San Joaquin Valley
Air Pollution Control District

Conservation Management Practices Program
Report for 2005

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EXECUTIVE SUMMARY

On August 19, 2004, the San Joaquin Valley Air Pollution Control District (the District) adopted Rule 4550 (Conservation Management Practices) as a part of the District's PM10 attainment strategy, committing to 33.8 tons per day of PM10 emissions reductions through the implementation of the rule. The District has received and approved over 6,000 Conservation Management Practices (CMP) Plan applications through the implementation of the CMP Program. As of December 31, 2005, the CMP Program is achieving 35.3 tons per day of PM10 emissions reductions, surpassing the 2003 PM10 Attainment Plan commitment.

This report serves to provide an explanation of the CMP Program's key components and a detailed summary of the process of identifying and quantifying the reductions made by the District's CMP Program during its implementation, through December 31, 2005.

1. Conservation Management Practices Program

The San Joaquin Valley Air Basin is classified as a serious nonattainment area for PM10. Because of this classification, the San Joaquin Valley Air Pollution Control District (District) is required to implement emission controls known as Best Available Control Measures (BACM) for all significant PM10 sources. Agricultural sources were identified as a significant source of fugitive PM10 emissions and a source for PM10 reductions in the District's 2003 PM10 Attainment Plan (PM10 Plan). The District adopted Rule 4550 (Conservation Management Practices) on August 19, 2004 as a component of the District 's PM10 attainment strategy, committing to a projected 33.8 tons per day of PM10 emissions reductions through the implementation of the rule.

The CMP Program is applicable to agricultural operations that grow crops and to Animal Feeding Operations (AFO), such as dairies, feedlots, and poultry operations. In general, growers with contiguous acreage of greater than 100 acres and dairies with greater than 500 mature cows are subject to the CMP requirements, and these sources represent the majority of agricultural sources subject to CMP requirements.

Rule 4550 specifies that agricultural operations must select at least one CMP from each of the identified applicable CMP categories. The AFO sources subject to Rule 4550 that also grow field crops must select CMPs for their field crops as well as their AFO. There are five CMP categories for the cropland source categories, four CMP categories for the dairy source category, four CMP categories for the feedlot source category, and five CMP categories for the poultry source category. The selected CMPs must be noted on the applications provided. The applications must be submitted to the District for approval. The completed applications will constitute a CMP Plan when approved by the District.

Emissions from agricultural operations vary by many factors, some beyond the control of the agricultural operations. PM10 emissions are generated during land preparation activities, harvest activities, and post-harvest activities. Emissions are caused by the mechanical disturbance of the soil by implements and the tractors pulling them, resulting in the entrainment of soil or plant materials into the air, and by the burning of prunings or residues. Wind blowing across exposed agricultural land also causes the entrainment of PM10 into the air. In addition, PM10 emissions can also become entrained from vehicular travel over unpaved roads and unpaved parking/equipment areas. The emissions result from the mechanical disturbance of the roadway by the tires of the vehicle.

Conservation management practices fall into several broad categories and address several aspects such as:

- The reduction of soil or manure disturbance;
- Soil protection from wind erosion;
- Equipment modifications to physically produce less PM10;
- Application of water or dust suppressants on unpaved roads and other travel areas to reduce emissions entrained by moving vehicles and equipment

Implementation of the CMP Program

The District embarked on an ambitious implementation strategy upon approval of Rule 4550, working extensively with agricultural stakeholders to ensure that affected sources were assisted as much as possible in complying with the requirements, and consequently ensuring that the CMP Program was as successful as possible. To this end, the District created special CMP application forms, which were designed to allow growers to select approved practices from simplified checklists. A special Internet web page was created that contains answers to frequently asked questions, application forms, and other forms of assistance for agricultural operations. The District hired additional District staff, including additional Small Business Assistance (SBA) staff, and took part in 40 workshops up and down the Valley to assist sources in completing and submitting the required CMP application forms (see Appendix A). The workshops were coordinated with agricultural stakeholders, and tremendous outreach was performed to ensure that as many sources as possible would attend and receive assistance at the workshops.

As a result of these efforts, the District's CMP Program realized the following notable achievements:

- The workshops attracted approximately 4,000 participants, with many of the participants submitting CMP Plan applications during the workshops.
- The District received and processed over 6,000 CMP Plan applications during 2005.
- The practices used by valley agricultural sources encompass over 3.2 million acres of farmland, and over 30,000 miles of unpaved roads.
- The PM10 reductions are quantifiable and enforceable through approved CMP Plans and inspections.
- The collaborative effort responsible for the CMP program received US EPA Region IX's "2005 Environmental Award for Outstanding Achievement."

2. PM10 Plan CMP Program Commitments

As previously mentioned, the District committed to a projected PM10 emissions reduction of 33.8 tons per day through the implementation of the CMP Program. The 2003 PM10 Plan includes contingency measures, also referred to as backstop provisions, that must be implemented to provide additional emission reductions in case a shortfall is encountered after rule implementation.

Appendix H of the PM10 Plan lists four actions that would trigger the imposition of backstop provisions, in the order listed in the PM10 Plan. They are the following:

1. If the CMP Program fails to achieve a compliance rate of 80 percent or greater by December 31, 2006.
2. If the field support agencies (NRCS and RCD) are unable to provide resources sufficient to collect CMP implementation data that is adequate to calculate emission reductions for the 2005 growing season.
3. If the CMP Program fails to achieve projected emission reduction targets by December 31, 2005 by a substantial margin. According to the plan, this was to be determined in the first PM10 Reasonable Further Progress report for the PM10 Plan.
4. If the District receives a complaint from a neighbor regarding excessive fugitive dust emissions from an agricultural source or District compliance staff witnesses the excessive emissions.

Trigger 1:
The compliance rate achieved by the CMP Program under Trigger 1 will largely be determined as the District's inspection process for CMP agricultural sources is more fully implemented during 2006. The backstop provision for Trigger 1 is that

the District will assume CMP program management duties, and will increase outreach to agricultural operations. The District has already assumed program management duties, and extensive outreach has been performed to agricultural operations to bring them into the CMP program. The District will continue to work with agricultural stakeholders and perform outreach to ensure that agricultural operations are aware of and comply with CMP requirements. While we believe it likely that the compliance rate already meets and exceeds the required 80%, we will have demonstrated this achievement by the end of 2006.

Trigger 2:

Trigger 2 is no longer relevant as the District has assumed CMP program management duties, and this report calculates emission reductions for the 2005 period.

Trigger 3:

Trigger 3 is the most important commitment made in the PM10 Plan regarding the CMP Program. It states that if the CMP Program fails to achieve the projected emission reduction target of 33.8 tons per day by December 31, 2005 by a substantial margin, that the District must increase the number of CMPs to be implemented, lower the exemption thresholds to expand the scope of the CMP program, or take other actions in the next PM10 Plan cycle to increase the PM10 emissions reductions resulting from the program. As shown in the following section, the District has calculated the emissions reductions achieved by the CMP program, and has determined that agricultural sources are reducing PM10 emissions by at least 35.3 tons per day, surpassing our PM10 Plan commitment. Therefore, expansion of the CMP program will not be required.

Trigger 4:

The District has implemented an inspection program for CMP facilities that will address the issues raised under trigger 4 as well as other compliance issues.

3. EMISSIONS REDUCTIONS ANALYSIS

Overview

The District received and approved over 6,000 applications that include over 800 AFO facilities, covering over 3.2 million acres, 1.5 million cattle, and 60 million poultry birds. Data from the CMP applications were entered into a database during the processing of CMP applications. Data collected and entered into the database include the type of crops grown, crop acreage, mileage of unpaved roads, acreage of unpaved equipment areas, animal head counts, CMPs selected, and other relevant miscellaneous details of the CMP. Based on assumptions listed in the following subsections, emissions reductions were calculated by the database based on data entered and emissions reductions factors for various CMPs. Detailed explanations of the emissions reductions methodologies developed for each CMP are included as Appendix B. Detailed summaries of the CMP control efficiencies are included as Appendix C.

The following sections identify the main assumptions used to calculate the PM10 emissions reductions associated with the CMP Program.

A. General assumptions Used in Calculating Emissions Reductions

The District conservatively reviewed the best available data regarding conservation management practices and compared them with the assumptions used to derive the District's emissions inventory from agricultural operations in order to establish the emissions reductions associated with various practices. Sources of information include various documents from UC Davis and California Air Resources Board (CARB), the 2003 PM10 Plan and its supporting documents, and other literature. The following general assumptions were made to estimate the PM10 emissions reductions associated with the CMP Program:

- Implementation of CMPs result in PM10 emissions reductions to the extent that the CMPs are not accounted for in the emission inventory.
- Several crop profiles identified by CARB were grouped. The emission factors of each major crop were weight-averaged based on each emission factor and acreage to establish one emission factor for the group.
- A weight-averaged emission factor was used for all windblown PM10 emissions. ARB identified several emissions factors per county for windblown PM10 emissions. A similar approach was used for harvest emission factors.
- All crop types, except Citrus, Grapes, Nut Crops, and Tree Fruit, were potentially rotated crops. When an agricultural operation applied for multiple crops with total crop acreage greater than that of the total farm, it was assumed that there was crop rotation.
- The analysis used weighted average emission factors and control efficiencies for similar crop types (e.g. vegetables, grapes, grains, and onions/garlic).

Main Assumptions for Land Preparation, Harvest, and Other CMP Categories

- The CMPs "Irrigation Power Units," and "Sulfur Dusting Reduction" address secondary PM10 emissions, and not fugitive PM10 emissions. Additionally, there is no fugitive PM10 emissions inventory for sulfur dusting emissions. Therefore, to be conservative, no PM10 emissions reductions were claimed from the implementation of these CMPs.
- There is no fugitive PM10 emissions inventory for the handling of bulk material, although there is an ongoing effort to establish an emissions inventory for this category of source. Therefore, PM10 emissions reductions from the implementation of Bulk Material CMPs were not claimed at this time.
- Emissions reductions from CMPs that address no burning of field and row crops were included since these crops were prohibited from being burned under State law effective July 2005, during this first CMP Program year.
- An adjustment factor was used to reconcile reductions from agricultural operations that claimed "No Burning" CMPs with records of crop burning from the District's Agricultural Burn Management program.
- There is no fugitive PM10 emissions inventory for "track out" emissions from rural roads. Therefore, PM10 emissions reductions from the implementation "Track Out Control" CMPs were not claimed at this time.
- There is no fugitive PM10 emissions inventory for windblown PM10 emissions from orchards and vineyards. Therefore, PM10 emissions reductions from the implementation of the "Permanent Crop" CMP were not claimed.

Main Assumptions for Animal Feeding Operations (AFO):

- The emissions factors for AFOs were converted to a single-head basis and were apportioned among the CMP categories (See Appendix D).
- A 10% control efficiency factor was assigned to each AFO CMP where no other information was available.

Main Assumptions for Unpaved Road and Unpaved Equipment and Parking Areas CMP Categories:

- The mileage and acreage of unpaved roads and areas specifically included in CMP Plan applications were used to calculate the emissions reduction associated with those roads and areas.

- The California Air Resources Board's Vehicle Mile Traveled (VMT) values per crop type were used as default values to calculate emissions reductions from CMPs used on unpaved roads and areas.

B. Emissions Reductions Calculations

Rule 4550 requires agricultural operations to utilize one practice per CMP category. These categories include land preparation; harvest; unpaved roads; unpaved equipment and traffic areas; other, which includes windblown dust and agricultural burning and other sources; corral/manure handling; overall management/feeding; open areas; and feeding.

The following primary steps were performed to calculate the overall emissions reductions associated with the CMP Program using data collected from approved CMP Plan applications:

- Uncontrolled PM10 emissions in pounds per year were calculated by multiplying the emission factor for a specific crop, AFO, or other source (such as unpaved areas) by the acreage, animal head count, or other relevant factor. See Appendix C for a summary of the emission factors used in the analysis.
- A control efficiency factor was established for each CMP and included in the equation. Appendices B and C summarize the control factors assigned to each CMP and include detailed information regarding the evaluation of control factors.
- A conversion factor from pounds to tons was applied to calculate the emissions reduction in tons.
- An adjustment factor was applied where necessary. For example, not all agricultural operations that reported the CMP "No Burning" for specific crops were legally authorized by the District to burn those crops. Therefore, an adjustment factor per crop type was added to account for actual authorized burning. See Appendix C for a list of adjustment factors.
- A VMT factor per crop type was used to determine the number of vehicle mile trips occurred per acre of crop.
- In situations where more than one CMP was selected in a CMP category, the CMP acreage or mileage was adjusted based on the number of CMPs selected, the total acreage of the facility, and potential crop rotation.

