384.6	350.4	397.5	385.2	480.0	480.0	459.6	480.0	480.0	480.0	480.0	480.0	480.0	480.0	480.0	480.0	480.0	480.0	480.0
	V14B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V15A	907.2	913.9	911.7	914.2	913.9	938.0	938.2	936.4	938.7	938.2	940.7	944.9	942.1	947.2	944.9	957.8	960.5	957.1	962.7	960.5	990.1	990.8	986.6	992.8	990.8
	V15B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V17	115.0	115.0	115.0	115.0	115.0	115.0	115.3	115.2	115.3	115.3	115.0	115.4	115.4	115.4	115.4	117.9	118.6	118.3	118.8	118.6	127.8	126.4	126.4	126.3	126.4
	V18	870.2	895.4	894.9	895.6	895.4	960.1	987.1	986.0	987.7	987.1	986.8	1013.5	1012.5	1013.7	1013.5	1110.9	1121.9	1117.4	1125.2	1121.9	1238.5	1259.0	1253.8	1261.8	1259.0
	V19A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V19B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V20	339.5	325.8	325.3	326.0	325.8	360.4	346.3	345.4	346.8	346.3	356.8	347.0	345.5	347.6	347.0	384.2	366.0	362.3	368.8	366.0	438.0	428.7	424.5	430.9	428.7
	V21A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V21B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V21C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Key:
Alt = Alternative NA = No Action TAF = thousand acre-feet

Appendix E
Air Quality Emission Calculations

Table 21. Total Irrigated Acreage (thousand Acres) by SWAP Region

SWAP Region		Wet Years					Above Normal					Below Normal					Dry					Critical				
		Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 2	Alt 3	Alt 5	Existing (2010)	Alt 1/ NA	Alt 3	Alt 3	Alt 5
Sacramento River	V01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V02	159.1	160.9	160.9	160.9	160.9	159.1	160.9	160.9	160.9	160.9	159.1	160.9	160.9	160.9	160.9	159.2	160.9	160.9	160.9	160.9	159.2	160.9	160.9	160.9	160.9
	V03A	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.2	275.3	275.2	275.2	275.3	275.2
	V03B	90.9	91.0	91.0	91.0	91.0	90.9	91.0	91.0	91.0	91.0	87.1	84.4	87.5	82.9	84.4	72.6	67.0	72.3	63.9	67.0	51.8	37.4	47.1	33.3	37.4
	V04	259.8	259.4	259.4	259.4	259.4	260.5	259.4	259.4	259.4	259.4	260.5	262.1	262.1	262.1	262.1	260.5	262.8	262.8	262.8	262.8	260.6	259.3	259.3	259.3	259.3
	V05	365.3	363.5	363.5	363.5	363.5	365.3	363.5	363.5	363.5	363.5	365.3	363.5	363.5	363.5	363.5	365.3	363.5	363.5	363.5	363.5	365.4	363.5	363.5	363.5	363.5
	V06	235.5	238.5	238.5	238.5	238.5	235.5	238.5	238.5	238.5	238.5	235.5	238.5	238.5	238.5	238.5	235.6	238.5	238.5	238.5	238.5	235.7	238.6	238.6	238.6	238.6
San Joaquin River	V07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V09	401.1	406.0	406.1	406.0	406.0	400.5	405.3	405.4	405.2	405.3	400.1	404.9	404.9	404.8	404.9	400.1	404.9	404.8	404.9	404.9	400.1	404.9	404.9	404.9	404.9
	V10	431.5	426.0	426.0	426.0	426.0	431.6	426.0	426.0	426.0	426.0	431.7	426.1	426.0	426.1	426.1	432.1	426.2	426.1	426.2	426.2	430.1	426.3	426.2	426.3	426.3
	V11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V13	569.3	573.1	573.1	573.1	573.1	569.4	573.1	573.1	573.1	573.1	569.5	573.2	573.1	573.2	573.2	569.7	573.2	573.2	573.2	573.2	569.9	573.1	573.1	573.1	573.1
Tulare Lake	V14A	485.7	479.5	479.5	479.5	479.5	485.7	479.6	479.6	479.6	479.6	466.3	473.0	479.6	466.4	473.0	428.9	426.4	455.0	408.4	426.3	339.9	326.7	360.9	303.9	326.6
	V14B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V15A	629.8	634.3	634.3	634.3	634.3	629.8	634.3	634.3	634.3	634.3	629.8	634.3	634.3	634.3	634.3	629.8	634.3	634.3	634.3	634.3	629.8	634.4	634.4	634.4	634.4
	V15B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V17	263.1	264.3	264.3	264.3	264.3	263.1	264.3	264.3	264.3	264.3	263.2	264.3	264.3	264.3	264.3	263.2	264.3	264.3	264.3	264.3	263.3	264.7	264.7	264.7	264.7
	V18	720.2	726.0	726.0	726.0	726.0	720.2	726.0	726.0	726.0	726.0	720.1	725.8	726.0	725.8	725.8	720.1	725.8	725.8	725.8	725.8	720.1	725.8	725.8	725.8	725.8
	V19A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V19B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V20	208.9	211.0	211.0	211.0	211.0	208.9	211.1	211.1	211.1	211.1	208.9	211.1	211.1	211.1	211.1	208.9	211.1	211.1	211.1	211.1	208.9	211.0	211.1	211.0	211.0
	V21A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V21B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	V21C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Key:
Alt = Alternative NA = No Action

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Diesel Exhaust Emission Factors

Table 22. Emission Factors for Uncontrolled Diesel Industrial Engines

Pollutant	Emission Factor	
	(lb/hp-hr) (power output)	(lb/MMBtu) (fuel input)
NOx	0.031	4.41
CO	6.68E-03	0.95
SOx	2.05E-03	0.29
PM10	2.20E-03	0.31
CO2	1.15	164
Aldehydes	4.63E-04	0.07
TOC		
Exhaust	2.47E-03	0.35
Evaporative	0.00	0.00
Crankcase	4.41E-05	0.01
Refueling	0.00	0.00

Source: EPA. 1996. *Compilation of Air Pollutant Emission Factors (AP-42)*, Fifth Edition, Volume I, Section 3.3: Gasoline and Diesel Industrial Engines, Table 3.3-1. October. Available online at: <http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s03.pdf> [Accessed on November 2, 2014].

Key:

CO = carbon monoxide

CO2 = carbon dioxide

lb/hp-hr = pounds per horsepower-hour

lb/MMBtu = pounds per million British Thermal Units

NOx = nitrogen oxides

SOx = sulfur oxides

TOC = total organic compounds

Table 23. Emission Standards Noncertified Greater than 50 BHP In-Use Stationary Diesel-Fueled Engines Used in Agricultural Operations

Horsepower Range	Application	Compliance On or After December 31	Diesel PM Not to Exceed (g/bp-hr)	HC, NOx, NMHC+NOx, and CO Not to Exceed (g/bhp-hr)
Greater Than 50 But Less Than 75	Generator Sets	2015	0.02	Off-Road CI Engine Certification Standards for an off-road engine of the model year and maximum rated power of the engine installed to meet the applicable PM standard. ¹
	All Other Applications	2011	0.30	
Greater Than or Equal to 75 But Less Than 100	Generator Sets	2015	0.01	
	All Other Applications	2011	0.30	
Greater Than or Equal to 100 But Less Than 175	Generator Sets	2015	0.01	
	All Other Applications	2010	0.22	
Greater Than or Equal to 175 But Less Than or Equal to 750	All Applications	2010	0.15	
Greater Than 750	All Applications	2014	0.075	

Note:

¹If no limits have been established for an off-road engine of the same model year and maximum rated power, then the in-use stationary diesel-fueled engine used in an agricultural operation shall not exceed Tier 1 standards in title 13, California Code of Regulations, section 2423 for an off-road engine of the same maximum rated power irrespective of model year.

Key:

BHP = brake-horsepower

CI = compression ignition

CO = carbon monoxide

g/bhp-hr = grams per brake-horsepower hour

HC = hydrocarbons

NOx = nitrogen oxides

PM = particulate matter

Table 24. Tier 1, Tier 2, and Tier 3 Exhaust Emission Standards

Maximum Rated Power	Tier	Model Year	(g/kW-hr)					(g/hp-hr)				
			NOx	HC	NMHC+NOx	CO	PM	NOx	HC	NMHC+NOx	CO	PM
kW<8 hp <11	T1	2000-2004	-	-	10.5	8.0	1	-	-	7.8	6.0	0.75
	T2	2005 -2007	-	-	7.5	8.0	0.8	-	-	5.6	6.0	0.60
8≤kW<19 11≤hp<25	T1	2000-2004	-	-	9.5	6.6	0.8	-	-	7.1	4.9	0.60
	T2	2005 -2007	-	-	7.5	6.6	0.8	-	-	5.6	4.9	0.60
19≤kW<37 25≤hp<50	T1	2000-2003	-	-	9.5	5.5	0.8	-	-	7.1	4.1	0.60
	T2	2004 -2007	-	-	7.5	5.5	0.6	-	-	5.6	4.1	0.45
37≤kW<56 50≤hp<75	T1	2000-2003	9.2	-	-	-	-	6.9	-	-	-	-
	T2	2004-2007	-	-	7.5	5.0	0.4	-	-	5.6	3.7	0.30
	T3	2008 -2011	-	-	4.7	5.0	0.4	-	-	3.5	3.7	0.30
56≤kW<75 75≤hp<100	T1	2000-2003	9.2	-	-	-	-	6.9	-	-	-	-
	T2	2004-2007	-	-	7.5	5.0	0.4	-	-	5.6	3.7	0.30
	T3	2008-2011	-	-	4.7	5.0	0.4	-	-	3.5	3.7	0.30
75≤kW<130 100≤hp<175	T1	2000-2002	9.2	-	-	-	-	6.9	-	-	-	-
	T2	2003-2006	-	-	6.6	5.0	0.3	-	-	-	-	-
	T3	2007 -2011	-	-	4.0	5.0	0.3	-	-	3.0	3.7	0.22
130≤kW<225 175≤hp<300	T1	1996-2002	9.2	1.3	-	11.4	0.54	6.9	1.0	-	8.5	0.40
	T2	2003-2005	-	-	6.6	3.5	0.2	-	-	4.9	2.6	0.15
	T3	2006 -2010	-	-	4.0	3.5	0.2	-	-	3.0	2.6	0.15
225≤kW<450 300≤hp<600	T1	1996-2000	9.2	1.3	-	11.4	0.54	6.9	1.0	-	8.5	0.40
	T2	2001-2005	-	-	6.4	3.5	0.2	-	-	4.8	2.6	0.15
	T3	2006 -2010	-	-	4.0	3.5	0.2	-	-	3.0	2.6	0.15
450≤kW≤560 600≤hp<750	T1	1996-2001	9.2	1.3	-	11.4	0.54	6.9	1.0	-	8.5	0.40
	T2	2002-2005	-	-	6.4	3.5	0.2	-	-	4.8	2.6	0.15
	T3	2006 -2010	-	-	4.0	3.5	0.2	-	-	3.0	2.6	0.15
kW>560 hp>750	T1	2000-2005	9.2	1.3	-	11.4	0.54	6.9	1.0	-	8.5	0.40
	T2	2006 -2010	-	-	6.4	3.5	0.2	-	-	4.8	2.6	0.15

Source: Title 13, California Code of Regulations, Division 3, Chapter 9, Article 4, Section 2423, "Off-Road Compression-Ignition Engines and Equipment."

Key:

CO = carbon monoxide
g/hp-hr = grams per horsepower-hour
g/kW-hr = grams per kilowatt-hour

HC = hydrocarbons
hp = horsepower
kW = kilowatts

NOx = nitrogen oxides
PM = particulate matter
T1 = Tier 1

T2 = Tier 2
T3 = Tier 3

Nitrogen oxides (NOx) and Non-Methane hydrocarbon (NMHC) fraction - Table B-26

NOx 95%
NMHC 5%

http://www.arb.ca.gov/msprog/mover/guidelines/cmp_guidelines_part4.pdf

PM Size Fractions

PM10 0.976
PM2.5 0.967
Ratio 0.99

CARB PMSIZE Profile No. 114 (STAT. I.C. ENGINE-DIST/DIESEL)

Conversion

1 kilowatt = 1.34 horsepower

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Agricultural Land Preparation

Table 25. Summary of Crop Profile, Acre-Pass, and Emission Factor

Crop profile	Land Preparation Operations	Category	Acre-Pass	Emission Factor	
				Operation (lbs PM10/Acre-pass)	Crop (lbs PM10/Acre/year)
Alfalfa	Unspecified	Discing	1.25	1.2	4
	Land Maintenance	Land Planing	0.2	12.5	
Almonds	Float	Land Planing	0.25	12.5	3.13
Citrus	Unspecified	Discing	0.06	1.2	0.07
Corn	List & Fertilize	Weeding	1	0.8	6.9
	Mulch Beds	Discing	1	1.2	
	Finish Disc	Discing	1	1.2	
	Land Maintenance	Land Planing	0.2	12.5	
	Stubble Disc	Discing	1	1.2	
Cotton	Land Preparation	Discing	4	1.2	8.9
	Land Maintenance	Land Planing	0.2	12.5	
	Seed Bed Preparation	Weeding	2	0.8	
DryBeans	Land Maintenance	Land Planing	0.2	12.5	7.7
	Chisel	Discing	1	1.2	
	Shaping	Weeding	1	0.8	
	Disc	Discing	2	1.2	
	Listing	Weeding	1	0.8	
Garbanzo	Chisel	Discing	1	1.2	7.7
	Listing	Weeding	1	0.8	
	Shaping	Weeding	1	0.8	
	Disc	Discing	2	1.2	
	Land Maintenance	Land Planing	0.2	12.5	
Garlic	Land Maintenance	Land Planing	0.2	12.5	6.5
	Disc & Roll	Discing	1	1.2	
	Chisel	Discing	1	1.2	
	List	Weeding	1	0.8	
	Shape Beds	Weeding	1	0.8	
Grapes-Raisin	Terrace	Weeding	1	0.8	2.6
	Spring Tooth	Weeding	0.2	0.8	
	Subsoil	Ripping	0.05	4.6	
	Disc & Furrow-out	Discing	1	1.2	
	Level (new vineyard)	Land Planing	0.02	12.5	
Grapes-Table	Subsoil	Ripping	0.05	4.6	0.83
	Disc & Furrow-out	Discing	0.5	1.2	
Grapes-Wine	Level (new vineyard)	Land Planing	0.02	12.5	1.5
	Spring Tooth	Weeding	0.2	0.8	
	Subsoil	Ripping	0.05	4.6	
	Disc & Furrow-out	Discing	0.75	1.2	

Appendix E
Air Quality Emission Calculations

Crop profile	Land Preparation Operations	Category	Acre-Pass	Emission Factor	
				Operation (lbs PM10/Acre-pass)	Crop (lbs PM10/Acre/year)
Lettuce*	Land Maintenance	Land Planing	0.2	12.5	12.75
	Disc & Roll	Discing	2/2	1.2	
	Chisel	Discing	2/2	1.2	
	List	Weeding	2/2	0.8	
	Plane	Land Planing	½	12.5	
	Shape Beds & Roll	Weeding	2/2	0.8	
Melon	Plow	Discing	1	1.2	5.7
	Shape Beds	Weeding	1	0.8	
	Land Maintenance	Land Planing	0.2	12.5	
	Disc	Discing	1	1.2	
No Land Prep.	Unspecified	Discing	0	1.2	0
Onions	List	Weeding	1	0.8	6.5
	Shape Beds	Weeding	1	0.8	
	Land Maintenance	Land Planing	0.2	12.5	
	Chisel	Discing	1	1.2	
	Disc & Roll	Discing	1	1.2	
Rice	Chisel	Discing	1	1.2	20
	Land Maintenance	Land Planing	0.2	12.5	
	Post Burn/Harvest Disc	Discing	0.5	1.2	
	Roll	Weeding	1	0.8	
	3 Wheel Plane	Land Planing	1	12.5	
	Harrow Disc	Discing	1	1.2	
	Stubble Disc	Discing	1	1.2	
Safflower	List	Weeding	1	0.8	4.5
	Land Maintenance	Land Planing	0.2	12.5	
	Stubble Disc	Discing	1	1.2	
Sugar Beets	Disc	Discing	1	1.2	22.8
	Land Plane	Land Planing	1	12.5	
	Subsoil-deep chisel	Ripping	1	4.6	
	Stubble Disc	Discing	1	1.2	
	List	Weeding	1	0.8	
	Land Maintenance	Land Planing	0.2	12.5	
Tomatoes	Bed Preparation	Weeding	2	0.8	10.1
	Land Preparation	Discing	5	1.2	
	Land Maintenance	Land Planing	0.2	12.5	
Vegetables	Land Maintenance	Land Planing	0.2	12.5	8.5
	Unspecified	Discing	5	1.2	
Wheat	Stubble Disc	Discing	1	1.2	3.7
	Land Maintenance	Land Planing	0.2	12.5	

Source:

CARB. 2003. *Emission Inventory Documentation, Section 7.4: Agricultural Land Preparation*. January.

Accessed on: May 5, 2012. Available at: <http://www.arb.ca.gov/ei/areasrc/arbmiscproccesfarmop.htm>

Key:

lbs = pounds

PM10 = inhalable particulate matter

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Agricultural Harvest Operations

Table 26. Summary of Crop Emission Factor Assumptions

CDFA Crop Code	CDFA Crop Description	Crop Profile	Assumption	Emission Factor (lbs PM10/acre/yr)
101999	WHEAT ALL	Wheat	Wheat/1	5.8
104999	RYE FOR GRAIN	Wheat	Wheat/1	5.8
106199	RICE, FOR MILLING	Rice	Cotton/2	1.68
106269	FIELD CROP BY PRODUCTS	Cotton	Cotton/20	0.17
108999	FOOD GRAINS, MISC	Corn	Cotton/2	1.68
111559	CORN, WHITE	Corn	Cotton/40	0.08
111991	CORN FOR GRAIN	Corn	Cotton/2	1.68
111992	CORN FOR SILAGE	Corn	Cotton/20	0.17
112999	OATS FOR GRAIN	Wheat	Wheat/1	5.8
113994	BARLEY, MALTING	Wheat	Wheat/1	5.8
113995	BARLEY, FEED	Wheat	Wheat/1	5.8
113999	BARLEY, UNSPECIFIED	Wheat	Wheat/1	5.8
114991	SORGHUM, GRAIN	Wheat	Wheat/1	5.8
121219	COTTON LINT, UPLAND	Cotton	Cotton/1	3.37
121229	COTTON LINT, PIMA	Cotton	Cotton/1	3.37
121299	COTTON LINT, UNSPEC	Cotton	Cotton/1	3.37
132999	SUGAR BEETS	Sugar Beets	Cotton/2	1.68
151999	COTTONSEED	Cotton	Cotton/1	3.37
153999	PEANUTS, ALL	Safflower	Cotton/2	1.68
158269	SAFFLOWER	Safflower	Wheat/1	5.8
158316	SUNFLOWER SEED, PLANTING	Corn	Wheat/1	5.8
158319	SUNFLOWER SEED	Corn	Wheat/1	5.8
158499	JOJOBA	Melon	Cotton/40	0.08
161131	BEANS, LIMAS, LG. DRY	Dry Beans	Cotton/2	1.68
161132	BEANS, LIMAS, BABY DRY	Dry Beans	Cotton/2	1.68
161199	LIMA BEANS, UNSPECIFIED	Dry Beans	Cotton/2	1.68
161717	BEANS, RED KIDNEY	Dry Beans	Cotton/2	1.68
161721	BEANS, PINK	Dry Beans	Cotton/2	1.68
161741	BEANS, BLACK EYE (PEAS)	Dry Beans	Cotton/2	1.68
161742	BEANS, GARBANZO	Garbanzo	Cotton/2	1.68
162399	BEANS, FAVA	Dry Beans	Cotton/2	1.68
163999	PEAS, DRY EDIBLE	Dry Beans	Cotton/20	0.17
169999	BEANS, UNSPEC. DRY EDIBLE	Dry Beans	Cotton/2	1.68
171019	SEED WHEAT	Wheat	Wheat/1	5.8
171049	SEED RYE	Wheat	Wheat/1	5.8
171069	SEED RICE	Rice	Cotton/2	1.68
171129	SEED OATS	Wheat	Wheat/1	5.8
171139	SEED BARLEY	Wheat	Wheat/1	5.8
171519	SEED, COTTON FOR PLANTING	Cotton	Cotton/1	3.37
171582	SEED, SAFFLOWER, PLANTING	Safflower	Wheat/1	5.8
171619	SEED BEANS	Dry Beans	Cotton/2	1.68