The following general equation was used to estimate the emissions reduction per CMP:

Emissions Reduction$_{CMP}$ =

Emission Factor$_{crop}$ x (Acres harvested$_{crop}$ OR Head Count OR Unpaved Area) x Control Efficiency Factor$_{CMP}$ x Adjustment Factor / 2000$_{lbs/tons}$

The following is an example for an agricultural parcel using the equation presented above for corn and the CMP Combined Operation:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 35_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.12 \text{ tons PM10/year}$$

The following is another example for unpaved roads for a Garlic field:

$$\text{Emission Reduction} = \frac{(2_{(\text{lbs/VMT})} \times 2.40_{(\text{VMT/acre})} \times 100_{(acre\,/\,year)} \times 87_{(\%)})}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{417.6_{(\text{lbs/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.20 \text{ tons PM10/year}$$

4. RESULTS

The estimated PM10 emissions reductions for the CMP Program through December 31, 2005, using the conservative set of assumptions explained in this report, are 35.3 tons per day. The estimated PM10 emissions reductions are summarized in the below table. Additional summary tables summarizing PM10 emissions reductions by crop type, CMP category, and CMPs are included in Appendix E.

Based on this analysis, the District's CMP Program is surpassing the PM10 Plan commitment of 33.8 tons per day of PM10 emissions reductions.

CMP Category/Source	CMP Program 2005 –Emissions Reductions (tons PM10/day)
Land Preparation	7.66
Harvest	5.80
Other	12.23
Unpaved Road	5.85
Unpaved Areas	0.94
Animal Feeding Operations	2.84
TOTAL	35.3
Covered Acreage	3,274,202

Appendices

A. CMP Application Forms

B. CMP Emissions Reduction Methodologies

C. CMP Control Efficiencies and Emissions Factors

D. San Joaquin Valley Air Pollution Control District. *Evaluation of PM10 Emission Factors For AFO CMPs.* September 2005.

E. CMP Program Summary Tables

Appendix A

CMP Application Forms

CMP Plan

San Joaquin Valley Air Pollution Control District
CONSERVATION MANAGEMENT PRACTICES PLAN APPLICATION

General Information

A Conservation Management Practices (CMP) plan is a requirement for all agricultural operation sites as specified in Section 5.0 of District Rule 4550. The goal of this CMP plan is to reduce sources of PM_{10} emissions from agricultural operations. Note: The CMPs chosen in this plan must be implemented by July 1, 2004.

Name of Facility: ______________________________

Facility Location: ______________________________

Total Farm Acreage: ______________

City/State/Zip Code: ______________________________

Mailing Address: ______________________________

City/State/Zip code: ______________________________

Phone: ______________ Fax: ______________

Other (Cell): ______________

Person Responsible: ______________ Title: ______________

Signature: ______________ Date: ______________

Please list the following information for the persons responsible for:

Plan Preparation:

☐ Same as Person Responsible Above?

Name: ______________

Title: ______________

Address: ______________

City/State/Zip code: ______________

Phone: ______________

Fax: ______________

Other (Cell): ______________

Plan Implementation:

☐ Same as Person Responsible Above?

Name: ______________

Title: ______________

Address: ______________

City/State/Zip code: ______________

Phone: ______________

Fax: ______________

Other (Cell): ______________

FOR CMP PLAN EVALULATOR USE ONLY

[ ] This CMP plan application has been verified to contain all supporting information required by the APCO to evaluate the application. Checklist attached.

Name: ______________ Title: ______________ Office Location: ______________

Signature: ______________ Date: ______________ Phone #: ______________

CMP Plan

San Joaquin Valley Air Pollution Control District
Supplemental Application Form

Conservation Management Practices: ALFALFA

Farm Name: ______________________ CMP Plan Years: __________ to __________

Maximum Crop Acreage: __________

Fallow Acreage Last Planted in Alfalfa: __________

Land Preparation/ Cultivation	Select at least one of the following CMPs. Note: 100% of the maximum crop acreage must be covered by the selected CMPs. ☐ Chemigation/Fertigation, _____ ac ☐ Combined Operations, _____ ac ☐ Conservation Irrigation, _____ ac ☐ Equipment Change/Tech. Improvements, _____ ac ☐ Multiple CMPs in Another Category ☐ Night Farming, _____ ac ☐ Non-Tillage/Chemical Tillage, _____ ac ☐ Precision Farming (GPS), _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above:
Harvest	Select at least one of the following CMPs. Note: 100% of the maximum crop acreage must be covered by the selected CMPs. ☐ Baling/Large Balers, _____ ac ☐ Green Chop, _____ ac ☐ Equipment Change/Tech. Improvements ☐ Multiple CMPs in Another Category, _____ ac ☐ Night Harvesting, _____ ac ☐ Shuttle System, _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above:
Other	Select at least one of the following CMPs. Note: 100% of the maximum crop acreage must be covered by the selected CMPs. ☐ Application Efficiencies, _____ ac ☐ Bulk Materials Control ☐ Cover Crop, _____ ac ☐ Irrigation Power Units ☐ Multiple CMPs in Another Category ☐ No Burning, _____ ac ☐ Surface Roughening, _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above:

CMP Plan

San Joaquin Valley Air Pollution Control District
Supplemental Application Form

Conservation Management Practices: CORN, GRAIN, AND SILAGE

Farm Name: ______________________ CMP Plan Years: __________ to __________

Maximum Crop Acreage: __________

Fallow Acreage Last Planted in Corn, Grain, or Silage: __________

Land Preparation/ Cultivation

Select at least one of the following CMPs.

Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Bed/Row Size or Spacing, _____ ac
- ☐ Chemigation/Fertigation, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ Combined Operations, _____ ac
- ☐ Conservation Irrigation, _____ ac
- ☐ Conservation Tillage, _____ ac
- ☐ Equipment Change/Tech. Improvements, _____ ac
- ☐ Integrated Pest Management (IPM), _____ ac
- ☐ Mulching, _____ ac
- ☐ Night Farming, _____ ac
- ☐ Precision Farming (GPS), _____ ac
- ☐ Transgenic Crops, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

Harvest

Select at least one of the following CMPs.

Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Equipment Change/Tech. Improvements, _____ ac
- ☐ Green Chop, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ Night Harvesting, _____ ac
- ☐ Shuttle System, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

Other

Select at least one of the following CMPs.

Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Application Efficiencies, _____ ac
- ☐ Bulk Materials Control
- ☐ Integrated Pest Management (IPM), _____ ac
- ☐ Irrigation Power Units
- ☐ Mulching, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ Night Farming, _____ ac
- ☐ No Burning, _____ ac
- ☐ Surface Roughening, _____ ac
- ☐ Transgenic Crops, _____ ac
- ☐ Wind Barrier, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

CMP Plan

San Joaquin Valley Air Pollution Control District
Supplemental Application Form

Conservation Management Practices: DRY BEANS, CEREAL GRAINS, SAFFLOWER, WHEAT, AND BARLEY

Farm Name: ______________________ CMP Plan Years: __________ to __________

Maximum Crop Acreage: __________

Fallow Acreage Last Planted in Dry Beans, Cereal Grains, Safflower, Wheat, or Barley: __________

Land Preparation/ Cultivation

Select at least one of the following CMPs.
Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Bed/Row Size or Spacing, _____ ac
- ☐ Chemigation/Fertigation, _____ ac
- ☐ Combined Operations, _____ ac
- ☐ Conservation Irrigation, _____ ac
- ☐ Conservation Tillage, _____ ac
- ☐ Equipment Change/Tech. Improvements, _____ ac
- ☐ Mulching, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ Night Farming, _____ ac
- ☐ Precision Farming (GPS), _____ ac
- ☐ Transgenic Crops, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

____

____

____

Harvest

Select at least one of the following CMPs.
Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Baling/Large Balers, _____ ac
- ☐ Combined Operations, _____ ac
- ☐ Equipment Change/Tech. Improvements, _____ ac
- ☐ Green Chop, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ Night Harvesting, _____ ac
- ☐ Shuttle System, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

____

____

____

Other

Select at least one of the following CMPs.
Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Application Efficiencies, _____ ac
- ☐ Baling/Large Balers (crop residue), _____ ac
- ☐ Bulk Materials Control
- ☐ Multiple CMPs in Another Category
- ☐ Conservation Irrigation, _____ ac
- ☐ Integrated Pest Management (IPM), _____ ac
- ☐ Irrigation Power Units
- ☐ Mulching, _____ ac
- ☐ No Burning, _____ ac
- ☐ Surface Roughening, _____ ac
- ☐ Transgenic Crops, _____ ac
- ☐ Wind Barrier, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

____

____

____

CMP Plan

San Joaquin Valley Air Pollution Control District
Supplemental Application Form

Conservation Management Practices: NUT CROPS

Farm Name: ______________________ CMP Plan Years: __________ to __________

Crop Acreage: __________

Land Preparation/ Cultivation	Select at least one of the following CMPs. Note: 100% of the total crop acreage must be covered by the selected CMPs. ☐ Chemigation/Fertigation, _____ ac ☐ Combined Operations, _____ ac ☐ Conservation Irrigation, _____ ac ☐ Conservation Tillage, _____ ac ☐ Cover Crop, _____ ac ☐ Equipment Change/Tech. Improvements, _____ ac ☐ Floor Management, _____ ac ☐ Integrated Pest Management (IPM), _____ ac ☐ Multiple CMPs in Another Category ☐ Night Farming, _____ ac ☐ Non-Tillage/Chemical Tillage, _____ ac ☐ Precision Farming (GPS), _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above: ____________
Harvest	Select at least one of the following CMPs. Note: 100% of the total crop acreage must be covered by the selected CMPs. ☐ Combined Operations, _____ ac ☐ Conservation Irrigation, _____ ac ☐ Equipment Change/Tech. Improvements, _____ ac ☐ Floor Management, _____ ac ☐ Multiple CMPs in Another Category ☐ Shuttle System, _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above: ____________
Other	Select at least one of the following CMPs. Note: 100% of the total crop acreage must be covered by the selected CMPs. ☐ Application Efficiencies, _____ ac ☐ Bulk Materials Control ☐ Cover Crop, _____ ac ☐ Grinding/Chipping/Shredding, _____ ac ☐ Integrated Pest Management (IPM), _____ ac ☐ Irrigation Power Units ☐ Multiple CMPs in Another Category ☐ No Burning, _____ ac ☐ Permanent Crop, _____ ac ☐ Reduced Pruning, _____ ac ☐ Surface Roughening, _____ ac ☐ Wind Barrier, _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above: ____________

CMP Plan

San Joaquin Valley Air Pollution Control District
Supplemental Application Form

Conservation Management Practices: SUGAR BEETS

Farm Name: ____________________ CMP Plan Years: ________ to ________

Maximum Crop Acreage: ________

Fallow Acreage Last Planted in Sugar Beets: ________

Land Preparation/ Cultivation	Select at least one of the following CMPs. Note: 100% of the maximum crop acreage must be covered by the selected CMPs. ☐ Bed/Row Size or Spacing, _____ ac ☐ Chemigation/Fertigation, _____ ac ☐ Combined Operations, _____ ac ☐ Conservation Irrigation, _____ ac ☐ Conservation Tillage, _____ ac ☐ Equipment Change/Tech. Improvements, _____ ac ☐ Multiple CMPs in Another Category ☐ Night Farming, _____ ac ☐ Precision Farming (GPS), _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above: ____________
Harvest	Select at least one of the following CMPs. Note: 100% of the maximum crop acreage must be covered by the selected CMPs. ☐ Equipment Change/Tech. Improvements, _____ ac ☐ Multiple CMPs in Another Category ☐ Shuttle System, _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above: ____________
Other	Select at least one of the following CMPs. Note: 100% of the maximum crop acreage must be covered by the selected CMPs. ☐ Application Efficiencies, _____ ac ☐ Bulk Materials Control ☐ Integrated Pest Management (IPM), _____ ac ☐ Irrigation Power Units ☐ Multiple CMPs in Another Category ☐ No Burning, _____ ac ☐ Surface Roughening, _____ ac ☐ Transgenic Crops, _____ ac ☐ Wind Barrier, _____ ac ☐ Other (approved on a case-by-case basis), _____ ac Please describe the specifics of the practice(s) chosen above: ____________

CMP Plan

San Joaquin Valley Air Pollution Control District
Supplemental Application Form

Conservation Management Practices: VEGETABLES, TOMATOES, MELONS, AND OTHER

Farm Name: ______________________ CMP Plan Years: __________ to __________

Maximum Crop Acreage: __________

Fallow Acreage Last Planted in Vegetables, Tomatoes, Melons, or Other: __________

Land Preparation/ Cultivation

Select at least one of the following CMPs.
Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Bed/Row Size or Spacing, _____ ac
- ☐ Chemigation/Fertigation, _____ ac
- ☐ Combined Operations, _____ ac
- ☐ Conservation Irrigation, _____ ac
- ☐ Conservation Tillage, _____ ac
- ☐ Equipment Change/Tech. Improvements, _____ ac
- ☐ Mulching, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ Night Farming, _____ ac
- ☐ Precision Farming (GPS), _____ ac
- ☐ Surface Roughening, _____ ac
- ☐ Transgenic Crops, _____ ac
- ☐ Transplanting, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

Harvest

Select at least one of the following CMPs.
Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Combined Operations, _____ ac
- ☐ Equipment Change/Tech. Improvements, _____ ac
- ☐ Hand Harvesting, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ Night Harvesting, _____ ac
- ☐ Shed Packing, _____ ac
- ☐ Shuttle System, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

Other

Select at least one of the following CMPs.
Note: 100% of the maximum crop acreage must be covered by the selected CMPs.