Appendix E
Air Quality Emission Calculations

CDFA Crop Code	CDFA Crop Description	Crop Profile	Assumption	Emission Factor (lbs PM10/acre/yr)
171639	SEED PEAS	Dry Beans	Cotton/20	0.17
171949	SEED, MISC FIELD CROP	Corn	Cotton/20	0.17
171959	SEED, VEG & VINE CROP	Vegetables	Cotton/20	0.17
172119	SEED, ALFALFA	Alfalfa	Zero/1	0
172289	CLOVER, UNSPECIFIED SEED	Alfalfa	Zero/1	0
173079	SEED, BERMUDA GRASS	Alfalfa	Zero/1	0
173669	SEED, SUDAN GRASS	Alfalfa	Zero/1	0
173999	SEED, GRASS, UNSPECIFIED	Alfalfa	Zero/1	0
178999	SEED, OTHER (NO FLOWERS)	Alfalfa	Cotton/20	0.17
181999	HAY, ALFALFA	Alfalfa	Zero/1	0
188499	HAY, GRAIN	Alfalfa	Cotton/2	1.68
188799	HAY, WILD	Alfalfa	Cotton/2	1.68
188899	HAY, SUDAN	Alfalfa	Zero/1	0
188999	HAY, OTHER UNSPECIFIED	Alfalfa	Cotton/2	1.68
194599	PASTURE, IRRIGATED	No Land	Zero/1	0
194699	PASTURE, RANGE	No Land	Zero/1	0
194799	PASTURE, MISC. FORAGE	No Land	Zero/1	0
195199	SILAGE	Wheat	Cotton/20	0.17
195299	HAY, GREEN CHOP	Alfalfa	Zero/1	0
195399	STRAW	Alfalfa	Wheat/1	5.8
198199	RICE, WILD	Rice	Cotton/2	1.68
198999	FIELD CROPS, UNSPEC.	Corn	Cotton/20	0.17
201119	ORANGES, NAVEL	Citrus	Cotton/40	0.08
201519	ORANGES, VALENCIAS	Citrus	Cotton/40	0.08
201999	ORANGES, UNSPECIFIED	Citrus	Cotton/40	0.08
202999	GRAPEFRUIT, ALL	Citrus	Cotton/40	0.08
203999	TANGERINES & MANDARINS	Citrus	Cotton/40	0.08
204999	LEMONS, ALL	Citrus	Cotton/40	0.08
205999	LIMES, ALL	Citrus	Cotton/40	0.08
206999	TANGELOS	Citrus	Cotton/40	0.08
207999	KUMQUATS	Citrus	Cotton/40	0.08
208059	CITRUS, MISC BY-PROD	Citrus	Cotton/40	0.08
209999	CITRUS, UNSPECIFIED	Citrus	Cotton/40	0.08
211999	APPLES, ALL	Citrus	Cotton/40	0.08
212199	PEACHES, FREESTONE	Citrus	Cotton/40	0.08
212399	PEACHES, CLINGSTONE	Citrus	Cotton/40	0.08
212999	PEACHES, UNSPECIFIED	Citrus	Cotton/40	0.08
213199	CHERRIES, SWEET	Citrus	Cotton/40	0.08
214199	PEARS, BARLETT	Citrus	Cotton/40	0.08
214899	PEARS, ASIAN	Citrus	Cotton/40	0.08
214999	PEARS, UNSPECIFIED	Citrus	Cotton/40	0.08
215199	PLUMS	Citrus	Cotton/40	0.08
215399	PLUMCOTS	Citrus	Cotton/40	0.08
215999	PRUNES, DRIED	Citrus	Cotton/40	0.08

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CDFA Crop Code	CDFA Crop Description	Crop Profile	Assumption	Emission Factor (lbs PM10/acre/yr)
216199	GRAPES, TABLE	Grapes-Table	Cotton/20	0.17
216299	GRAPES, WINE	Grapes-Wine	Cotton/20	0.17
216399	GRAPES, RAISIN	Grapes-Raisin	Cotton/20	0.17
216999	GRAPES, UNSPECIFIED	Grapes-Wine	Cotton/20	0.17
217999	APRICOTS, ALL	Citrus	Cotton/40	0.08
218199	NECTARINES	Citrus	Cotton/40	0.08
218299	PERSIMMONS	Citrus	Cotton/40	0.08
218399	POMEGRANATES	Citrus	Cotton/40	0.08
218499	QUINCE	Citrus	Cotton/40	0.08
218839	CHERIMOYAS	Citrus	Cotton/40	0.08
218889	ORCHARD BIOMASS	Almonds	Cotton/40	0.08
218899	FRUITS & NUTS, UNSPEC.	Citrus	Cotton/40	0.08
221999	AVOCADOS, ALL	Citrus	Cotton/40	0.08
224999	DATES	Citrus	Almonds/20	2.04
225999	FIGS, DRIED	Citrus	Almonds/20	2.04
226999	OLIVES	Citrus	Cotton/40	0.08
228019	GUAVAS	Citrus	Cotton/40	0.08
229999	KIWIFRUIT	Citrus	Cotton/40	0.08
230639	BERRIES, BLACKBERRIES	Grapes-Table	Cotton/40	0.08
230869	BERRIES, BOYSENBERRIES	Grapes-Table	Cotton/40	0.08
234799	BERRIES, LOGANBERRIES	Grapes-Table	Cotton/40	0.08
236199	BERRIES, RASPBERRIES	Grapes-Table	Cotton/40	0.08
237199	STRAWBERRIES, FRESH MKT	Melon	Cotton/40	0.08
237299	STRAWBERRIES, PROC	Melon	Cotton/40	0.08
237999	STRAWBERRIES, UNSPECIFIED	Melon	Cotton/40	0.08
239999	BERRIES, BUSH, UNSPECIFIED	Grapes-Table	Cotton/40	0.08
261999	ALMONDS, ALL	Almonds	Almonds/1	40.77
263999	WALNUTS, ENGLISH	Almonds	Almonds/1	40.77
264999	PECANS	Almonds	Almonds/10	4.08
265999	WALNUTS, BLACK	Almonds	Almonds/1	40.77
266999	CHESTNUTS	Almonds	Almonds/10	4.08
267999	MACADAMIA NUT	Almonds	Almonds/10	4.08
268079	PISTACHIOS	Almonds	Almonds/10	4.08
268099	ALMOND HULLS	Almonds	Almonds/1	40.77
301999	ARTICHOKES	Melon	Cotton/40	0.08
302199	ASPARAGUS, FRESH MKT	Melon	Cotton/2	1.68
302299	ASPARAGUS, PROC	Melon	Cotton/2	1.68
302999	ASPARAGUS, UNSPECIFIED	Melon	Cotton/2	1.68
303999	BEANS, GREEN LIMAS	Dry Beans	Cotton/2	1.68
304199	BEANS, SNAP FR MKT	Dry Beans	Cotton/20	0.17
304299	BEANS, SNAP PROC	Dry Beans	Cotton/20	0.17
304399	BEANS FRESH UNSPECIFIED	Dry Beans	Cotton/20	0.17
304999	BEANS, UNSPECIFIED SNAP	Dry Beans	Cotton/20	0.17
305999	BEETS, GARDEN	Sugar Beets	Cotton/2	1.68

Appendix E
Air Quality Emission Calculations

CDFA Crop Code	CDFA Crop Description	Crop Profile	Assumption	Emission Factor (lbs PM10/acre/yr)
306999	RAPINI	Sugar Beets	Cotton/40	0.08
307189	BROCCOLI, FOOD SERV	Vegetables	Cotton/40	0.08
307199	BROCCOLI, FR MKT	Vegetables	Cotton/40	0.08
307299	BROCCOLI, PROC	Vegetables	Cotton/40	0.08
307919	BROCCOLI, UNSPECIFIED	Vegetables	Cotton/40	0.08
308999	BRUSSELS SPROUTS	Melon	Cotton/40	0.08
309999	CABBAGE, CH. & SPECIALTY	Lettuce	Cotton/40	0.08
310999	CABBAGE, HEAD	Lettuce	Cotton/40	0.08
313189	CARROTS, FOOD SERV	Sugar Beets	Cotton/20	0.17
313199	CARROTS, FR MKT	Sugar Beets	Cotton/20	0.17
313299	CARROTS, PROC	Sugar Beets	Cotton/20	0.17
313999	CARROTS, UNSPECIFIED	Sugar Beets	Cotton/20	0.17
314189	CAULIFLOWER, FOOD SERV	Vegetables	Cotton/40	0.08
314199	CAULIFLOWER, FR MKT	Vegetables	Cotton/40	0.08
314299	CAULIFLOWER, PROC	Vegetables	Cotton/40	0.08
314999	CAULIFLOWER, UNSPECIFIED	Vegetables	Cotton/40	0.08
316189	CELERY, FOOD SERV	Lettuce	Cotton/40	0.08
316199	CELERY, FR MKT	Lettuce	Cotton/40	0.08
316299	CELERY, PROC	Lettuce	Cotton/40	0.08
316999	CELERY, UNSPECIFIED	Lettuce	Cotton/40	0.08
318999	RADICCHIO	Lettuce	Cotton/40	0.08
320999	CHIVES	Lettuce	Cotton/40	0.08
322999	COLLARD GREENS	Lettuce	Cotton/40	0.08
323999	CORN, SWEET ALL	Corn	Cotton/40	0.08
325999	CUCUMBERS	Vegetables	Cotton/40	0.08
330999	EGGPLANT, ALL	Vegetables	Cotton/40	0.08
331999	ENDIVE, ALL	Lettuce	Cotton/40	0.08
332999	ESCAROLE, ALL	Lettuce	Cotton/40	0.08
333999	ANISE (FENNEL)	Lettuce	Cotton/2	1.68
335999	GARLIC, ALL	Garlic	Cotton/2	1.68
337999	KALE	Lettuce	Cotton/40	0.08
338999	KOHLRABI	Lettuce	Cotton/40	0.08
339196	LETTUCE, BULK SALAD PRODS.	Lettuce	Cotton/40	0.08
339999	LETTUCE, UNSPECIFIED	Lettuce	Cotton/40	0.08
340999	LETTUCE, HEAD	Lettuce	Cotton/40	0.08
341999	LETTUCE, ROMAINE	Lettuce	Cotton/40	0.08
342999	LETTUCE, LEAF	Lettuce	Cotton/40	0.08
343999	MELON, CANTALOUPE	Melon	Cotton/40	0.08
348999	MELON, HONEYDEW	Melon	Cotton/40	0.08
354299	MELON, UNSPECIFIED	Melon	Cotton/40	0.08
354999	MELON, WATER MELONS	Melon	Cotton/40	0.08
355999	MUSHROOMS	No Land Prep.	Zero/1	0
356999	MUSTARD	Lettuce	Cotton/40	0.08
357999	OKRA	Lettuce	Cotton/40	0.08