- ☐ Application Efficiencies, _____ ac
- ☐ Bulk Materials Control
- ☐ Integrated Pest Management (IPM), _____ ac
- ☐ Irrigation Power Units
- ☐ Mulching, _____ ac
- ☐ Multiple CMPs in Another Category
- ☐ No Burning, _____ ac
- ☐ Surface Roughening, _____ ac
- ☐ Wind Barrier, _____ ac
- ☐ Other (approved on a case-by-case basis), _____ ac

Please describe the specifics of the practice(s) chosen above: ______________________

CMP Plan

San Joaquin Valley Air Pollution Control District
Supplemental Application Form

Conservation Management Practices: UNPAVED ROADS AND UNPAVED VEHICLE/ EQUIPMENT AREAS FOR CROPS

Farm Name: ____________________ CMP Plan Years: ________ to ________

Unpaved Road Mileage: ________ Unpaved Vehicle/Equipment Areas Acreage: ________

Unpaved Roads

If daily vehicle trips are ≥ 75 on unpaved roads, select at least one of the following controls (Reg. VIII compliance).

- ☐ Dust Suppressant, _____ mi
- ☐ Paving, _____ mi
- ☐ Road Mix, _____ mi
- ☐ Road Oil, _____ mi
- ☐ Washed Gravel, _____ mi
- ☐ Water, _____ mi
- ☐ Other (approved on a case-by-case basis), _____ mi

Please describe the specifics of the practice(s) chosen above: ____________________

____

____

____

If daily vehicle trips are < 75 on unpaved roads, select at least one of the following controls (CMP compliance).

- ☐ Chips/Mulches, _____ mi
- ☐ Less Than 10 Vehicle Trips on Any Day, _____ mi
- ☐ Mechanical Pruning, _____ mi
- ☐ Organic Materials, _____ mi
- ☐ Paving, _____ mi
- ☐ Polymers, _____ mi
- ☐ Restricted Access, _____ mi
- ☐ Road Oil, _____ mi
- ☐ Sand, _____ mi
- ☐ Speed Limit Posted, _____ mi
  What Speed? _____ mph (must be ≤ 25 mph)
- ☐ Track Out Control, _____ mi
- ☐ Water, _____ mi
- ☐ Washed Gravel, _____ mi
- ☐ Wind Barrier, _____ mi
- ☐ Other (approved on a case-by-case basis), _____ mi

Please describe the specifics of the practice(s) chosen above: ____________________

____

____

____

Appendix B

CMP Emissions Reduction Methodologies

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Dairies and Feedlots CMPs

Description of CMPs under the CMP Category Manure Handling

Fugitive particulate matter (PM) emissions in animal feeding operations originate from feed, bedding material, and manure, and can depend on several factors such as stocking density, and feeding methods. Emissions result from the disturbance of dry and loose surface caused by animal movement and mechanical disturbances by the tires and vehicle.

a. Sprinkle or Sprinkling of Open Corral

The practice "Sprinkle" or "Sprinkling of Open Corral" means to ensure adequate surface moisture level by sprinkling water on the open corral/pen. It can be achieved by using a mobile sprinkler or fence line sprinkler, or installing other watering devices. This control method is not recommended on areas used by lactating cows.

For this area of the facility, emissions result from the disturbance of dry and loose surface caused by animal movement. For example, the top layer of an open corral or pen becomes dusty as it dries, and when animals walk on it to go to the feed bunk, drink water, or do other things, the dust particles become suspended in the air by hoof action. By sprinkling water on the surface, it adds moisture and improves soil compaction. It is one of the methods used by most operators in controlling dust in a beef feedlot situation[1].

There are concerns with odor and flies when moisture increases. Moisture content is the primary factor for dust and odor[2]. At low moisture content, dust dominates over odor. At high moisture content, the opposite happens. Therefore, minimizing both dust and odor by moisture management alone is impossible. However, several researchers found that when moisture content of the open lot surface is between 25% and 40%, both dust and odor are at manageable levels[2]. Fly control is a concern that will influence the suitability of this method. Higher moisture levels provide better habitat for flies.

b. Frequent Scraping and/or Manure Removal

The practice "Frequent Scraping and/or Manure Removal" involves removal of manure from the open corral/pen. For this area of the facility, emissions result from the disturbance of the dry and loose surface caused by animal movement and mechanical disturbance by the tires and vehicle.

This practice prevents build-up of powdery dust from materials deposited in designated areas, involves removals of manure to another storage location, and decreases surface area of powdery dust. It minimizes the amount fugitive PM emissions caused by animal's hoof action by maintaining minimal amount of dry dust on corral surface. The frequency of removal will depend on the individual facility and current management.

One ideal management suggested by researchers is keeping the surface firm and hard between one to three inches of dry manure, but preferably less than one inch[2]. Keeping the dusty manure depth less than one inch above the ground, and therefore keeping the corral surface thin and well compacted reduces PM emissions.

c. Fibrous Layer in Working/Dusty Areas

The practice "Fibrous Layer in Working Areas" or "Fibrous Layer in Dusty Areas" means to add fibrous or damp material to these areas. Emissions result from the disturbance of the dry and loose surface caused by animal movement.

This practice prevents fugitive dust disturbance and entrainment by retaining moisture longer. This practice is more applicable to areas that heifers occupy. For example, it can be achieved by adding wood chips, dry separated manure solids, or other materials to sorting alleys and high traffic areas to hold moisture and keep down dust disturbance. Another example is to put damp manure solids right off of the separator into the heifer pens on a daily basis and working it with a rotary harrow. This keeps the more fibrous materials at the surface and the finer below, enabling the fibrous layer to trap the finer particles.

d. Pull-Type Manure Harvesting Equipment

The practice "Pull-type Manure Harvesting Equipment" involves using a pull-type piece of equipment to leave an even corral/pen surface. For this area of the facility, emissions result from the disturbance of the dry and loose surface caused mechanical disturbance by the tires and vehicle.

An even surface can be achieved with a piece of equipment that allows operators to leave it leveled evenly with compacted manure on top of soil. Pulling blades will do better than pushing blades[2]. It is physically more difficult to ensure that a pushed scraper blade (e.g.: front loader) leaves an even, smooth surface than a pulled blade (e.g.: box scraper). A pull-type equipment stabilizes soil surface by avoiding floor depressions for dust accumulation and accumulation of dry soil/manure.

e. Shade for Animal/Shaded Areas in Open Corral

The practice "Shade for Animal" or "Shaded Areas in Open Corrals" involves providing shades for the animals to loaf in. For this area of the facility, emissions result from the disturbance of the dry and loose surface caused by animals.

By providing shades, it allows the animals to stay in shaded areas together, thus increasing stocking density under the shades, which in turn, increases the moisture content of the surface, and thereby reduces dust emissions.

f. Freestall Housing (Dairies only)

The practice "Freestall Housing" means to use freestall housing. For this area of the facility, emissions would otherwise result from the disturbance of dry and loose corral surface caused by animal movement.

Having a concrete floor eliminates having a dry, loose surface, thus eliminating fugitive PM. It also allows for manure deposition to be cleaned through a flushing system. The manure would already be in a high moist state at that stage. The practice may also be practical for dry cows and heifers.

g. Scraping/Harrowing (Dairies only)

The practice "scraping and harrowing" means to scrape and harrow manure in morning hours when moisture and humidity is higher.

This practice is to scrape/harrow manure during cooler times of the day such as morning or evening and during times of low wind. It would help reduce the amount of particulate matter released in the air. For this case, emissions result from the disturbance of the materials.

Description of CMPs under the CMP Category Feeding

a. Bulk Material Control

The practice "Bulk Material Control" involves minimizing visible entrained particulate matter emissions from bulk materials.

Uncovered or unprotected bulk material can become a source of windblown dust. To reduce these types of emissions, protection can be achieved by applying suppressants (e.g.: water, chemical, organic), providing coverage (e.g.: tarps, plastic), and providing wind barriers (e.g.: fences, 4-sided structure).

For example, dry loose feed can be stored inside a commodity barn and bedding and dry manure can be covered with a tarp or a crust. Depending on the types of bulk, a significant increase in temperature may occur based on moisture content due to microbial heat production when stacked for storage. So, caution should be taken.

b. Feeding Near Dusk

The practice "Feeding near dusk" involves feeding young stock (not applicable to milking cows) during evening hours. For this area of the facility, emissions result from the disturbance of the dry and loose surface caused by animals.

This practice is thought to minimize animal behaviors that cause fugitive PM emissions. For example, young stock at dairies tend to play when temperature cools off. By feeding them at a later time breaks that activity pattern[2].

There is a study performed by Morrow-Tesch that evaluated discouraging end-of-day spike in livestock activity[2]. The preliminary data suggested that a delay of the last feeding of the day reduces cattle activity in the late afternoon or early evening. Thus, there is less surface disturbance caused by animal movement. This practice is still in an experimental stage but provides a starting concept.

c. Wet Feed During Mixing & Place Wet Material in Feed Wagon First Before Mixing

The practice "Wet Feed During Mixing" means to add water, high moisture feedstuffs, or moist supplements to the feed when preparing the total mixed ration (TMR).

The practice "Place Wet Material in Feedwagon First Before Mixing" is self-explanatory. Placing wet material first suppresses dust generation when mixing is initiated. Caution in recommending this practice is advised as wet feeds placed into the mixer equipment first may not be sufficiently captured by the mixing system and fail to be properly blended with the rest of the ration.

For these situations, emissions result from the preparation of feed by mechanical mixing. Added moisture to the feed assists in reducing the amount of generated dust.

d. Downwind Shelterbelts/Boundary Trees

The practice "Downwind Shelterbelts/Boundary Trees" involves establishing a boundary that disrupts the erosive flow of wind over unpaved roads and areas. Wind barrier reduces the particulate matters emissions typically stirred up in the process due to winds.

The effectiveness of a barrier depends on the height, density, orientation, and length. For instance, it was found that wind barrier reduces wind speeds up to 30 times their height downwind[3], and that the sheltered area is defined as ten times the height on the leeward side and two times the height on the windward side of the barrier[4]. The maximum benefit of using this practice is when the barriers are perpendicular as possible to the prevailing wind direction.

Examples of barrier are continuous board fences, trees, shrubs, conifers, burlap fences, crate walls, bales of hay, etc. A basic requirement is to have a continuous row of barriers. The longer it is, the better protection it provides. Barrier also helps to dissipate odor around corrals, manure stockpiles, and lagoons.

The Natural Resources Conservation Service has a conservation practice that addresses reducing soil erosion from winds and already has developed recommendations on the specifics of wind barrier labeled as windbreak or shelterbelt in their documents. Further information on designs such as types of windbreak and spacing can be found in their practice standard documents[4].

Emission Factor

The California Air Resources Board compiled several emission factors for livestock. The emission factor is 6.7 lbs/1000/head/day for dairy cattle and 28.9 lbs/1000/head/day for feedlot cattle. The development of the emission factors is described in ARB's methodology[5] for Emission Inventory Source Category Section 7.6. The emission factors were based on research studies conducted by the University of California, Davis, and Texas A&M[5].

The San Joaquin Valley Air Pollution Control District (District) evaluated these emission factors and estimated a break down of the emission factors for each CMP category; see Tables 1 and 2. Please refer to Attachment A for staff evaluation of emissions factors.