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CDFA Crop Code	CDFA Crop Description	Crop Profile	Assumption	Emission Factor (lbs PM10/acre/yr)
358999	ONIONS	Onions	Cotton/2	1.68
359999	PARSLEY	Lettuce	Cotton/40	0.08
361299	PEAS, GREEN, PROCESSING	Dry Beans	Cotton/20	0.17
361999	PEAS, GREEN, UNSPECIFIED	Dry Beans	Cotton/20	0.17
363999	PEPPERS, BELL	Tomatoes	Cotton/40	0.08
364999	PEPPERS, CHILI, HOT	Tomatoes	Cotton/40	0.08
366999	PUMPKINS	Melon	Cotton/20	0.17
367999	RADISHES	Sugar Beets	Cotton/40	0.08
368999	RHUBARB	Lettuce	Cotton/40	0.08
370999	RUTABAGAS	Sugar Beets	Cotton/2	1.68
372999	ONIONS, GREEN & SHALLOTS	Onions	Cotton/40	0.08
374189	SPINACH, FOOD SERV	Lettuce	Cotton/40	0.08
374199	SPINACH, FR MKT	Lettuce	Cotton/40	0.08
374299	SPINACH, PROC	Lettuce	Cotton/40	0.08
374999	SPINACH UNSPECIFIED	Lettuce	Cotton/40	0.08
375999	SQUASH	Melon	Cotton/20	0.17
376999	SWISS CHARD	Lettuce	Cotton/40	0.08
378199	TOMATOES, FRESH MARKET	Tomatoes	Cotton/40	0.08
378299	TOMATOES, PROCESSING	Tomatoes	Cotton/20	0.17
378999	TOMATOES, UNSPECIFIED	Tomatoes	Cotton/20	0.17
380999	TURNIPS, ALL	Sugar Beets	Cotton/2	1.68
381999	GREENS, TURNIP & MUSTARD	Lettuce	Cotton/40	0.08
387999	LEEKs	Onions	Cotton/40	0.08
391999	POTATOES, IRISH ALL	Sugar Beets	Cotton/2	1.68
392999	SWEET POTATOES	Sugar Beets	Cotton/2	1.68
393999	HORSERADISH	Onions	Cotton/40	0.08
394199	SALAD GREENS NEC	Lettuce	Cotton/40	0.08
394999	PEAS, EDIBLE POD (SNOW)	Dry Beans	Cotton/20	0.17
395999	VEGETABLES, ORIENTAL, ALL	Vegetables	Cotton/40	0.08
396999	SPROUTS, ALFALFA & BEAN	Lettuce	Cotton/40	0.08
398199	CUCUMBERS, GREENHOUSE	No Land Prep.	Zero/1	0
398299	TOMATOES, GREENHOUSE	No Land Prep.	Zero/1	0
398399	TOMATOES, CHERRY	Tomatoes	Cotton/40	0.08
398499	TOMATILLO	Tomatoes	Cotton/40	0.08
398559	CILANTRO	Lettuce	Cotton/40	0.08
398599	SPICES AND HERBS	Lettuce	Cotton/40	0.08
398899	VEGETABLES, BABY	Vegetables	Cotton/40	0.08
398999	VEGETABLES, UNSPECIFIED	Vegetables	Cotton/20	0.17
832919	POTATOES SEED	Sugar Beets	Cotton/2	1.68
892999	NURSERY TURF	No Land Prep.	Zero 1	0

Source:

CARB. 2003. Emission Inventory Documentation, Section 7.5: Agricultural Harvest Operations. January.

Accessed on: May 5, 2012. Available at: <http://www.arb.ca.gov/ei/areasrc/arbmiscprogresfarmop.htm>.

Key:

CDFA = California Department of Food and Agriculture

lbs = pounds

PM10 = inhalable particulate matter

Table 27. Estimated Regional Emission Factors for Windblown Dust

Region	Counties	Emission Factor (tons/acre/year)	Process Rate (acres)	Weighted Average Emission Factor (tons/acre/year)
Sacramento River	Tehama	0.00035146	955,350	0.001320
	Glenn	0.004957	186,067	
	Butte	0.001154	116,869	
	Colusa	0.004702	229,747	
	Sutter	0.00037084	71,500	
	Yolo	0.00061919	136,870	
	Solano	0.00039453	131,360	
	Yuba	0.00023892	207,600	
San Joaquin River	Solano	0.00039453	131,360	0.009747
	Sacramento	0.002479	117,770	
	Contra Costa	n/a	n/a	
	San Joaquin	0.003527	387,278	
	Alameda	n/a	n/a	
	Stanislaus	0.009052	229,805	
	Merced	0.013659	364,804	
	Fresno	0.013761	864,164	
Tulare Lake	Madera	0.008032	141,617	0.010701
	Fresno	0.013761	864,164	
	Kings	0.012856	473,817	
	Tulare	0.004693	471,664	
	Kern	0.008662	408,313	

Note:

Emission factor for pasture lands used if emission factor for agricultural lands is not available.

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Table 28. Windblown Dust - Agricultural Lands

Air Basin Code	County Name	Emission Factor (tons/acre/year)	Process Rate (acres)	Particulate Matter Emissions (tons/year)
NCC	Monterey	0.020478	279,178	5,717.07
	San Benito	0.015936	50,009	796.96
	Santa Cruz	0.002485	14,873	36.97
SCC	San Luis Obispo	0.006876	109,694	754.2
	Santa Barbara	0.00319	80,732	257.56
	Ventura	0.018418	54,568	1,005.02
SED	Imperial	0.141666	490,409	69,474.43
SJV	Fresno	0.013761	864,164	11,891.35
	Kern	0.008662	408,313	3,536.73
	Kings	0.012856	473,817	6,091.62
	Madera	0.008032	141,617	1,137.47
	Merced	0.013659	364,804	4,982.86
	San Joaquin	0.003527	387,278	1,365.96
	Stanislaus	0.009052	229,805	2,080.26
	Tulare	0.004693	471,664	2,213.29
SV	Butte	0.001154	116,869	134.87
	Colusa	0.004702	229,747	1,080.31
	Glenn	0.004957	186,067	922.39
	Placer	0.002172	6,963	15.12
	Sacramento	0.002479	117,770	291.92

Note:

Fraction of PM10 (FRPM10): 0.50
(PM10 Emissions = PM x FRPM10)

Key:

NCC = North Central Coast
SCC = South Central Coast

SED = Salton Sea

SJV = San Joaquin Valley

SV = Sacramento Valley

Table 29. Windblown Dust - Pasture Lands

Air Basin Code	County Name	Emission Factor (tons/acre/year)	Process Rate (acres)	Particulate Matter Emissions (tons/year)
NCC	Monterey	0.00110562	1,108,000	1,225.03
	San Benito	0.00109336	512,000	559.8
	Santa Cruz	0.0001605	8,000	1.28
SCC	Santa Barbara	0.00021801	602,913	131.44
	San Luis Obispo	0.00046964	1,102,500	517.78
	Ventura	0.00050356	210,918	106.21
SED	Imperial	0.00867346	158,449	1,374.30
SJV	Fresno	0.00149089	907,300	1,352.69
	Kern	0.00082834	1,527,603	1,265.37
	Kings	0.00146875	142,777	209.7
	Madera	0.00116178	421,000	489.11
	Merced	0.00155578	642,700	999.9
	San Joaquin	0.0005228	167,700	87.67
	Stanislaus	0.00107875	434,300	468.5
	Tulare	0.00063424	713,400	452.47
SV	Butte	0.00014292	288,500	41.23
	Colusa	0.00046444	181,900	84.48
	Glenn	0.00048846	256,575	125.33
	Placer	0.00026499	65,656	17.4
	Sacramento	0.00019538	118,000	23.05
	Shasta	0.00034146	459,000	156.73
	Solano	0.00039453	131,360	51.83
	Sutter	0.00037084	71,500	26.51
	Tehama	0.00035146	955,350	335.76
	Yolo	0.00061919	136,870	84.75
	Yuba	0.00023892	207,600	49.6

Note:

Fraction of PM10 (FRPM10): 0.50
(PM10 Emissions = PM x FRPM10)

Key:

NCC = North Central Coast

SED = Salton Sea

SV = Sacramento Valley

SCC = South Central Coast

SJV = San Joaquin Valley

Source:

CARB. 1997. *Emission Inventory Documentation, Section 7.12: Windblown Dust - Agricultural Lands*. July.
Accessed on: May 5, 2012. Available at: <http://www.arb.ca.gov/ei/areasrc/arbmiscprocfugwdbdst.htm>.

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Appendix F

Climate Change Analysis Emissions Calculations

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Groundwater Pumping Emissions

Table 1. Alternative 1: Diesel Exhaust Emissions

Location	Change from Ex. Cond. (TAF)	Operation (hr/yr)	Fuel Consumption (gallons/year)	GHG Emissions						
				(metric tons/year)			(metric tons CO2e per year)			
				CO2	CH4	N2O	CO2	CH4	N2O	Total
Wet Condition										
Sacramento River	-67.8	-147,293	-1,322,128	-13,499	-0.55	-0.11	-13,499	-14	-33	-13,545
San Joaquin River	-48.5	-105,413	-946,206	-9,661	-0.39	-0.08	-9,661	-10	-23	-9,694
Tulare Lake	-21.5	-46,685	-419,051	-4,279	-0.17	-0.03	-4,279	-4	-10	-4,293
Wet Condition Total				-27,438	-1.11	-0.22	-27,438	-28	-66	-27,532
Above Normal Condition										
Sacramento River	-70.5	-153,080	-1,374,066	-14,029	-0.57	-0.11	-14,029	-14	-34	-14,077
San Joaquin River	-49.9	-108,309	-972,195	-9,926	-0.40	-0.08	-9,926	-10	-24	-9,960
Tulare Lake	-30.1	-65,311	-586,245	-5,986	-0.24	-0.05	-5,986	-6	-14	-6,006
Above Normal Condition Total				-29,941	-1.21	-0.24	-29,941	-30	-72	-30,044
Below Normal Condition										
Sacramento River	-69.4	-150,712	-1,352,812	-13,812	-0.56	-0.11	-13,812	-14	-33	-13,860
San Joaquin River	-46.2	-100,291	-900,224	-9,191	-0.37	-0.07	-9,191	-9	-22	-9,223
Tulare Lake	21.5	46,666	418,883	4,277	0.17	0.03	4,277	4	10	4,291
Below Normal Condition Total				-18,727	-0.76	-0.15	-18,727	-19	-45	-18,791
Dry Condition										
Sacramento River	-62.1	-134,817	-1,210,141	-12,356	-0.50	-0.10	-12,356	-13	-30	-12,398
San Joaquin River	-33.0	-71,729	-643,851	-6,574	-0.27	-0.05	-6,574	-7	-16	-6,596
Tulare Lake	-3.7	-8,136	-73,026	-746	-0.03	-0.01	-746	-1	-2	-748
Dry Condition Total				-19,675	-0.80	-0.16	-19,675	-20	-48	-19,742
Critical Condition										
Sacramento River	-50.1	-108,919	-977,676	-9,982	-0.40	-0.08	-9,982	-10	-24	-10,016
San Joaquin River	-6.4	-13,865	-124,457	-1,271	-0.05	-0.01	-1,271	-1	-3	-1,275
Tulare Lake	10.5	22,883	205,399	2,097	0.09	0.02	2,097	2	5	2,104
Critical Condition Total				-9,156	-0.37	-0.07	-9,156	-9	-22	-9,187

Key:

CH4 = methane

CO2e = carbon dioxide equivalent

hr/yr = hours per year

TAF = thousand acre-feet

CO2 = carbon dioxide

GHG = greenhouse gas

N2O = nitrous oxide

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Table 2. Alternative 2: Diesel Exhaust Emissions

Location	Change from Alt 1 (TAF)	Operation (hr/yr)	Fuel Consumption (gallons/year)	GHG Emissions						
				(metric tons/year)			(metric tons CO2e per year)			
				CO2	CH4	N2O	CO2	CH4	N2O	Total
Wet Condition										
Sacramento River	-3.0	-6,530	-58,612	-598	-0.02	0.00	-598	-1	-1	-600
San Joaquin River	-9.5	-20,670	-185,539	-1,894	-0.08	-0.02	-1,894	-2	-5	-1,901
Tulare Lake	-25.1	-54,420	-488,485	-4,987	-0.20	-0.04	-4,987	-5	-12	-5,005
Wet Condition Total				-7,480	-0.30	-0.06	-7,480	-8	-18	-7,506
Above Normal Condition										
Sacramento River	-4.6	-9,950	-89,310	-912	-0.04	-0.01	-912	-1	-2	-915
San Joaquin River	-11.9	-25,933	-232,777	-2,377	-0.10	-0.02	-2,377	-2	-6	-2,385
Tulare Lake	-38.0	-82,586	-741,301	-7,569	-0.31	-0.06	-7,569	-8	-18	-7,595
Above Normal Condition Total				-10,857	-0.44	-0.09	-10,857	-11	-26	-10,894
Below Normal Condition										
Sacramento River	-1.3	-2,780	-24,956	-255	-0.01	0.00	-255	0	-1	-256
San Joaquin River	-17.4	-37,849	-339,735	-3,469	-0.14	-0.03	-3,469	-4	-8	-3,481
Tulare Lake	-25.7	-55,809	-500,954	-5,115	-0.21	-0.04	-5,115	-5	-12	-5,132
Below Normal Condition Total				-8,838	-0.36	-0.07	-8,838	-9	-21	-8,869
Dry Condition										
Sacramento River	-1.4	-2,946	-26,445	-270	-0.01	0.00	-270	0	-1	-271
San Joaquin River	-30.2	-65,601	-588,841	-6,012	-0.24	-0.05	-6,012	-6	-15	-6,033
Tulare Lake	-12.0	-25,996	-233,340	-2,382	-0.10	-0.02	-2,382	-2	-6	-2,391
Dry Condition Total				-8,664	-0.35	-0.07	-8,664	-9	-21	-8,694
Critical Condition										
Sacramento River	-3.1	-6,791	-60,961	-622	-0.03	-0.01	-622	-1	-2	-625
San Joaquin River	-34.8	-75,554	-678,187	-6,924	-0.28	-0.06	-6,924	-7	-17	-6,948
Tulare Lake	-13.5	-29,426	-264,132	-2,697	-0.11	-0.02	-2,697	-3	-7	-2,706
Critical Condition Total				-10,243	-0.42	-0.08	-10,243	-10	-25	-10,279

Key:

CH4 = methane

CO2 = carbon dioxide

CO2e = carbon dioxide equivalent

GHG = greenhouse gas

hr/yr = hours per year

N2O = nitrous oxide

TAF = thousand acre-feet

Table 3. Alternative 3: Diesel Exhaust Emissions

Location	Change from Alt 1 (TAF)	Operation (hr/yr)	Fuel Consumption (gallons/year)	GHG Emissions						
				(metric tons/year)			(metric tons CO2e per year)			
				CO2	CH4	N2O	CO2	CH4	N2O	Total
Wet Condition										
Sacramento River	0.4	924	8,295	85	0.00	0.00	85	0	0	85
San Joaquin River	3.4	7,396	66,385	678	0.03	0.01	678	1	2	680
Tulare Lake	11.0	23,860	214,171	2,187	0.09	0.02	2,187	2	5	2,194
Wet Condition Total				2,949	0.12	0.02	2,949	3	7	2,959
Above Normal Condition										
Sacramento River	2.0	4,276	38,380	392	0.02	0.00	392	0	1	393
San Joaquin River	4.3	9,318	83,641	854	0.03	0.01	854	1	2	857
Tulare Lake	14.5	31,535	283,059	2,890	0.12	0.02	2,890	3	7	2,900
Above Normal Condition Total				4,136	0.17	0.03	4,136	4	10	4,150
Below Normal Condition										
Sacramento River	0.6	1,304	11,708	120	0.00	0.00	120	0	0	120
San Joaquin River	9.9	21,476	192,768	1,968	0.08	0.02	1,968	2	5	1,975
Tulare Lake	3.1	6,747	60,558	618	0.03	0.01	618	1	1	620
Below Normal Condition Total				2,706	0.11	0.02	2,706	3	7	2,715
Dry Condition										
Sacramento River	-0.3	-710	-6,370	-65	0.00	0.00	-65	0	0	-65
San Joaquin River	20.6	44,832	402,417	4,109	0.17	0.03	4,109	4	10	4,123
Tulare Lake	8.5	18,437	165,492	1,690	0.07	0.01	1,690	2	4	1,695
Dry Condition Total				5,733	0.23	0.05	5,733	6	14	5,753
Critical Condition										
Sacramento River	1.2	2,627	23,583	241	0.01	0.00	241	0	1	242
San Joaquin River	18.7	40,713	365,442	3,731	0.15	0.03	3,731	4	9	3,744
Tulare Lake	7.0	15,224	136,650	1,395	0.06	0.01	1,395	1	3	1,400
Critical Condition Total				5,367	0.22	0.04	5,367	5	13	5,386

Key:

CH4 = methane

CO2 = carbon dioxide

CO2e = carbon dioxide equivalent

GHG = greenhouse gas

hr/yr = hours per year

N2O = nitrous oxide

TAF = thousand acre-feet

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Table 4. Alternative 5: Diesel Exhaust Emissions

Location	Change from Alt 1 (TAF)	Operation (hr/yr)	Fuel Consumption (gallons/year)	GHG Emissions						
				(metric tons/year)			(metric tons CO2e per year)			
				CO2	CH4	N2O	CO2	CH4	N2O	Total
Wet Condition										
Sacramento River	-0.002	-5	-45	0	0.00	0.00	0	0	0	0
San Joaquin River	0.034	74	662	7	0.00	0.00	7	0	0	7
Tulare Lake	0.177	385	3,453	35	0.00	0.00	35	0	0	35
Wet Condition Total				42	0.00	0.00	42	0	0	42
Above Normal Condition										
Sacramento River	0.02	38	343	4	0.00	0.00	4	0	0	4
San Joaquin River	0.07	151	1,355	14	0.00	0.00	14	0	0	14
Tulare Lake	0.59	1,287	11,551	118	0.00	0.00	118	0	0	118
Above Normal Condition Total				135	0.01	0.00	135	0	0	136
Below Normal Condition										
Sacramento River	-0.002	-3	-30	0	0.00	0.00	0	0	0	0
San Joaquin River	-0.007	-16	-141	-1	0.00	0.00	-1	0	0	-1
Tulare Lake	0.083	180	1,620	17	0.00	0.00	17	0	0	17
Below Normal Condition Total				15	0.00	0.00	15	0	0	15
Dry Condition										
Sacramento River	0.1	232	2,086	21	0.00	0.00	21	0	0	21
San Joaquin River	0.1	176	1,584	16	0.00	0.00	16	0	0	16
Tulare Lake	0.0	62	553	6	0.00	0.00	6	0	0	6
Dry Condition Total				43	0.00	0.00	43	0	0	43
Critical Condition										
Sacramento River	0.006	12	111	1	0.00	0.00	1	0	0	1
San Joaquin River	0.058	126	1,133	12	0.00	0.00	12	0	0	12
Tulare Lake	0.012	27	240	2	0.00	0.00	2	0	0	2
Critical Condition Total				15	0.00	0.00	15	0	0	15

Key:

CH4 = methane

CO2 = carbon dioxide

CO2e = carbon dioxide equivalent

GHG = greenhouse gas

hr/yr = hours per year

N2O = nitrous oxide

TAF = thousand acre-feet

Average Pump Rate: 2,500 gallons per minute
(estimated from Long-Term Water Transfers data)

Average Engine Rating: 160 horsepower
(estimated from Long-Term Water Transfers data)

Conversions

1 acre-foot = 325,851 gallons http://www.water.ca.gov/pubs/dwrnews/california_water_facts_card/waterfactscard.pdf
1 TAF = 1,000 acre-feet
1 hour = 60 minutes
1 metric ton = 1,000 kilograms

Diesel Engine Fuel Consumption

0.4 pounds per horsepower-hour (Based on spec sheet for John Deere 6068H, 6.8L Engine, 173 HP)
0.855 grams per milliliter (Based on Material Safety Data Sheet for Hess Diesel Fuel [All Types])
7.13 pounds per gallon

Global Warming Potential

CO2 1
CH4 25
N2O 298

Table 5. SWAP Output - Annual Groundwater Pumped

SWAP Region	Annual Groundwater Pumped (TAF)					Change from Alt 1 (TAF)			
	Alternative 1 (No Action Alternative)	Alternative 2	Alternative 3	Alternative 5	Existing Conditions	Alternative 2	Alternative 3	Alternative 5	Existing Conditions
	Wet Condition								
Sacramento River	1,248.5	1,245.5	1,249.0	1,248.5	1,316.3	-3.0	0.4	-0.002	-67.8
San Joaquin River	996.2	986.7	999.6	996.3	1,044.7	-9.5	3.4	0.03	-48.5
Tulare Lake	2,432.4	2,407.3	2,443.4	2,432.6	2,453.9	-25.1	11.0	0.2	-21.5
Above Normal Conditions									
Sacramento River	1,240.5	1,235.9	1,242.4	1,240.5	1,310.9	-4.6	2.0	0.02	-70.5
San Joaquin River	1,122.3	1,110.3	1,126.6	1,122.4	1,172.1	-11.9	4.3	0.1	-49.9
Tulare Lake	2,771.5	2,733.4	2,786.0	2,772.0	2,801.5	-38.0	14.5	0.6	-30.1
Below Normal Conditions									
Sacramento River	1,265.8	1,264.5	1,266.4	1,265.8	1,335.2	-1.3	0.6	-0.002	-69.4
San Joaquin River	1,208.7	1,191.3	1,218.6	1,208.7	1,254.8	-17.4	9.9	-0.01	-46.2
Tulare Lake	2,900.7	2,875.1	2,903.9	2,900.8	2,879.3	-25.7	3.1	0.1	21.5
Dry Condition									
Sacramento River	1,271.6	1,270.2	1,271.3	1,271.7	1,333.6	-1.4	-0.3	0.1	-62.1
San Joaquin River	1,315.5	1,285.3	1,336.1	1,315.6	1,348.5	-30.2	20.6	0.1	-33.0
Tulare Lake	3,047.0	3,035.1	3,055.5	3,047.1	3,050.8	-12.0	8.5	0.03	-3.7
Critical Condition									
Sacramento River	1,317.1	1,314.0	1,318.3	1,317.1	1,367.2	-3.1	1.2	0.01	-50.1
San Joaquin River	1,570.0	1,535.2	1,588.8	1,570.1	1,576.4	-34.8	18.7	0.1	-6.4
Tulare Lake	3,284.8	3,271.3	3,291.9	3,284.9	3,274.3	-13.5	7.0	0.01	10.5