Control Efficiency

No data could be found in the literature search on which to base a control efficiency factor for these practices. The District has conservatively assumed a minimal 10% control effectiveness. As information becomes available, it will be added to this methodology. Additional air quality benefits and control effectiveness of these practices would have to be further evaluated through research studies and literature search.

Table 1: Control factors and efficiencies for Dairy Cattle

CMP Category	Emission Factor[9]	Control Efficiency (%)
Corral/Manure Handling	1.845 lbs/head-yr (freestall) 4.6 lbs/head-yr (open corral)	10
Overall Management/Feeding	1.845 lbs/head-yr (freestall) 4.6 lbs/head-yr (open corral)	10
Unpaved Road	0.369 lbs/head-yr	See Table 3
Unpaved Area	0.123 lbs/head-yr	See Table 3

Table 2: Control factors and efficiencies for Feedlot Cattle

CMP Category	Emission Factor[9]	Control Efficiency (%)
Pens/Manure Handling	7.94 lbs/head-yr	10
Overall Management/Feeding	0.53 lbs/head-yr	10
Unpaved Road	1.59 lbs/head-yr	See Table 3
Unpaved Area	0.53 lbs/head-yr	See Table 3

Emission Reduction Calculation for an Agricultural Operation Parcel

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left(\text{Animal Heads} \times \text{ Emission Factor}_{(\text{lbs/head-yr})} \times \text{Control Efficiency}_{(\%)}\right)}{2000_{(\text{lbs/ton})}}$$

Where:

Animal Head = the number of animals on the agricultural operation parcel

Emission Factor = PM10 emission factor (CMP Category specific), see Table 1 or 2

Control Efficiency = CMP efficiency to reduce emissions, 10% or Table 3

Example for a facility containing 900 dairy cattle:

$$\text{Emission Reduction} = \frac{\left(900 \times 1.845_{(\text{lbs/head-yr})} \times 10_{(\%)}\right)}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

Sources of Information

1. Brent W. Auverman et al. Manure Harvesting Frequency: The Key to Feedyard Dust Control in a Summer Drought. E-52. 2000. Texas Agricultural Extension Service.

2. Lesson 42: Controlling Dust and Odor from Open Lot Livestock Facilities. Brent Auvermann (Texas A&M University), California Dairy Quality Assistance Program

3. Mike Kuhns. Windbreak Benefits and Design. Utah State University Extension. June 1998.

4. Natural Resources Conservation Service Conservation Practice Standard.

5. California Air Resources Board, *Section 7.6—Livestock Husbandry*. Methods for Assessing Area Source Emissions. May 2004.

6. Desert Research Institute, *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Final Report. . Prepared for the California Regional Particulate Air Quality Study. December 1996.

7. Air Quality Group, Crocker Nuclear Laboratory, *Evaluation of the Emission of PM10 Particulates from Unpaved Roads in the San Joaquin Valley*, Final Report. University of California, Davis. Prepared for San Joaquin Valley Air Pollution Control District. April 1994.

8. San Joaquin Valley Air Pollution Control District, *Reference 12: Detailed Documentation for Fugitive Dust and Ammonia Emission Inventory Changes for the SJVUAPCD Particulate Matter SIP*, for SJVUAPCD 2003 PM10 Plan. June 2003.

9. San Joaquin Valley Air Pollution Control District. *Evaluation of PM10 Emission Factors For AFO CMPs.* September 2005.

10. San Joaquin Valley Air Pollution Control District, *Appendix G: Exhibit C Supplemental BACM Analysis*, for SJVUAPCD 2003 PM10 Plan. December 2003.

Table 3: Unpaved Area and Road Control Efficiency[6,7]

CMP	Control Efficiency (%)
Appropriate Equipment/Vehicle[a]	20
Chips/mulch	33
Gravel[8]	46
Less than 10 VT	87 (unp. Rd) 60 (unp. Area)
Organic materials/vegetation	33
Paving	98
Polymers	80
Restricted access	10
Road oil*	76
Sand	33
Speed bumps[b]	81
Speed limit	58 (10mph) 42 (15mph) 3 (25mph)
Water	70
Wind barrier	30

*Note: The control efficiency is the average of DRI's and UC Davis' control efficiency for road oil.

(a) This one refers to using light/lighter type of vehicle to cause less soil disturbance from unpaved roads. Using information found in the 2003 PM10 Plan[10], it is assumed that an ATV with an average weight of 500 lbs can be used instead of a truck weighing 6,000lbs:

weight effect factor for 6,000 lbs= 1
weight effect factor for 500 lbs = 500/6000 = 0.08
Truck emissions at speed 15 mph:
2 lbs/vmt x 0.5792 speed effect x 1 weight effect factor x 1 wheel effect factor = 1.158 lbs/vmt

ATV emissions at speed 15 mph:
2 lbs/vmt x 0.5792 speed effect x 0.08 weight effect factor x 1 wheel effect factor = 0.93 lbs/vmt

Control Efficiency = 1 - (0.93-1.158) = 0.196 = 20%

(b) A speed bump would cause reduction in speed. Based on appendix[10] for the 2003 PM10 Plan, PM10 emissions and speed have a linear relation. It is assumed that speed due to speed bump can decrease from 25 mph to 5 mph thus:

Emission Factor = 2 lbs/VMT
baseline speed for this Emission Factor = 25.9 mph
Emission Factor for speed 5 mph = (2 lbs/VMT x 5 mph) / 25.9 mph = 0.38 lbs/VMT
CE= 1 - (0.38lbs/2lbs) = 0.81 = 81 %

Attachment A

EVALUATION OF PM10 EMISSION FACTORS FOR AFO CMPS

September 1, 2005

Prepared by: Sheraz Gill, Senior Air Quality Engineer

Dairy:

The Air Resources Board assigned an emission factor of 6.72 lbs PM10/1000 head/day to dairy cattle. This number has been converted on a single head basis and is shown below as the "*Overall Dairy EF*" of 2.46 lbs-head/year below. This emission factor has been apportioned among the CMP categories to address emissions from different sources of the facility.

Based on the study this emission was derived from it was determined that the emission factor was based on dairy facilities with freestall housing. Due to the similarity of housing for feedlot cattle and heifers, it was assumed that dairies with open corrals would generate more emissions than those with freestalls. Therefore, District staff assigned an emission factor of 4.6 lbs/head/year to account for dairy facilities with an open corral. The calculation for this emission factor is shown in the footnotes.

Overall Dairy EF:	2.46 lbs/hd-yr[1]
Unpaved Roads EF:	0.369 lbs/hd-yr[2]
Unpaved Equipment Areas EF:	0.123 lbs/hd-yr[3]
Feed EF:	0.123 lbs/hd-yr[4]
EF from Cows (Freestall):	1.845 lbs/hd-yr[5]
EF from Cows (Open Corral):	4.6 lbs/hd-yr[6]

[1] ARB – This emission factor includes emissions from the cows, feed, and emissions from the unpaved roads

[2] It will be assumed that 15% of the total dairy PM10 emissions are generated from the unpaved areas. Therefore, the emission factor from the unpaved areas = 2.46 lbs/hd-yr x 0.15 = 0.369 lbs/hd-yr

[3] It will be assumed that 5% of the total dairy PM10 emissions are generated from unpaved equipment areas. Therefore, the emission factor from the unpaved equipment areas = 2.46 lbs/hd-yr x 0.05 = 0.123 lbs/hd-yr

[4] It will be assumed that 5% of the total dairy PM10 emissions are generated from the feed areas. Therefore, the emission factor from the feed areas = 2.46 lbs/hd-yr x 0.05 = 0.123 lbs/hd-yr

[5] The emissions from the unpaved roads, unpaved equipment areas, and feed will be subtracted from the overall dairy PM10 EF in order to calculate the emissions from the dairy cows. Therefore, the EF from the dairy cows = 2.46 - 0.369 - 0.123 - 0.123 = 1.845 lbs/hd-yr

[6] The emission factor for open corral housing will be back calculated by using the emission factor from freestall housing and dividing it out by the control efficiency of the freestall housing. As calculated above, the emissions from the freestall housing is = 1.845 lbs/hd-yr. The PM10 control

Note: EF= emission factor

The CMPs under each CMP Category are as follows:

CMPs for Feed - Bulk Material Control, Feeding near Dusk, wet feed during mixing

CMPs for Cows - Sprinkling of open corral, Fibrous layer in dusty area, Freestall housing, Frequent scraping and/or manure removal, Pull-type manure harvesting, Scraping/harrowing, Shaded areas in open corral, Feeding near dusk, Downwind shelterbelts/boundary trees

CMP Formula for Cows

1. Sprinkling of open corral = # of cows x 1.845 lbs/hd-yr x Control Efficiency (CE)
2. Fibrous layer in dusty area = # of cows x 1.845 lbs/hd-yr x CE
3. Freestall housing = # of cows x 1.845 lbs/hd-yr x 0
4. Frequent scraping and/or manure removal = # of cows x 1.845 lbs/hd-yr x CE
5. Pull-type manure harvesting = # of cows x 1.845 lbs/hd-yr x CE
6. Scraping/harrowing = # of cows x 1.845 lbs/hd-yr x CE
7. Shaded areas in open corral = # of cows x 1.845 lbs/hd-yr x CE
8. Feeding near dusk = # of cows x 1.845 lbs/hd-yr x CE
9. Downwind shelterbelts/boundary trees = # of cows x 1.845 lbs/hd-yr x CE

CMP Formula for Feed

10. Bulk material control = # of cows x 0.123 lbs/hd-yr x CE
11. Wet feed during mixing = # of cows x 0.123 lbs/hd-yr x CE
12. Place wet material in feedwagon first before mixing = # of cows x 0.123 lbs/hd-yr x CE

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efficiency for freestall housing is approximately 60%. Therefore, the EF for open corral housing is = 4.6 lbs/hd-yr.

Feedlot:

The Air Resources Board assigned an emission factor of 28.9 lbs PM10/1000 head/day for feedlot cattle. This number has been converted on a single head basis as well and is shown below as *"Overall Feedlot EF"* of 10.59 lbs/head/year. It is also apportioned among the CMP categories to address emissions from different sources of a facility.

Overall Feedlot EF:	10.59 lbs/hd-yr[7]
Unpaved Roads EF:	1.59 lbs/hd-yr[8]
Unpaved Equipment Areas EF:	0.53 lbs/hd-yr[9]
Feed EF:	0.53 lbs/hd-yr[10]
EF from Cattle:	7.94 lbs/hd-yr[11]

The CMPs under each CMP Category are as follows:

CMPs for Feed - Bulk Material Control, Feeding near Dusk, wet feed during mixing

CMPs for Cows - Sprinkling of open corral, Fibrous layer in dusty area, Frequent scraping and/or manure removal, Pull-type manure harvesting, Shaded areas, Feeding near dusk, Downwind shelterbelts/boundary trees

CMP Formula for Cows

13. Shade for Animal = # of cows x 7.94 lbs/hd-yr x CE

[7] ARB – This emission factor includes emissions from the cows, feed, and emissions from the unpaved roads

[8] It will be assumed that 15% of the total feedlot PM10 emissions are generated from the unpaved areas. Therefore, the emission factor from the unpaved areas = 10.59 lbs/hd-yr x 0.15 = 1.59 lbs/hd-yr

[9] It will be assumed that 5% of the total feedlot PM10 emissions are generated from unpaved equipment areas. Therefore, the emission factor from the unpaved equipment areas = 10.59 lbs/hd-yr x 0.05 = 0.53 lbs/hd-yr

[10] It will be assumed that 5% of the total feedlot PM10 emissions are generated from the feed areas. Therefore, the emission factor from the feed areas = 10.59 lbs/hd-yr x 0.05 = 0.53 lbs/hd-yr

[11] The emissions from the unpaved roads, unpaved equipment areas, and feed will be subtracted from the overall feedlot cattle PM10 EF in order to calculate the emissions from the cows. Therefore, the EF from the feedlot cattle = 10.59 – 1.59 - 0.53 - 0.53 = 7.94 lbs/hd-yr

14. Sprinkle = # of cows x 7.94 lbs/hd-yr x CE

15. Fibrous layer in working areas = # of cows x 7.94 lbs/hd-yr x CE

16. Frequent scraping and/or manure removal = # of cows x 7.94 lbs/hd-yr x CE

17. Pull-type manure harvesting = # of cows x 7.94 lbs/hd-yr x CE

18. Feeding near Dusk = # of cows x 7.94 lbs/hd-yr x CE
19. Downwind shelterbelts/boundary trees = # of cows x 7.94 lbs/hd-yr x CE

<u>CMP Formula for Feed</u>

20. Bulk material control = # of cows x 0.53 lbs/hd-yr x CE

21. Wet feed during mixing = # of cows x 0.53 lbs/hd-yr x CE

22. Place wet material in feedwagon first before mixing = # of cows x 0.53 lbs/hd-yr x CE

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Poultry CMPs

Description of CMPs under the CMP Category Manure Handling

Fugitive particulate matter (PM) emissions in poultry operations originates from feed, bedding material, manure/litter, and can depend on several factors such as animal activity, and feeding methods.

a. Time of Manure Spreading

The practice "Time of Manure Spreading" involves spreading the manure at a time that would help reduce the amount of particulate matter released in the air. It is preferable to spread it during cooler times of the day such as morning or evening and during times of low wind. For this case, emissions result from the disturbance of the materials.

There are concerns with odor when moisture increases. Moisture content is the primary factor for the level of dust and odor[1]. At low moisture content, dust dominates over odor. At high moisture content, the opposite happens. Therefore, minimizing both dust and odor by moisture management alone is impossible. However, several researchers found that when moisture content of the open lot surface is between 25% and 40%, both dust and odor are at manageable levels[1]. Therefore, doing that activity around that moisture content would assist in reducing the amount of fugitive PM emissions.

b. Cleanout Frequency

The practice "Cleanout Frequency" is to adjust the frequency of house cleanouts. It is to allow bedding materials and manure to remain in the house for multiple flocks or grow cycles, or to decrease the frequency of house cleanouts to minimize dust emissions.

This practice reduces particulate matters released from poultry litter/manure accumulating or stored inside houses. The less disturbance and handling of the litter/manure, the less emissions there are. Any time poultry bedding material is moved, some of the bulk material may become airborne. The bedding may be used for several grow out cycles before it becomes so laden with waste that it is unsuitable for continued use. Optimizing the reuse of the bedding material can reduce the number of material transfers, thus the opportunity for some of the material to become airborne.

c. Outdoor Storage

The practice "Outdoor Storage" is the use of a structure design to store bulk materials (e.g.: used poultry litter/manure, bedding material) or to securely cover bulk materials with tarps, plastics, or suitable materials if it must be stored outdoors not within any enclosure.

Poultry litter consists mainly of light organic materials such as rice hulls or wood shavings. During a poultry house cleanout the used litter is scrapped out of the house and left in piles outdoors. If left in these outdoor piles for extended periods, winds can cause material to become airborne. Any technique that can shield the litter from wind will prevent or reduce the amount of material becoming airborne. Securely tarping the piles will protect the used litter from precipitation and windblown dispersal until the litter can be removed from the ranch. A partially enclosed structure, with walls situated in the prevailing wind direction, may be used to protect used litter stored onsite from precipitation and windblown dispersal.

Description of CMP under the CMP Category Feeding

Boot or Sock

The practice "Boot or Sock" is to employ one of them when loading feed into the feed storage bins. They're a short piece of flexible material surrounding the open-end of the pipe of the delivery truck. In this case, boot or sock provides a coverage that minimizes the potential for PM emissions to be blown back into the air due to air current or entrained by winds.

Description of CMPs under the CMP Category Open Areas

a. Vegetation

"Vegetation" involves allowing and maintaining some sort of vegetation such as native grasses on vacant section of the operation.

Since emissions come from the soil being disturbed, vegetation acts as a cover crop that provides protection from wind erosion by shielding the soil with vegetation and anchoring the soil with roots. This reduces windblown particulate matter emissions from soil erosion.

b. Dust Suppressants

The practice "Dust Suppressants" refers to applying nontoxic chemical or organic dust suppressant as a control measure on open areas to reduce entrainment of fugitive particulate matter (PM) when wind/vehicle pass over the open area surface. These control measures must be those that are not prohibited for use by any applicable regulation and also must meet any specification required by any federal, state, or local water agency.

Because PM emissions result from the mechanical disturbance of soil by the tires and vehicle and soil erosion due to winds, they can be reduced by changing the surface of the road either with "wet suppression" or "chemical stabilization"[2]. Wet suppression keeps the road surface wet to control emissions. Chemical stabilization tries to change the physical characteristics of the surface.

For example, road oil forms a coat over dust particles forming a hard crust and also improves the cohesive resistance of road material. It usually can be applied once every two to three months and re-applied several times per year to maintain its efficiency. Other types of dust suppressant have a high water content to dilution ratio that allows the water to evaporate once applied to the soil and the non-water solution bonds to the fine soil particles making them into larger particles. Thus making those particles less susceptible to being entrained. Other ones draw moisture from the environment that acts to keep road surfaces moist, thus holding dust down.

c. Reduced Tillage

The practice "Reduced Tillage" involves reducing the number of tillage on open areas either through chemical or mechanical means with very minimal soil tillage. With less soil disturbance, there are less PM10 emissions.

Examples are hand-weeding or using a flail mower that cuts the plants instead of using an implement that would actually till the soil. Also in general, this practice reduces soil compaction and stabilizes soil through elimination or reduction of soil tillage passes thus reducing wind erosion.

d. Windblocks

The practice "Windblocks" involves establishing a boundary that disrupts the erosive flow of wind over unprotected land. Wind barrier reduces the particulate matters emissions typically stirred up in the process caused by winds.

The effectiveness of a barrier depends on the height, density, orientation, and length. For instance, it was found that wind barrier reduces wind speeds up to 30 times their height downwind[3], and that the sheltered area is defined as ten times the height on the leeward side and two times the height on the windward side of the barrier[4]. The maximum benefit of using this practice is when the barriers are perpendicular as possible to the prevailing wind direction.

Examples of barrier are continuous board fences, trees, shrubs, conifers, burlap fences, crate walls, bales of hay, etc. A basic requirement is to have a continuous row of barriers. The longer it is, the better protection it provides.

The Natural Resources Conservation Service has a conservation reserve program that addresses reducing soil erosion from winds and already has developed recommendations on the specifics of wind barrier labeled as windbreak or shelterbelt in their documents. Further information on designs such as types of windbreak and spacing can be found in their practice standard documents[4].

There is research study that evaluated management practices to address wind erosion in the Northwest Columbia Plateau in Idaho/Washington/Oregon, an area with windblown dust problem. The study indicated that vegetative barriers can reduce wind erosion rates by up to 25 tons per acre per year as well as dust emissions[5].

Emission Factor and Control Efficiency

The San Joaquin Valley Air Pollution Control District (District) evaluated a study[6] conducted by Texas A&M and estimated an emission factor of 0.0213 lbs per head per year[7] based on that study research. No emission factor was assigned to the CMP Category Feeding because the emissions from the feeding system are not known[7].

No data could be found in the literature search on which to base control efficiency factors, but the District assumed that it is probably reasonable to estimate at minimal 10% control effectiveness. As information becomes available, the control efficiency factors will be adjusted. Additional air quality benefits and control effectiveness of these practices would have to be further evaluated through research studies and literature search.

Table 1: Control factors and efficiencies

CMP Category	Emission Factor	Control Efficiency (%)
Manure Handling and Storage	0.0213 lbs/hr-yr	10
Feeding	0	N/A
Open Areas	13.56 lbs/acre-yr	10
Unpaved Road	2 lbs/VMT	See Table 2
Unpaved Area	2 lbs/VMT	See Table 2

Emission Reduction Calculation for an Agricultural Operation Parcel

a. Manure Handling and Storage CMP Category

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left(\text{Animal Heads} \times \text{ Emission Factor}_{(\text{lbs/head-yr})} \times \text{Control Efficiency}_{(\%)}\right)}{2000_{(\text{lbs/ton})}}$$

Where:

Animal Heads	=	the number of animal heads on the agricultural operation parcel
Emission Factor	=	PM10 emission factor (CMP Category specific), see Table 1
Control Efficiency	=	CMP efficiency to reduce emissions, 10%

Example for a facility containing 120,000 broilers:

$$\text{Emission Reduction} = \frac{\left(120{,}000 \times 0.0213_{(\text{lbs/head-yr})} \times 10_{(\%)}\right)}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.13 \text{ tons/year}$$

b. Open Area CMP Category

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	acreage of open area for CMP
Emission Factor	=	windblown PM emission factor[11], 13.56 lbs/acre/year
Control Efficiency	=	CMP efficiency to reduce emissions, 10%

Example:

$$\text{Emission Reduction} = \frac{\left\lfloor 5_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 10_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left\lfloor 6.78_{(\text{lbs/yr})} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.003 \text{ tons/year}$$

c. Unpaved Roads and Unpaved Areas CMP Categories

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left(\text{Emission Factor}_{(\text{lbs/VMT})} \times \text{VMT}_{(\text{VMT/ acre})} \times \text{Acreage}_{(\text{acre/year})} \times \text{Control Efficiency}_{(\%)}\right)}{2000_{(\text{lbs/ton})}}$$

Where:

Emission Factor	=	2 lbs per VMT[12]
VMT	=	vehicle mile traveled, 0.4 VMT[7]
Acreage	=	total facility acreage
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 2

Example:

$$\text{Emission Reduction} = \frac{(2_{(\text{lbs/VMT})} \times 0.40_{(\text{VMT/acre})} \times 100_{(acre\,/\,year)} \times 87_{(\%)})}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{69.6_{(\text{lbs/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.0348_{(\text{tons/yr})}$$

Sources of Information

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6. Particulate Matter and Ammonia Emission Factors for Tunnel-Ventilated Broiler Houses in the Southern US, C.B. Parnell et al., ASAE. Vol. 46(4): 1203-1214. 2003

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11. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
12. California Air Resources Board, *Section 7.10a: SJV Private Unpaved Road Dust (SJV only) – Farm Roads.* Methods for Assessing Area Source Emissions. May 2004.

Table 2: Assigned Control Efficiency[8,9]

CMP	Control Efficiency (%)
Chips/mulch	33
Gravel[10]	46
Less than 10 VT	87 (unp. Rd) 60 (unp. Area)
Organic materials/vegetation	33
Paving	98
Polymers	80
Restricted access	10
Road oil*	76
Sand	33
Speed limit	58 (10mph) 42 (15mph) 3 (25mph)
Water	70
Wind barrier	30

*Note: The control efficiency is the average of DRI's and UC Davis' control efficiency for road oil.

Attachment A

EVALUATION OF PM10 EMISSION FACTORS FOR AFO CMPS

September 1, 2005

Prepared by: Sheraz Gill, Senior Air Quality Engineer

Poultry (Broilers and Layers):

The Air Resources Board has no emission factor assigned to poultry. Therefore based on the study[1], District staff assigned an emission factor of 0.0213 lbs/head/year.

Overall Poultry EF:	0.0213 lbs/hd-yr[1]
Open Area EF:	13.56 lbs-acre/yr[2]
Unpaved Roads EF:	2.0 VMT
Unpaved Equipment Areas EF:	2.0 VMT
Feeding EF:	0 lbs/hd-yr[3]

Note: EF= emission factor

The CMPs under each category are as follows:

CMPs for manure handling - Time of manure spreading, cleanout frequency, outdoor storage

CMPs for open areas - Vegetation, dust suppressants, reduced tillage, wind blocks

CMP Practices Formula for Poultry

1. Time of manure spreading = # of birds x 0.0213 lbs/hd-yr x Control Efficiency (CE)
2. Cleanout Frequency = # of birds x 0.0213 lbs/hd-yr x CE
3. Outdoor Storage = # of birds x 0.0213 lbs/hd-yr x CE

[1] Particulate Matter and Ammonia Emission Factors for tunnel-Ventilated broiler houses in the Southern US", R.E. Lacey, J.S. Redwine, C.B Parnell, Jr., ASAE. Vol. 46(4): 1203-1214. 2003.
[2] Based on windblown dust EF for agriculture cropland
[3] The emissions from the feeding system are not known. However, when feed is conveyed into the feed bins or silos, a boot or sock is used in all facilities to mitigate the emissions into the air. Therefore, any further reduction in emissions will be negligible.