Note:
 Change from No Action Alternative for Action Alternatives = Alternative minus Alternative 1 (No Action)
 Change from No Action Alternative for Existing Conditions = Alternative 1 (No Action) minus Existing Conditions
 Key:
 SWAP = Statewide Agricultural Production TAF = thousand acre-feet

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Table 6. Diesel Emission Factors

Pollutant	Emission Factor	Unit	Emission Factor Description
CO2	10.21	kg/gallon	Table 12.1, Distillate Fuel Oil No. 2
CH4	0.003	kg/MMBtu	Table 12.9, Petroleum Products, Industrial
N2O	0.0006	kg/MMBtu	Table 12.9, Petroleum Products, Industrial
Heat Content	0.138	MMBtu/gallon	Table 12.1, Distillate Fuel Oil No. 2

Source: The Climate Registry. 2014. 2014 Climate Registry Default Emission Factors with U.S. EPA 11/29/2013 Update (Released: March 14, 2014). Accessed on: May 12, 2014. Available at: <http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-TCR-Default-EFs-with-EPA-11.29.2013-update.pdf>

Key:

CH4 = methane

MMBtu = million British Thermal Units

CO2 = carbon dioxide

N2O = nitrous oxide

kg = kilograms

Appendix G

M&I Economic Model Documentation

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Appendix G

M&I Economic Model Documentation

This technical appendix documents two economic models used to develop economic impact estimates for water supply changes to Central Valley Project (CVP) municipal and industrial (M&I) water service contractors for the regional economic analysis of the M&I Water Shortage Policy (WSP) Environmental Impact Statement. This appendix provides results of the analyses and explains linkages to the regional impact analysis.

Both the Least Cost Planning Simulation Model (LCPSIM) and the Other Project Water Economic Model (OPWEM) accept an annual time series of CVP M&I water service contractor deliveries as input, and estimate amounts and costs of water supplies and shortage needed to balance demand and supply. In this analysis, LCPSIM includes all the San Francisco Bay Area CVP M&I water service contractors, and OPWEM includes all other CVP M&I water service contractors who might be affected by the M&I WSP. Cost and retail revenue changes are calculated by comparison to the No Action Alternative. Water supply cost changes are assumed to be passed onto regional water end-users who must change their discretionary spending by a similar amount. These changes in regional spending have “multiplier effects” in the regional economy which are estimated using the IMPact analysis for PLANning (IMPLAN) model. The IMPLAN analysis is presented in Chapter 13, Socioeconomics.

G.1 LCPSIM

For this analysis, the Bay Area LCPSIM is used to estimate the economic benefits and costs of water supply for M&I purposes in the urban areas of Santa Clara Valley Water District, Contra Costa Water District, and East Bay Municipal Utility District (EBMUD).

LCPSIM uses CalSim II results for annual CVP deliveries to M&I water service contractors under the 2030 condition over the 1922 to 2003 hydrologic period as input (See Appendix B, Water Operations Model Documentation, for more detail on the CalSim II model, assumptions, and results). For each year of the hydrologic period, demand and supply quantities are compared. If supply is insufficient to meet demand, the costs of additional water supplies are calculated. Additional water supplies can be temporary, such as temporary water transfers, or long-term, such as permanent water use efficiency improvements or water reclamation facilities. LCPSIM is an annual time-step urban water system model that finds the mix of temporary and long-term options that minimizes the sum of the total annual cost of these options, including the total expected annual shortage

costs that remain after their adoption. To estimate costs of shortage, the model uses a shortage loss function derived from contingent valuation studies and water agency shortage allocation strategies.

Long-term measures available for the Bay Area LCPSIM are indoor conservation, outdoor conservation, and water recycling. The model accounts for the ability of shortage management (contingency) measures, including temporary water transfers, to reduce regional costs and losses associated with shortage events, and for the ability of long-term regional demand reduction and supply augmentation measures, in conjunction with regional carryover storage opportunities, to reduce the frequency, magnitude, and duration of shortage events.

The model requires data on water demands and supplies and the costs and amounts of water supply and conservation options as input. Some local supplies and supply options are modeled using conveyance and storage capacities, and the model conducts storage operations to utilize these options. Data for the model were generally obtained from California Department of Water Resources (DWR) planning documents and from local sources such as the Urban Water Management Plans (UWMPs). Most of these data were vetted as part of the CALFED common assumptions process in 2007 to 2008. The Bay Area version of the model was reviewed and updated in 2008 to 2009, and again, more recently, for the Bay Delta Conservation Plan.

The model outputs include annual shortage size, costs and losses due to shortage, quantities and costs of water transfers, surface and groundwater carryover storage operations, and overall system operations costs.

G.1.1 LCPSIM Results

Table G-1 provides a summary of LCPSIM results for the five M&I WSP alternatives. Alternative 2, Equal Agricultural and M&I Allocation, would increase economic costs, including net operations costs, urban water supply and shortage costs in the Bay Area by an average of about \$14.2 million annually, relative to the No Action Alternative (Alternative 1). Alternative 3, Full M&I Allocation Preference, would decrease these net costs by about \$6.5 million annually, under 2030 conditions, relative to the No Action Alternative. For modeling purposes, there is no difference between the No Action Alternative and Alternative 4, Updated M&I WSP (see Appendix B); therefore, Alternative 4 has the same economic effects as the No Action Alternative. The effects of Alternative 5, M&I Contractor Suggested WSP, in the Bay Area are near zero relative to the No Action Alternative.

Table G-1. Bay Area LCPSIM Model Results

Model inputs and results	Alternative				Change Relative to the No Action Alternative		
	Alternative 1 (No Action Alternative) & Alternative 4	Alternative 2	Alternative 3	Alternative 5	Alternative 2	Alternative 3	Alternative 5
CVP M&I Contract Deliveries (thousand acre-feet [TAF]) ¹							
Wet Year Average (26 years)	267	248	275	267	-19	8	0
Above Normal Year Average (12 years)	267	236	284	267	-31	17	0
Below Normal Year Average (14 years)	228	154	269	228	-74	41	0
Dry Year Average (18 years)	198	123	258	198	-75	60	0
Critical Year Average (12 years)	166	57	211	166	-109	45	0
Annual Average							
CVP M&I Contract Deliveries (TAF)	230	175	262	230	-56	32	0
Average Applied Demand Reduction (TAF)	25	32	0	25	7	-25	0
Average Water Market Deliveries (TAF)	5	25	4	5	20	-1	0
Annual Average Cost (\$1,000)							
System Operations Cost	\$188,074	\$186,961	\$194,138	\$188,074	(\$1,113)	\$6,064	(\$0)
Shortage Loss/Cost	\$12,926	\$21,531	\$8,349	\$12,927	\$8,605	(\$4,576)	\$1
Annualized Option Cost	\$6,885	\$9,438	(\$777)	\$6,885	\$2,553	(\$7,662)	\$0
Water Market Cost	\$1,055	\$5,200	\$760	\$1,056	\$4,144	(\$296)	\$0
Total Loss/Cost	\$208,940	\$223,129	\$202,471	\$208,942	\$14,189	(\$6,470)	\$1
Reduced Expenditure for Regional Models					\$6,697	(\$7,958)	\$0
Marginal Option Cost (\$/AF)	\$354	\$381	\$330	\$354	\$27	(\$24)	\$0

¹Does not include EBMUD deliveries

G.1.2 Bay Area Regional Economic Effects

LCPSIM was developed to calculate economic costs and benefits. Regional economic analysis focuses on different economic measures such as value of output, income and employment. The relationship between economic costs or benefits and regional economic effects is complicated.

The regional input-output analysis uses LCPSIM results that are not the same, but are related to, costs and benefits. In particular, LCPSIM calculates the change in water supply cost experienced by water suppliers. It is assumed that an increase in water costs must be recovered. For the regional analysis, this cost is passed onto end-users which reduces their discretionary spending by an equivalent amount. For Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by \$6.697 million relative to the No Action Alternative, so by assumption, other expenditures by end-users would be reduced by \$6.697 million. For Alternative 3, annual average water supply costs would be reduced by \$7.958 million, and these savings would be passed onto end-users who would increase their spending by \$7.958 million.

LCPSIM also calculates end-user shortage cost. This cost is the disutility or unhappiness of end-users who must reduce their water use even though they would prefer to buy the water at the existing price. LCPSIM shortage cost does not have a direct regional effect because most of this cost is not reflected in regional sales, income, or other economic activity. This unhappiness might affect the decisions of water end-users (primarily residents and businesses) about where to live and do business, and those decisions might have regional effects. These regional effects, if any, cannot be modeled with LCPSIM and IMPLAN.

G.1.3 LCPSIM Limitations for Regional Effects Analysis

This section discusses modeling limitations in LCPSIM and suggests how associated regional effects might be affected.

LCPSIM models the entire region as one region. All demands and supplies are aggregated. This aggregation would not create inaccuracy if all water agencies within the region shared equally in water supplies and shortages. Bay Area water suppliers have infrastructure in place to share some water supplies, recognize that potential cost savings can be obtained by more sharing, and are actively engaged in projects that will allow for more sharing among them (Bay Area Water Supply and Conservation Agency [BAWSCA] 2014). There may be more sharing of water supplies by 2030, but even under anticipated conditions, the LCPSIM aggregation is not entirely appropriate.

In particular, some Bay Area CVP water service contractors are currently in a better position to cope with changes in CVP water allocations than others. Marginal and total costs in some sub-regions of the Bay Area are likely to be less than, and some more than, LCPSIM implies. Given increasing marginal costs, the

net effect is likely to be an understatement of total economic costs and impacts of CVP M&I supply reductions.

The LCPSIM aggregation assumption, combined with the different reliability of water supplies by sub-region, means that some sub-regions have relatively more costs and impacts than others. The relatively large additional shortages in some sub-regions could be a disincentive for people and industry to locate in these sub-regions. Similarly, the improvement in water supply conditions could provide incentive for people, businesses, and industry to operate in these sub-regions.

LCPSIM was designed to operate more or less within the range of historical experience. CVP M&I water delivery reductions in some years under Alternative 2 would be much larger than have historically occurred. To cope with such supply reductions, Bay Area providers might develop new supply alternatives that are included in LCPSIM. There is no information to judge whether these alternative might be more or less expensive than the costs implied by LCPSIM results.

LCPSIM alone does not include all potential economic effects of water shortage. LCPSIM estimates the economic costs of water shortage, but these costs might themselves have economic consequences that are not quantified. In particular, the end-user shortage cost, or reduced end-user shortage benefit, may affect the decisions of water users about where to live and do business, and these decisions might have regional effects. These regional effects cannot be directly modeled with LCPSIM or IMPLAN.