CMP Practices Formula for Open Areas

1. Vegetation = 13.56 lbs-acre/yr x # of acres of open areas x CE
2. Dust suppressant = 13.56 lbs-acre/yr x # of acres of open areas x CE
3. Reduced Tillage = 13.56 lbs-acre/yr x # of acres of open areas x CE
4. Wind Blocks = 13.56 lbs-acre/yr x # of acres of open areas x CE

CMP Practices Formula for unpaved roads and equipment areas

Emissions reductions = 2.0 VMT x # of **TOTAL** acres of land x 0.4 VMT per acre per year[4] x CE

[4] The 0.4 VMT per acre per year is based on the alfalfa crop profile, since poultry operations don't have much traffic throughout the entire year. The main trips at a poultry facility consist of chicken and feed transport several times a year. Therefore, the use of the 0.4 VMT per acre is consistent with the alfalfa crop profile.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Alternate Till

Description

The practice "Alternate Till" involves tilling every other row. A grower may till alternate rows in the field to manage weed population or a cover crop instead of tilling every single row. Reducing particulate matter emissions from soil disturbance can be achieved by reducing the number of passes over the field. This practice allows passes for field cultivation to be reduced.

In addition, because row spacing may measure as wide as twelve feet wide in vineyards, for example, there is also the possibility of partially discing rows rather than the entire twelve feet. Another added benefit is the protection against windblown dust for a longer period from the rows that are not tilled.

With this concept, it is possible to estimate the number of field passes reduced using the emission factors developed by the California Air Resources Board (ARB), as well as the reduction in windblown dust.

Applicable Crops

This practice can be used for the crop category Grapes.

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and "Other".

Emission Factor

ARB compiled several emission factors for land preparation activities per crop type; refer to Table 1. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

ARB also developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[2]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12.

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated a 28% control efficiency factor for the CMP category "Land Preparation" and 32.5% under the CMP category "Other".

Tilling rows allows the soil to not become compacted by the time a grower prepares the ground to form terraces for the harvest season. Tilling alternate rows would reduce half of the soil disturbance. It is assumed that alternate row tilling would eliminate a discing pass needed to establish terraces.

Based on the number of discing passes identified by ARB, it is assumed that alternate tilling would eliminate half of a discing pass. This resulted in 28% control effectiveness. Please refer to Appendix B2 for the analysis.

A technical supporting document[3] regarding quantification of agricultural best management practices prepared for the Arizona Department of Environmental Quality provides a control efficiency of 66% based on the percent of surface cover. Although a surface cover may not be present in the rows not tilled, at least a stable surface would be present. With alternate tillage, it was also assumed that at least half of the ground will not be tilled thus not easily disturbed by the wind. Based on this information, a 32.5% (half of 66%) control effectiveness was estimated under the CMP category "Other" for preventing windblown dust.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\ \sum \left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\ \right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 1
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1\text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1\text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{(\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10\text{ tons/year}$$

2. **Option 2 (Use when the number of pass reduced is not available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor, 1.82 lbs/acre
Control Efficiency	=	CMP efficiency to reduce emissions, 28 %

Example for Grapes:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 1.82_{(\text{lbs/acre})} \times 28_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{50.96_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.03\text{ tons/year}$$

B. "Other" (windblown PM)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	windblown PM emission factor, 13.56 lbs/acre/year
Control Efficiency	=	CMP efficiency to reduce emissions, 32.5 %

Example:

$$\text{Emission Reduction} = \frac{\left\lfloor 100_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 32.5_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left\lfloor 440.7_{(\text{lbs/yr})} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.22 \text{ tons/year}$$

<u>Sources of Information</u>

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation.* Methods for Assessing Area Source Emissions. January 2003.
2. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
3. Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.

Table 1: Emission Factor[1] for Type of Land Preparation Operations

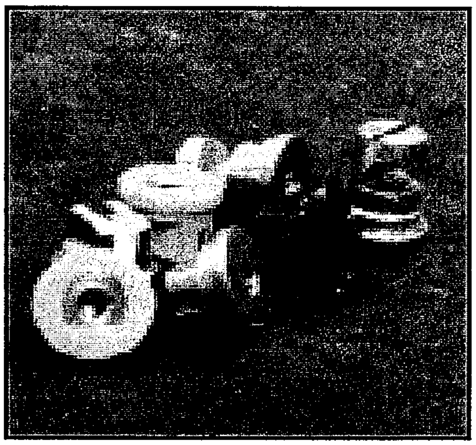
Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Application Efficiencies

Description

The practice "Application Efficiencies" is to use methods that conserve the amount of chemicals sprayed. These methods are based on the concept of making the application more efficient, thus reducing chemical usage but also spraying passes.



Reducing particulate emissions from soil disturbance can be achieved by reducing the number of passes over the field. However, this practice may not necessarily reduce the number of field passes but reduces the number of activities in the field by identifying and working with the specific areas of need, thus causing less soil disturbance.

Some examples are using spray equipment with low or concentrate volume quantity, micro-heads or infrared spot sprayers; electrostatic sprayers in closed area, aerial application, low volume sprayers, photosynthetic ID heads, and hand-spot spraying.

Applicable Crops

This practice can be used on all crops where it's feasible. These include the following crop categories:

- Corn/grain and silage,
- Cotton,
- Alfalfa,
- Vegetables, tomatoes, melons, and other
- Sugar beets,
- Dry beans, cereal grains, safflower, wheat, barley,
- Onions and garlic
- Nut crops

CMP Category

This practice is applicable to the CMP Category "Other".

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation activities per crop type; refer to Table 2. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies using ARB's information; see Table 1. It is assumed that applications over numerous small portion of the field or the entire field would equal to a field pass used to remove weeds (less soil disturbance than discing). Using the number and type of field passes identified by ARB, it was assumed that at least one weeding pass can be eliminated using this practice. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency
Alfalfa	8
Corn Grain and Silage	12
Cotton	9
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	14
Nut Crops	14
Onions and Garlic	12
Sugar Beets	4
Vegetables, Tomatoes, Melons, and Other	4

Emission Reduction Calculation

A. Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(2\text{ weeding passes} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08\text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Corn:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 1_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{69_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.035\text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.

Table 2: Emission Factors[1] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[1] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

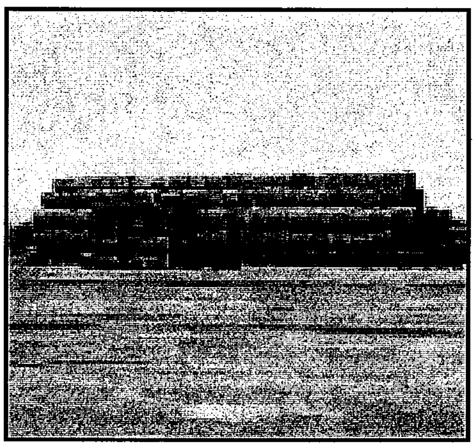
CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Baling/Large Balers

Description

The practice "Baling/Large Balers" means to bale the forage or use a larger bale size. This is applicable to the larger types of load that are baled and not to the smaller loads that can use some sort of shuttle/multiple-bin transportation system.

Straw bales come in all shapes and sizes, from small two-string bales to round or rectangular bales. Large square bales have become very popular across the country in the past ten years[1]. Part of the large square bale attraction is the fact that the operator has to handle fewer bales since a large square bale contains the equivalent of 20 to 40 small square bales. Another attraction is the ease of stacking them for transport. The typical size of a bale is 3x3x6 foot long.



For example, many growers are turning to baling instead of burning flax straw as there are alternative uses of it as in livestock bedding, windbreaks, or new fiber-based products like strawboard and paper[1]. This concept allows for burning to be eliminated and field passes to be reduced.

Applicable Crops

This practice can be used on the following crop categories where applicable: alfalfa, and grains (=Dry beans/cereal grains/safflower/wheat/barley).

CMP Category

This practice is applicable to these CMP Categories: Harvest and "Other".

Emission Factor

The California Air Resources Board compiled several emission factors for harvest activities per crop type; see Table 1. The development of the emission factors is described in ARB's Methodologies for Emission Inventory Source Category Section 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2].

Regarding agricultural burning, ARB compiled a list of emission factors per crop type based on AP-42 values and from a study conducted by B.M. Jenkins[3,4]. Fuel loading values from AP-42 are also associated with each emission factor. Some of the factors and values were adjusted as needed by the San Joaquin Valley Air Pollution Control District (District) to better reflect the conditions in the San Joaquin Valley[3].

Control Efficiency

The District estimated 11% control efficiency for the Crop Type Alfalfa and 26% for the Crop Type Grains. No data could be found in the literature search on which to base a control efficiency factor, but it is reasonable to assume that using large or larger balers will reduce about one-fourth of the field trips from harvesting operations and post-burn and/or stubble discing. The more traditional type of bales is the small square or rectangle shape. Larger bales (round or square) can equal to as much as 20 to 45 times the size of the small ones. The larger ones will be too heavy to be manually handled. Therefore, the bales could not be dropped on the ground to be picked up but would be stacked on a wagon following the balers and tractor. Thus, this would eliminate a field pass used to pick them up.

Also, it is reasonable to assume that using larger balers will reduce field trips during harvesting operations and post-burn and/or stubble discing. Eliminating these passes equal to about 92.46% of the operations. Please refer to Appendix B2 and Attachment A for staff evaluation of this control efficiency.

Emission Reduction Calculation for an Agricultural Parcel

Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor (crop specific), see Table 1
Control Efficiency	=	CMP efficiency to reduce emissions, 11% for alfalfa or 26% for grains

Example for Alfalfa:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 0.24_{(\text{lbs/acre})} \times 11_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 264_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.13 \text{ tons/year}$$

Sources of Information

1. Agrabilitiy Quaterly. October 2003, Vol. 4, No. 1.Assistive Technology-Making and Handling Hay Bales Has Gotten Easier. Retrieved September 24, 2004: http://www.agrabilityproject.org/newsletter/october_2003/3.cfm
2. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003
3. Patrick Gaffney, Emission Inventory Branch, California Air Resources Board, Draft Memorandum to Bill Sandman, Colusa County Air Pollution Control District. May 23, 2000.
4. Steve Shaw. " Ag burn emission factors." E-mail to Patia Siong. July 30, 2004.

Table 1: Emission Factors[2] for Harvest Operations

Crop Category	Harvest Emission Factor (lbs PM10/acre/year)
Alfalfa	0.24
Dry Beans, cereal grains, safflower, wheat, and barley	3.45

Attachment A

District staff performed this analysis to determine a control efficiency for the CMP "Baling/Large Balers" under the CMP Category "Other".

Baling is considered an alternative method to burning. Thus, using this CMP would eliminate burning. However, it could add at least two field passes, one for baling and one for hauling. Based on these assumptions, District staff estimated 92.46% control effectiveness.

<u>Calculation formula:</u>
Crop type: Emission Factor x Fuel Load = Emission Factor (lbs/acre)

Alfalfa: 28.5 x 0.8 = 22.8
Wheat: 10.6 x 1.9 = 20.14
Rice: 6.3 x 3 = 18.9
Safflower: 17.7 x 1.3 = 23.01
Average = (22.8 + 20.14 + 18.9 + 23.01) /4 = 21.21 lbs/acre

Using 100 acres = 21.21 x 100 acres = 2121 lbs/100 acres

Adding 2 passes to cut and bale and haul and assigning the Weeding emission factor of 0.8 lbs/acre to each pass:

100 acres x 0.8 lbs/acre x 2 passes = 160 lbs/100 acres

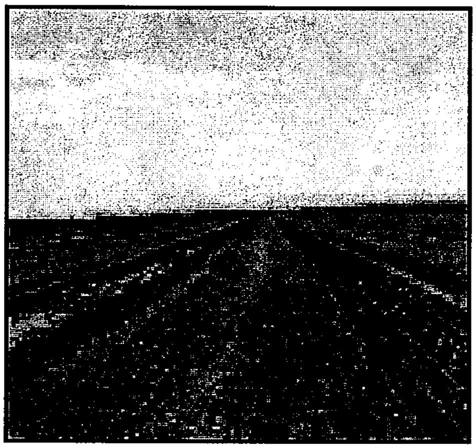
Control Efficiency = (2121-160) x 100 / 2121 = 92.46%

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Bed/Row Size or Spacing

Description

The practice "Bed/row size or spacing" means to increase or decrease the size of the planting bed area.



The emissions come from the soil being disturbed by tractors and their implements. Reducing emissions from soil disturbance can be achieved by reducing the number of passes over the field. Spacing adjustments reduce the number of passes and soil disturbances by increasing plant density through reduction of row width or increasing canopy such as converting to overhead vineyard production systems to contain particulate matter emissions within the canopy.

An example of increasing the bed size is planting multiple rows on a wide bed thus reducing two to three cultivation or weeding passes. An example of decreasing the bed size is using a vineyard system that creates an overhead to shade unwanted vegetation and reduce discing and passes for chemical treatment.

It is possible to estimate the emissions using California Air Resources Board (ARB) emissions factors and to estimate the emissions reduction from identifying the quantity and type of passes reduced or by using a control efficiency factor.

Applicable Crops

This practice can be used on the following crop categories where applicable:

- Corn/grain and silage,
- Cotton,
- Vegetables, tomatoes, melons, and other
- Sugar beets,
- Tree fruit,
- Grapes,
- Dry beans, cereal grains, safflower, wheat, barley,
- Onions and garlic.

CMP Category

This practice is applicable to the CMP Category Land Preparation.

Emission Factor

ARB compiled several emission factors for land preparation per crop type; see Table 2. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies in Table 1. There is the potential of reducing cultivation passes and soil disturbance. Two separate studies evaluated the effect of row spacing/planting. One[3] uses a system that evaluated double-row 30 inch-row cotton and found that cotton planted in double-rows versus single-row 30-inch bed could result in less cultivations, weed control, and irrigation ditch work. The other[4] evaluated row spacing for corn and found that higher density planting (twice the corn population planted versus standard population) suppresses weed population from 69% to 99%. Based on this information, it was assumed that one weeding pass was eliminated. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Tree fruit	9
Corn Grain and Silage	12
Cotton	9
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	14
Grapes	18
Nut Crops	14
Onions and Garlic	12
Sugar Beets	4
Vegetables, Tomatoes, Melons, and Other	4

Emission Reduction Calculation for an Agricultural Parcel

Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1 \text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1 \text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{(\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10 \text{ tons/year}$$

2. **Option 2 (Use when the number of pass reduced is not available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Corn:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 12_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{82.8_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.04 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
2. S. Darrel Mundy et a.l., *Chapter 8: Transplanting and Spacing*. n.d.
3. Ultra-narrow row cotton holds promise,Field Check, by the University of California Cooperative Extension and California Cotton Growers Association, August 2000
4. Influence of corn (Zea amys) population and row spacing on corn and velvetleaf (Abutilon theophrasti) yield, by Sustainable Agricultural Systems Laboratory-Teasdale Abstracts, at http://www.barc.usda.gov/anri/sasl/jrtabst.html, December 3, 2002.

Table 2: Emission Factors[1] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[1] for Land Preparation Operations

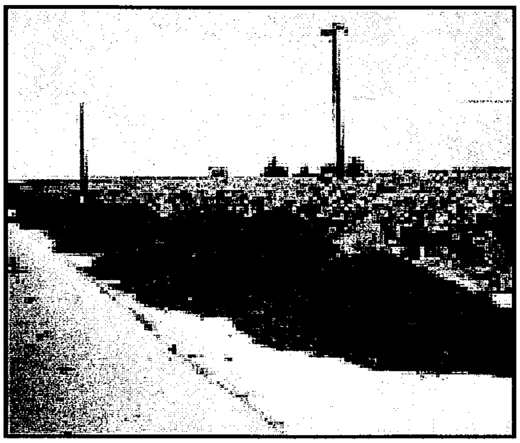
Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Bulk Material Control

Description

The practice "Bulk Material Control" involves minimizing visible entrained particulate matter emissions from bulk materials.



Uncovered or unprotected dry bulk materials can become a source of windblown dust. To reduce these types of emissions, protection can be achieved by applying dust suppressants (e.g.: water, chemical, organic), providing coverage (e.g.: tarps, plastic), or providing wind barriers (e.g.: fences, 4-sided structure).

Depending on the types of dry bulk material, a significant increase in temperature may occur based on moisture content due to microbial heat production when stacked for storage. So, caution should be taken.

The control effectiveness and additional air quality benefits of this practice would have to be further evaluated through research studies or literature search.

Applicable Crops and Animal Feeding Operations

This practice can be used for dairy and feedlot operations and all crops categories categories.

CMP Category

This practice is applicable to these CMP Categories "Other" and Overall Management/Feeding.

Emission Factor

Currently, there is no emission factor assigned to this source.

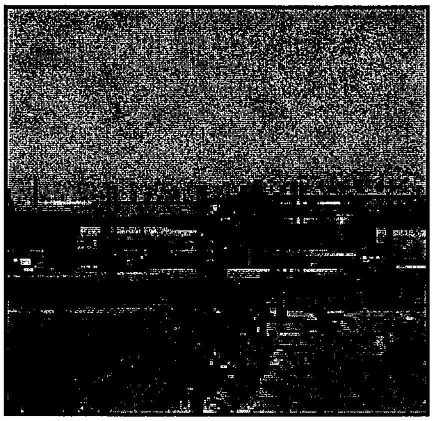
Control Efficiency and Emission Reduction Calculation

There is currently no control efficiency factor assigned to this practice. As information becomes available, it will be added to this methodology. There is no methodology for calculating the emissions reduction from implementing this CMP.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Chemigation/Fertigation

Description



The practice "Chemigation/Fertigation" means to incorporate chemical or fertilizer applications along with water through an irrigation system. This practice can also be extended to include the use of aerial applications. Each application reduces the need to travel in the field with tractors and sprayers for application purposes, thus reducing the number of passes and soil disturbances while increasing the efficiency of the application.

Chemigation is mostly used to apply liquid nitrogen fertilizer along with irrigation water. Insecticides, herbicides, nematicides, fungicides, growth regulators, and other fertilizer products also can be applied through the irrigation system[1].

Applicable Crops

This practice can be used on all crop categories.

CMP Category

This practice is applicable to the CMP Category "Land Preparation".

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation per crop type; see Table 2. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates several control efficiencies using ARB's information; see Table 1. It is reasonable to assume that, where feasible, the soil will be less disturbed since chemigation/fertigation application will be done through the irrigation system. Without chemigation/fertigation, field applications will be done driving through the field with sprayers. There can be two passes used for weed control and one pass for fertilizer. It is assumed that at least one weeding pass can be eliminated by replacing the use of sprayers with the irrigation system for each crop type. Please refer to Appendix B2 for the analysis.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Alfalfa	2
Citrus	9
Corn Grain and Silage	1
Cotton	9
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	7
Grapes	4
Nut Crops	31
Onions and Garlic	6
Sugar Beets	3.5
Vegetables, Tomatoes, Melons, and Other	2

Emission Reduction Calculation for an Agricultural Parcel

Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass = number of field passes reduced per acre per year

Emission Factor = emission factor for type of pass (operation specific), see Table 2

Acreage = parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(2 \text{ weeding passes} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

2. **Option 2 (Use when the number of pass reduced is not available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Vegetables:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 9.3_{(\text{lbs/acre})} \times 2_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{18.6_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.09 \text{ tons/year}$$

Sources of Information

1. Hal Werner. *Chemigation-Is it for you?* Irrigation Facts. April 2002.
2. California Air Resources Board, *Section 7.4—Agricultural Land Preparation.* Methods for Assessing Area Source Emissions. January 2003.

Table 2: Emission Factors[2] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[2] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/yr
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Combined Operations

Description

The practice "Combined Operations" means to combine pieces of equipment or operations to perform several operations during one pass over the field. The emissions come from the soil being disturbed by tractors and their implements.

Reducing emissions from soil disturbances can be achieved by reducing the number of passes over the field. One example is combining two practices such as cane cutting or discing, or flat furrowing into one single pass. This reduces soil disturbance with the elimination of passes.

It is possible to estimate the emissions using California Air Resources Board (ARB) emission factors and the reduction from combined operations using a study performed by Coates[1]. The control effectiveness of this practice would have to be further evaluated through research studies, quantitative analysis, or literature search.

Applicable Crops

This practice can be used on all crops where combined operations are feasible. These include the following crop categories: corn/grain and silage, cotton, alfalfa, vegetables/tomatoes, melons, sugar beets, tree fruit, grapes, dry beans/cereal grains/safflower/wheat/barley, onion/garlic, and nut crops.

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and Harvest.

Emission Factor

ARB compiled several emission factors for land preparation and harvest activities per crop type; see Tables 1 and 3. The development of the emission factors is described in ARB's Methodologies for Emission Inventory Source Category, sections 7.4 and 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis[2,3], and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts.

Control Efficiency

Based on Appendix B of a technical supporting document compiled by Arizona Department of Environmental Quality[1], the control efficiency is 35% for combining land preparation operations and 43% for harvest operations. Their assumptions are based on a 1994 study by Coates that identifies the total PM10 emissions generated for five different cotton tillage systems. Four of the systems evaluated combined shredding, discing, and mulching. A minimal control efficiency of 35% to a maximum 50% (average 43%) was determined to be possible. It was also assumed that the control efficiency is transferable to other crop types.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 1
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1\text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1\text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{(\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10\text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 2
Control Efficiency	=	CMP efficiency to reduce emissions, 35%

Example for Corn:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 35_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{241.5_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.12\ \text{tons/year}$$

B. Harvesting

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, 43%

Example for Corn:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 1.7_{(\text{lbs/acre})} \times 43_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left[73.1_{(\text{lbs/yr})}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.04\ \text{tons/year}$$

Sources of Information

1. Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.

2. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.

3. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003.

Table 1: Emission Factors[2] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 2: Emission Factors[2] for Land Preparation Operations

Crop Categories	Land Preparation Emission Factor (lbs PM10/acre/yr
Alfalfa	4
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

Table 3: Emission Factors[3] for Harvest Operations

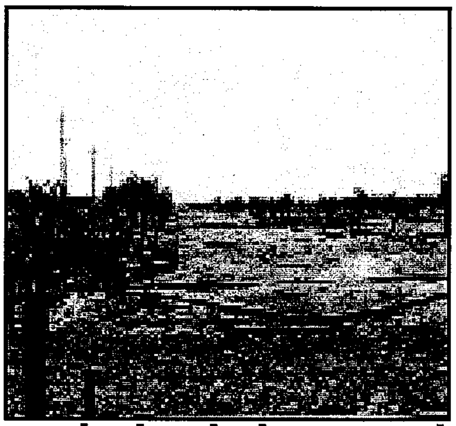
Crop Category	Harvest Emission Factor (lbs PM10/acre/yr)
Alfalfa	0.24
Corn grain and silage	0.43
Cotton	3.37
Dry Beans, cereal grains, safflower, wheat, and barley	3.45
Grapes	0.17
Nut crops	36.50
Onions and garlic	1.68
Tree Fruit	0.14
Sugar Beets	1.69
Vegetables, tomatoes, melons, and other	0.23

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Conservation Irrigation

Description

The practice "Conservation Irrigation" means to use a method to irrigate crops that conserves the quantity of water use. Choosing a watering scheme that is less disturbing to the land results in lower emissions because fewer activities and fewer field passes are required to return the land to a manageable state. Conserving water also reduces weed population, which in turn reduces the need for tillage.



Examples are the use of drip or buried line in crop production including permanent or semi-permanent line, water flow meters or soil monitoring devices to avoid over-irrigation such as pressure bombs, and evapotranspiration management (use of an automated watering system based on weather). The type of soil is a factor in deciding which irrigation system is best.

In addition, fields without any vegetation are one of the largest sources of windblown dust. Applying water to soil prevents it from eroding due to the wind because water allows large soil clods to form.

Applicable Crops

This practice can be used on all crop categories where feasible. These include the following crop categories: alfalfa, corn/grain and silage, cotton, vegetables/tomatoes/ melons, sugar beets, citrus, tree fruit, grapes, dry beans/cereal grains/safflower/wheat/barley, onion/garlic, and nut crops.

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and "Other"

Emission Factor

The Air Resources Board (ARB) compiled several emission factors for land preparation activities per crop type; see Table 2. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

ARB also developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[2]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12.

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies under the CMP category "Land Preparation" using ARB's information; see Table 1 below. It is reasonable to assume that conservation irrigation reduces at least one weeding field pass. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies under "Land Preparation"

Crop Category	Control Efficiency (%)
Alfalfa	6
Citrus and Tree Fruit	9
Corn Grain and Silage	12
Cotton	9
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	14
Grapes	18
Nut Crops	14
Onions and Garlic	12
Sugar Beets	4
Vegetables, Tomatoes, Melons, and Other	4

A technical supporting document[3] regarding quantification of agricultural best management practices prepared for the Arizona Department of Environmental Quality provides some control efficiencies based on the percent of surface cover. No additional data could be found in the literature search on which to base a control efficiency factor. Therefore based on this information, the District estimated a 10% control effectiveness under the CMP category "Other" for preventing windblown dust.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. Option 1 (Use when the number of pass reduced is available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1\text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1\text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{\ (\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10\text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Corn:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 12_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{82.8_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.04\text{ tons/year}$$

B. "Other" (windblown PM)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	windblown PM emission factor, 13.56 lbs/acre/year
Control Efficiency	=	CMP efficiency to reduce emissions, 10%

Example:

$$\text{Emission Reduction} = \frac{\left\lfloor 100_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 10_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left\lfloor 135.6_{(\text{lbs/yr})} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.0678 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
2. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
3. Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.