LCPSIM does not include an explicit production or cost function for commercial and industrial (C&I) water shortage. Water suppliers generally protect C&I users from water shortage, and this is reflected in LCPSIM logic. However, CVP water delivery reductions in some years under Alternative 2 would be very severe. CalSim II results show that, during critical years (12 out of 82 years), CVP supplies for the region would be reduced from 166,000 acre-feet (AF) to 57,000 AF on average. Parts of the Bay Area also receive State Water Project supplies that would be unreliable in dry years. Under the Alternative 2, the portfolio of supplies for the region becomes even less reliable in dry years. C&I users would incur unusual costs in some years to cope with water shortage, and without economical supply alternatives, decisions regarding production, employment, and siting of facilities might be affected.

G.2 OPWEM

OPWEM has been developed to estimate representative economic benefits or costs of changes in CVP M&I supplies for all urban areas outside of the Bay Area that receive these supplies. The model is intended to be similar to LCPSIM in terms of the types of water management actions taken in response to changing CVP supplies, and in the calculation and costs of end-user shortage. Water

demands and non-CVP supplies for the 2030 condition are based on information provided by 2010 UWMPs, where available.

The model includes areas served by CVP water service contractors in the Sacramento Valley, American River basin, and San Joaquin Valley. Twenty-four providers who have CVP M&I water service contracts and 13 providers who have CVP agricultural water service contracts and provide some water for M&I purposes are included. Each provider is modeled separately. The model includes small amounts of agricultural use that could not be separated from urban use.

The model uses CalSim II results for annual CVP M&I water deliveries under the 2030 condition over the 1922 to 2003 hydrologic period as input. For each year of this hydrologic period, demand and supply quantities are compared. If supply is insufficient to meet demand, the costs of additional water supplies are calculated. These costs are the amount of supply times its unit cost. Each provider is associated with two different unit costs of water supplies: one for years that are wetter than dry years; and another for dry and critical years. The unit costs are based on data from individual providers, where available, but most costs are representative groundwater costs or water transfer costs developed from secondary information.

The model also includes potential water shortage costs in dry and critical years. Shortage costs are based on individual retail water prices and quantities, and a short-run demand elasticity of -0.1. That is, demand functions used to estimate shortage costs are fit using a price-quantity point and a slope (see Attachment A for more detail regarding OPWEM). Shortage costs developed in this manner are similar to the shortage costs in LCPSIM for a similar retail price.

The regional analysis assumes that the change in water supply costs must be passed onto end-users who then must reduce their other spending accordingly. Water costs are smaller (as absolute values) than the total cost because they do not include the end-user shortage costs.

G.2.1 OPWEM Results

Table G-2 provides aggregated results of the OPWEM analysis. Alternative 3, Full M&I Allocation Preference, has the largest average amount of CVP M&I deliveries at 317,500 AF, and Alternative 2, Equal Agricultural and M&I Allocation, has the least at 210,200 AF.

**Table G-2. OPWEM Results by CVP Contractor Group and Alternative;
Annual Average CVP Deliveries and Shortage Costs**

Region	Alternatives			
	Alternative 1 & 4	Alternative 2	Alternative 3	Alternative 5
Sacramento Valley Region				
Average Annual CVP Deliveries (TAF)	49.2	39.3	56.1	49.2
Costs, \$1,000 Annual Average, Difference from No Action Alternative				
Total Shortage Cost		\$3,589	-\$1,140	NA
Water Supply Only		\$2,234	-\$1,140	NA
Average \$/AF Change from No Action Alternative		\$364	\$165	NA
American River Region				
Average Annual CVP Deliveries (TAF)	154.6	120.3	173.9	154.6
Costs, \$1,000 Annual Average, Difference from No Action Alternative				
Total Shortage Cost		\$21,735	-\$6,451	NA
Water Supply Only		\$8,024	-\$4,606	NA
Average \$/AF Change from No Action Alternative		\$632	\$334	NA
San Joaquin Valley Region				
Average Annual CVP Deliveries (TAF)	73.1	50.6	87.4	73.8
Costs, \$1,000 Annual Average, Difference from No Action Alternative				
Total Shortage Cost		\$13,868	-\$5,047	-\$287
Water Supply Only		\$6,998	-\$3,807	-\$254
Average \$/AF Change from No Action Alternative		\$619	\$352	\$371
All Regions				
Average Annual CVP Deliveries (TAF)	276.9	210.2	317.5	277.6
Average \$/AF Change from No Action Alternative		\$413	\$381	\$349

In the Sacramento Valley region, Alternative 3 would increase average CVP M&I deliveries by 6,900 AF and reduce total costs by \$1.14 million annually compared to the No Action Alternative. All of this cost savings consists of costs of supplies no longer needed to meet demands. The average value of an acre-foot of CVP M&I delivery above the No Action Alternative levels in terms of reduced costs is \$165. In this region, Alternative 2 reduces CVP M&I average deliveries by 9,900 AF relative to the No Action Alternative. Total costs increase by \$3.589 million, so the average additional total cost per acre-foot of delivery reduction from the No Action Alternative is \$364. Most of this cost increase consists of water supply costs, but Alternative 2 also results in some end-user shortage costs.

For the regional analysis, for Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by \$2,234 million, so other expenditures by end-users would be reduced by \$2.234 million. For Alternative 3, annual average water supply costs would be reduced by \$1.14 million, and these savings would be passed onto end-users who would increase their spending by \$1.14 million.

In the American River Region, Alternative 3 would increase average CVP M&I deliveries by 19,300 AF and reduce total costs by \$6.451 million annually compared to the No Action Alternative. Most of this cost savings consists of costs of avoided supplies, but the total includes \$1.845 million of reduced end-user shortage costs. The average total reduced cost of an acre-foot of change in CVP delivery (compared to No Action Alternative levels) is \$334. In this region, Alternative 2 reduces average CVP M&I deliveries by 34,300 AF relative to the No Action Alternative. Total costs increase by \$21.735 million annually, so the average additional total cost per acre-foot change in deliveries is \$632. Most of this cost increase consists of end-user shortage costs, but the total cost of Alternative 2 includes \$8.024 million of water supply costs.

For the regional analysis, for Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by \$8.024 million, so other expenditures by end-users would be reduced by \$8.024 million. For Alternative 3, annual average water supply costs would be reduced by \$6.451 million, and these savings would be passed onto end-users who would increase their spending by \$6.451 million.

In the San Joaquin Valley region, Alternative 3 would increase average CVP M&I deliveries by 14,300 AF and reduce total costs by \$5.047 million annually compared to the No Action Alternative. Most of this cost savings (\$3.807 million) consists of costs of avoided supplies. The average value of an acre-foot of CVP M&I delivery above No Action levels in terms of reduced costs is \$352. In this region, Alternative 2 reduces average CVP M&I deliveries by 22,500 AF relative to the No Action Alternative. Total costs increase by \$13,868 million, so the average additional shortage cost per acre-foot of delivery reduction is \$619. About half of this cost increase consists of water supply costs, and half is end-user shortage costs. San Joaquin Valley results for Alternative 5 are strongly affected by one individual contractor whose deliveries in some years are protected by public health and safety criteria.

For the regional analysis, for Alternative 2, Equal Agricultural and M&I Allocation, annual average water supply costs would be increased by \$6.998 million, so other expenditures by end-users would be reduced by \$6.998 million. For Alternative 3, annual average water supply costs would be reduced by \$3.807 million, and these savings would be passed onto end-users who would increase their spending by \$3.807 million.

Alternative 2, with reduced CVP delivery amounts, has higher marginal and average shortage costs than Alternative 3 because shortage becomes increasingly expensive as the amount of shortage increases. Alternative 3 has the smallest average shortage cost per acre-foot of CVP delivered above the No Action Alternative. The overall average cost per acre-foot delivered below the No Action Alternative for Alternative 2 is \$588/AF. The overall average benefit per AF delivered above the No Action Alternative for Alternative 3 is \$311/AF. This

pattern is expected as a given increment of water supply is more valuable as the total amount of water supply decreases.

G.2.2 OPWEM Limitations for Regional Effects Analysis

OPWEM limitations are similar to those for LCPSIM except that OPWEM considers each CVP contract holder to be a separate entity so there is little potential error arising from aggregation.

For some M&I water service contractors in the OPWEM model, total water supply under Alternative 2 is very unreliable. CVP water delivery reductions in some years under Alternative 2 would be unprecedented. Some urban providers currently rely solely on CVP M&I supplies and have limited alternatives. New supply development might be required to maintain an attractive economic climate and public health and safety ~~levels~~needs.

G.3 References

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Attachment A

Additional Information for OPWEM

A.1 Detailed Description of OPWEM for M&I WSP

OPWEM is a spreadsheet model of water supplies and demands for CVP contractors not covered by LCPSIM. Each of the CVP service areas is independent of the others so their benefits are additive. All CVP service areas are analyzed in a similar way. Annual CVP M&I deliveries are input from CalSim II model results. The 2010 UWMPs were used, if available, to estimate 2030 water demand and non-CVP supplies for an average condition and a dry condition, and data on marginal water supplies and their costs were obtained.

A number of M&I water service contractors do not prepare UWMPs. For these, data from the Bureau of Reclamation were used to estimate demand¹. The UWMP data were often inadequate for this analysis, especially for costs (which are not required in an UWMP), so other planning documents, typical groundwater pumping costs, and local transfer prices were often relied on.

For each year of the hydrologic period, demand and supply quantities are compared. If supply is insufficient to meet demand, the costs of additional water supplies are calculated. If the year type is below normal or wetter, the model calculates the cost of supply based on a unit value per AF for these year types.

If the year type is dry or critical, the model allows for shortfalls to be eliminated with dry/critical supply sources and with end-user shortage. The incremental amounts and costs of additional supplies and shortage needed to achieve water balance in the dry condition are estimated and a cost is assigned. In dry and critical years, the difference between with and without CVP deliveries is provided a value even if there is no shortage showing in these years. This is appropriate under the assumption that there are opportunity costs for CVP water in dry and critical years even if the local agency has no shortage. The provider could take the CVP supply and free up the same amount of some other supply which, because it is a dry year, can then be put to valuable use elsewhere.

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

¹ See Appendix A, M&I Contractor Data Summary.

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

The model calculates shortage costs based on recent retail water prices (Black and Veatch 2006), the level of demand, and a constant elasticity of demand (CED) loss function with a demand elasticity of -0.1. That is, the retail price and demand quantity are a point on the demand function, and the elasticity provides the slope. The marginal value of water from the CED function can be capped; the current cap is set at \$7,000/AF more than the provider's retail water price.

Table 1 shows the CVP agencies included in OPWEM, their expected CVP contract amount, and a 2030 demand forecast. Other (non-CVP) supplies for an average and dry condition must be included. Table 2 provides these 2030 supply estimates for years that are wetter than dry years for each agency, and Table 3 provides dry and critical condition supplies.

The model includes about 318,000 AF of CVP M&I contract amounts, 11,000 AF of additional use of agricultural contracts for meeting 2030 M&I demand, and 750,000 AF of M&I demand in 2030. This demand includes small amounts of agricultural demand which is included because water supplies for urban and agricultural uses cannot be separated.

Table 1. Agencies Included in OPWEM, Their Contracts, and 2030 Demand Forecast

CVP Contract Holder Agency	CVP Contract (AF/year)	2030 Normal Year Demand (AF/year)	Notes
City of Redding	6,140	27,852	City of Redding 2012
Bella Vista Water District	24,578	24,578	See Appendix A
Clear Creek Community Services District (CSD)	15,300	15,300	See Appendix A
Shasta CSD, City of Shasta Lake, and United States Forest Service (USFS)	5,410	5,410	See Appendix A
Centerville CSD, Mountain Gate CSD, and Shasta County Water Agency	5,272	5,272	See Appendix A
City of Roseville	32,000	49,334	City of Roseville 2011: Table 3.11a
El Dorado Irrigation District	7,550	57,039	El Dorado Irrigation District 2011: Total Use Table 3-9 minus agriculture, Table 3-5.
Placer County Water Agency (PCWA)	35,000	130,711	PCWA 2011: Western Area, minus untreated sales to others
Sacramento County Water Agency (SCWA)	52,000	114,898	SCWA 2011: Table 4-15
Sacramento Municipal Utility District (SMUD)	30,000	30,000	See Appendix A
San Juan Water District (SJWD)	24,200	94,290	SJWD 2011: No agricultural water included, sales to cities of Folsom and Roseville, page 18
San Benito County Water District	43,800	89,345	Water Resources Association of San Benito County 2004: Includes about half agriculture, 3,000 losses
United States (U.S.) Department of Veterans Affairs, and State of California	860	860	See Appendix A
City of Tracy	17,500	31,000	City of Tracy 2011: Table 8
City of Avenal	3,500	3,500	See Appendix A
City of Coalinga	10,000	11,819	City of Coalinga 2006
City of Huron	3,000	3,000	See Appendix A
Cross Valley Canal	1,704	1,704	See Appendix A
Agricultural contractors with small M&I delivery, Sacramento River Division	508	508	See Appendix A
Agricultural contractors with small M&I delivery, Delta Division	1,150	1,150	See Appendix A
Agricultural contractors with small M&I delivery, Export	7,904	7,904	See Appendix A
TOTAL	328,716	704,852	

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Table 2. 2030 Non-CVP Supplies (AF), Years Wetter than Dry Years

CVP Contract Holder	Surface Water	Natural Groundwater	Other Groundwater	Recycled Water	Transfers	Other, or Multiple Sources
City of Redding	21,000	13,405				
Bella Vista Water District						
Clear Creek CSD		30				
Shasta CSD, City of Shasta Lake, and USFS		2,000				
Centerville CSD, Mountain Gate CSD, and SCWA		900				
City of Roseville	34,000			1,709	4,000	
El Dorado Irrigation District	0	23,000	15,080	7,730	21,560	7,500
PCWA	100,400	0		6,987	3,400	36,000
SCWA	27,000	25,000	7,500	4,400	14,498	7,540
SMUD	0					18,024
SJWD	33,000					25,000
San Benito County Water District		49,925				
U.S. Department of Veterans Affairs, and State of California						
City of Tracy						18,500
City of Avenal						
City of Coalinga			1,500	500		
City of Huron						
Cross Valley Canal						
Agricultural contractors with small M&I delivery, Sacramento River Division						
Agricultural contractors with small M&I delivery, Delta Division						
Agricultural contractors with small M&I delivery, Export						

Note: supplies amounts are not always unambiguously associated with the type of supply indicated. Some supplies from diverse sources are disaggregated into these columns rather than show them all as "Other." The totals are unaffected by the categorization.

Table 3. 2030 Non-CVP Supplies (AF), Dry and Critical Years

CVP Contract Holder Agency	Surface Water	Natural Groundwater	Other Groundwater	Recycled Water	Transfers	Banking	Storage Depletion	Other
City of Redding	16,600	13,405						
Bella Vista Water District								
Clear Creek CSD								
Shasta CSD, City of Shasta Lake, and USFS		2,000						
Centerville CSD, Mountain Gate CSD, and SCWA		930						
City of Roseville	24,000			3,397				
El Dorado Irrigation District	0	23,000	15,080	7,730	17,000	7,500	4,560	
PCWA	100,400	0		6,987	1,700			28,800
SCWA	63,000	37,200	7,500	4,400	9,300	6,000		5,198
SMUD								18,024
SJWD	33,000				20,000			
San Benito County Water District		49,925						
U.S. Department of Veterans Affairs, and State of California								
City of Tracy								25,000
City of Avenal								
City of Coalinga								
City of Huron								
Cross Valley Canal								
Agricultural contractors with small M&I delivery, Sacramento River Division								
Agricultural contractors with small M&I delivery, Delta Division								
Agricultural contractors with small M&I delivery, Export								

Note: supplies are not always unambiguously associated with the type of supply indicated

A.2. OPWEM M&I Water Service Contractor Assumptions

Other than the San Francisco Bay Area (which is covered in LCPSIM), the primary areas that obtain urban water from the CVP are the Shasta and Trinity River Divisions, the American River Division, and the City of Tracy and San Benito County Water District south of the Sacramento-San Joaquin River Delta (Delta).

A.2.1 Shasta and Trinity River Divisions

In the Shasta and Trinity River Divisions, 56,700 AF of CVP M&I contract is available to serve over 78,000 AF of urban demand in 2030. Most urban users have limited supplies to augment their CVP contracts, except that the City of Redding also has surface water rights and groundwater. Relatively small amounts of groundwater are also available to the City of Shasta Lake (2,000 AF) and Centerville CSD (900 AF). For this region, the alternative supply available in case of shortage is generally groundwater (\$145 per AF) or water transfers (\$246 or \$307 in below normal/above normal/wet or dry/critical years, respectively). For Clear Creek CSD, a recent claim of \$200 per AF for M&I use is used.

A.2.2 American River Division

Most water demand and supply estimates in the American River Division are based on 2010 UWMPs. The American River basin includes about 476,000 AF of 2030 urban demands and 445,000 AF of non-CVP supplies in normal years. There are a number of permanent transfers among agencies within this region and overlying service areas that complicate the counting of demands and supplies. PCWA has over 250,000 AF of contract and water right supply. About 120,000 AF of PCWA's total supplies are provided by the Middle Fork Project, and most of the remainder, over 100,000 AF, is provided by agreements with Pacific Gas & Electric Company.

A large share of PCWA's supply is wholesaled to other agencies. PCWA expects to provide about 20,400 AF to SJWD in 2030, of which 4,000 AF will be provided to the City of Roseville. PCWA also wholesales 29,000 AF to Sacramento Suburban Water District in wetter years, but no delivery is expected for dry years. The City of Roseville obtains another 30,000 AF from PCWA in normal years (PCWA 2011). SJWD has its own pre-1914 water right for 33,000 AF, and SJWD expects to wholesale 1,540 AF to the City of Folsom by 2030 (SJWD 2011). Water provided to the City of Lincoln is included with PCWA. A summary of water rights and contract entitlements is provided in the 2006 American River Basin Integrated Regional Water Management Plan (Regional Water Authority 2006).

El Dorado Irrigation District has a variety of non-CVP supplies including, in normal years, water from Jenkinson Lake (23,000 AF), and a variety of other surface water sources (El Dorado Irrigation District 2011). El Dorado Irrigation District 2030 demands and supplies are reduced for 12,581 AF of agricultural demands (El Dorado Irrigation District 2011).

SMUD is expected to have a 2030 demand of 30,000 AF, the same amount as its CVP M&I contract, and 18,024 AF of other supplies are available to meet demand (see Appendix A).

SCWA wholesales some of its supplies; City of Folsom obtains 7,000 AF of 101-514 “Fazio water” when available from SCWA, and SCWA obtains wholesale water through agreements with the City of Sacramento. Regional demands and supplies include the City of Folsom, included with SCWA, which has 22,000 AF of its own pre-1914 water rights, and City of Folsom receives 5,000 AF from Golden State Water Company.

A.2.3 South of the Delta

In San Benito County, it is assumed that the CVP M&I water service contract will be entirely converted to M&I use by 2030. San Benito County Water District has groundwater supplies to augment its CVP contract. In the San Joaquin Valley, the City of Tracy is the largest single user of CVP M&I contract water. Tracy has a variety of other water supplies.

A.2.4 Agricultural Water Service Contractors

Relatively small amounts of contract and demand are included for Sacramento Valley agricultural water service contractors, the San Joaquin Valley cities of Avenal, Coalinga, and Huron, and San Joaquin Valley agricultural water service contractors with relatively small M&I use projected for 2030. UWMPs were generally not available for these smaller water users. Appendix A contains assumptions about supplies and 2030 demand levels are generally assumed equal to the contract amounts.

Table 4 provides unit costs used for alternative water supplies in years that are classified as below normal or wetter, and in dry and critical years. Cost data were generally based on a provider’s most likely alternative supply source. Groundwater costs are intended to be based on full costs including capital, energy, and external costs. External costs are generally effects on groundwater tables and expected value for that water for future use. Groundwater costs are intended to reflect the groundwater tables used for urban supply which are often much deeper than water used for agricultural supplies. Conjunctive use costs are assumed for providers having access to established projects. Groundwater and conjunctive use costs estimates were updated to 2030 levels using forecast increases in real energy prices amounting to 2.3 percent annually. A large share of groundwater and conjunctive use costs are energy.

Water transfer costs are based on an evaluation of opportunity costs of agricultural water use conducted in the mid-2000s using the Central Valley Production Model, water transfer price data, and information on land rents and prices. Central Valley transfer costs are assumed to increase at a real rate of 1.5 percent per year. This rate of increase is consistent with observed rates of increase from the mid-2000s water transfer studies (Mann and Hatchett 2006).

Table 4. Unit Costs of Additional Water Supplies in OPWEM (\$/AF, 2030 Condition)

Contractors	Wetter than Dry Condition	Dry or Critical Condition
City of Redding	\$145	\$217
Bella Vista Water District	\$145	\$217
Agricultural contractors with small M&I delivery, Sacramento River Division	\$145	\$217
Clear Creek CSD	\$254	\$254
Shasta CSD, City of Shasta Lake, and USFS	\$216	\$269
Centerville CSD, Mountain Gate CSD, and SCWA	\$145	\$217
All American River Contractors	\$236	\$331
San Benito County Water District	\$336	\$336
U.S. Department of Veterans Affairs, and State of California	\$297	\$345
Cities of Tracy, Avenal, Coalinga, Huron	\$297	\$345
Cross Valley Canal	\$297	\$345
Agricultural contractors with small M&I delivery, Delta Division	\$297	\$345
Agricultural contractors with small M&I delivery, Export	\$297	\$345

Note: In wetter than dry condition, unit costs can be zero when there is excess supply.

A.3 References

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