Table 2: Emission Factors[1] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[1] for Land Preparation Operations

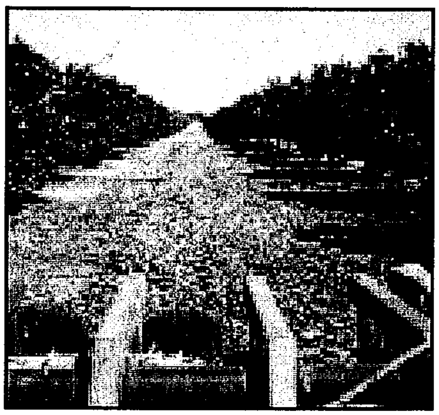
Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Conservation Tillage

Description

The practice "Conservation Tillage" involves using a system in which the soil is being tilled or cultivated to a lesser extent compared to a conventional system. It is intended to reduce primary soil disturbance operations such as plowing, discing, ripping, and chiseling.



The emissions come from the soil being disturbed by tractors and their implements. This system allows for passes to be reduced, therefore reducing PM10 emissions. For example, one type of tillage system involves leaving up to 30% of the soil covered with previous crop residue and continuing working with the soil in that state. Subsequent crops are planted in the same bed or growing area year after year. This eliminates numerous discing, plowing, and other field operations involved in the conventional tillage.

No-tillage, the strictest form of conservation tillage, uses no tillage of the soil except for minimal disturbance of the soil surface in the row during planting and in some cases during injection of fertilizers. The result is that 60% to 95% of the surface of a planted field is covered with crop residue from the previous season.

The USDA Natural Resources Conservation Service (NRCS) conducted a survey in 2002 to evaluate the usage of conservation tillage with 30% residue. The result indicated that less than one percent of row crop production acreage in California's Central Valley is currently using that type of conservation tillage[1].

The Cotton Research Station at Shafter, California, has conducted several studies, as did various other research centers around the country[1]. At present, the University of California Davis Cooperative Extension in Five points continues to examine soil, water, and air quality related to conservation tillage. Few research studies evaluated dust reduction only in terms of total suspended particulate matters. A 2002 research conducted by Julie Baker shows a direct relationship between the number of tractor passes and the amount of airborne particulate matter emissions[2]. Baker concluded that total dust concentrations were reduced from conservation tillage versus conventional tillage. No measurement of PM10 emissions was taken during that research.

Applicable Crops

This practice can be used for the following crop categories where applicable:

- Corn grain and silage
- Cotton
- Vegetables, tomatoes, melons, and other
- Sugar beets
- Tree fruit
- Grapes
- Dry beans, cereal grains, safflower, wheat, barley
- Onions, garlic
- Nut crops

CMP Category

This practice is applicable to the CMP Category Land Preparation.

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation activities per crop type; refer to Table 1. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[3].

Control Efficiency

A technical document written by the University of California Davis Cooperative Extension in Five Points[4] contains short reports from research studies that evaluate the number of passes reduced from a standard tillage system to conservation tillage system in addition to other savings. The number of passes reduced ranges from 1 to over 10 passes. Therefore based on this information, the San Joaquin Valley Air Pollution Control District estimated at minimum one discing pass to be eliminated. The control efficiencies are found in Table 1 below.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Tree fruit	9
Corn Grain and Silage	35
Cotton	28

Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	19
Grapes	26
Nut Crops	3
Onions and Garlic	11
Sugar Beets	3
Vegetables, Tomatoes, Melons, and Other	25

The District estimated 10% control effectiveness under the CMP category Harvest for Cotton. Please refer to Appendix B2 for the analysis on these control efficiencies.

Emission Reduction Calculation for an Agricultural Parcel

Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1 \text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1 \text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{\ (\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10 \text{ tons/year}$$

2. **Option 2 (Use when the number of pass reduced is not available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Corn:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 35_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{241.5_{(\text{lbs})}}{2000_{\;(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.12 \text{ tons/year}$$

Sources of Information

1. Jeffrey Mitchell et a.l., *Minimum Tillage Vegetable Crop Production in California*. University of California, Division of Agriculture and Natural Resources, Publication 8132. 2004.
2. Baker,J., R.J. Southard, and J.P. Mitchell, *Agricultural dust production in standard and conservation tillage systems in the San Joaquin Valley*. In Proceedings—Conservation tillage 2002: Research and farmer innovation conferences. Davis and Five Points, CA. September 17 and September 19, 2002
3. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
4. Agriculture and Natural Resources, University of California, *Conservation Tillage 2002: Research and Farmer Innovation Conferences, Highlighting Research and Farmer Innovation to Conservation Tillage in California*, University of California Cooperative Extension. September 2002.

Table 2: Emission Factors[3] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[3] for Land Preparation Operations

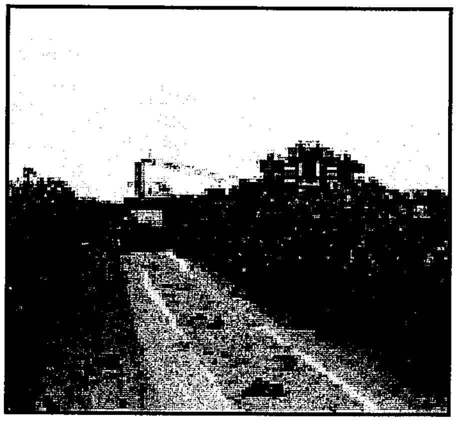
Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Continuous Tray/Dried-On-Vine

Description

The practice "Continuous Tray/Dried-On-Vine" is used to refer in general to raisin drying techniques.



Continuous tray involves a machine harvesting grapes and placing them to be dried on a continuous paper tray to dry. Dried-On-Vine (DOV) systems, in general, involve leaving the grapes on the vines, cutting the canes, and allowing the grapes to dry while still on the severed canes. Once the drying process is complete, the raisins are collected with machines. The DOV systems also can be used on existing trellis, retrofits and new plantings. The Overhead Horizontal Trellis system actually creates one full, continuous overhead canopy under which harvesting activities are performed, and does not involved ground preparation or use of paper tray. The systems can be used on existing vineyards, retrofit, or new plantings.

Particulate matters less than 10 microns in size (PM10) emissions reduction can be achieved by reducing activity during harvest and eliminating the burning of paper trays. Typically, an operator tills the ground to form a terrace along one side within the rows at an appropriate angle so that it can expose the grapes to maximum sun exposure. Then, the grapes are placed on paper trays to be dried. Once the harvest is complete, the operator tills the ground again to create a flat floor. A DOV system eliminates the passes needed to create and remove the terrace.

In the early 1990's there were no technologies for mechanical alternatives for raisin harvest, but since that time it appears that concern over labor has increased[1], and new developments have evolved. Therefore, these systems have become more popular and will most likely continue to grow.

Using California Air Resources Board (ARB) emission factors, it is possible to estimate the emissions reduction. However, the control effectiveness of this practice as an alternative to burning and tillage would have to be further evaluated.

Applicable Crops

This practice is applicable to the crop category Grapes (Raisin).

CMP Category

This practice is applicable to the CMP Category Harvest.

Emission Factor

ARB compiled several emission factors for harvest and land preparation activities per crop type; see Tables 1and 3. The development of the emission factors is described in ARB's Methodologies for Emission Inventory Source Category Sections 7.4 and 7.5 for agricultural operations[2,3].

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[3].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates 30% control efficiency for the land preparation activities associated with this practice and 32% control efficiency for the harvesting activities using ARB's information. It was assumed that passes to form/remove terrace, to spray, and to turn and roll paper tray could be eliminated. Under harvest, it is assumed that the operation "turn and roll" would be eliminated. Please refer to Appendix B2 for the analysis on these control efficiencies.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{[\sum(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})})] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 1
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1\text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1\text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{(\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10\text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor[3], 1.82 lbs/acre/yr
Control Efficiency	=	CMP efficiency to reduce emissions, 30%

Example:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 1.82_{(\text{lbs/acre})} \times 30_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{54.6_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.03\text{ tons/year}$$

B. Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor[2], 0.17 lbs/acre/yr
Control Efficiency	=	CMP efficiency to reduce emissions, 32%

Example:

$$\text{Emission Reduction} = \frac{\left\lfloor 100_{(\text{acre/year})} \times 0.17_{(\text{lbs/acre})} \times 32_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left\lfloor 5.44_{(\text{lbs/yr})} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.003 \text{ tons/year}$$

Sources of Information

1. Bert Mason, September 1998, *The Raisin Grape Industry*, Retrieved November 2002: http://migration.ucdavis.edu/rmn/changingface/cf_sep1998/Mason-Raisin.html
2. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January Emissions, Agricultural Harvest Operation, Section 7.5, January 2003.
3. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.

Table 1: Emission Factors[3] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation for Cover Crop

Description

The practice "Cover Crop" involves using seeded or natural vegetation to provide coverage on bare soil. Reseeding annual or perennial plants can be planted depending on farming conditions. Since emissions come from the soil being disturbed, cover crops provide protection from wind erosion by shielding the soil with vegetation and anchoring the soil with roots. This reduces windblown particulate matter emissions from soil erosion. In addition, it also improves soil structure, which reduces the number of cultivating passes that may be needed in the next phase of the farming operation.

For example, a cover crop that is planted in the rows between the planting beds suppresses weeds growth thus reducing a weeding pass.

National research studies such as the ones conducted by the Agricultural Research Service of the United States Department of Agriculture evaluate the effects of cover crops on soil. The control effectiveness for reducing windblown particulate matters would have to be further evaluated through quantitative analysis or literature search. In terms of field pass reduced, it is possible to estimate the operations that can be eliminated from having a cover crop.

Applicable Crops

This practice can be used for the following crop categories where applicable:

- Tree fruit
- Grapes
- Nut crops
- Alfalfa (counts as a cover crop under the CMP category "Other")

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and "Other".

Emission Factor

The California Air Resources Board (ARB) developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[1]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12.

ARB also compiled several emission factors for land preparation per crop type; refer to Table 1. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates several control efficiencies in Table 1 under the CMP category "Land Preparation" using ARB's information. It is reasonable to assume that cover crop provides soil coverage which reduces the need for soil tillage, weed management, and floor preparation. It is assumed that one discing pass is eliminated per crop type. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies under "Land Preparation"

Crop Category	Control Efficiency (%)
Tree Fruit	27
Grapes	26
Nut Crops	36

A technical supporting document[3] regarding quantification of agricultural best management practices prepared for the Arizona Department of Environmental Quality provides control efficiencies based on the percent of surface cover. The emission reduction is 39% with 10% surface cover, and 92% with 50% surface cover. Therefore based on this information, the District estimated an average 32.5% control effectiveness under the CMP category "Other" for preventing windblown dust for the crop types Alfalfa, Citrus, and Nut Crops.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. Option 1 (Use when the number of pass reduced is available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum \left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1\text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1\text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{\ (\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10\text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Grapes:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 1.82_{(\text{lbs/acre})} \times 26_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{47.32_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.02\text{ tons/year}$$

C. "Other" (windblown PM)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	windblown PM emission factor, 13.56 lbs/acre/year
Control Efficiency	=	CMP efficiency to reduce emissions, 32.5 %

Example:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 32.5_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 440.7_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.22 \text{ tons/year}$$

<u>Sources of Information</u>

1. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
2. California Air Resources Board, *Section 7.4—Agricultural Land Preparation.* Methods for Assessing Area Source Emissions. January 2003.
3. Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.

Table 2: Emission Factors[2] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[2] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Tree fruit	0.07
Grapes	1.82
Nut crops	3.13

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for: Chips/Mulch, Organic Materials, Polymers, Road Oil, and Sand

Description

The practices "Chips/Mulch", "Organic Materials", Polymers", "Road Oil", and "Sand" all refer to applying nontoxic chemical or organic dust suppressants as a control measure on unpaved roads and unpaved vehicle/equipment traffic areas to reduce entrainment of fugitive particulate matter (PM) when vehicle pass over the unpaved road or area surface. These control measures must not be prohibited for use by any applicable regulation and also must meet any specification required by any federal, state, or local water agency.

Because PM emissions result from the mechanical disturbance of soil by the tires and vehicle, they can be reduced by changing the surface of the road either with "wet suppression" or "chemical stabilization"[1]. Wet suppression keeps the road surface wet to control emissions. Chemical stabilization tries to change the physical characteristics of the surface.

For example, road oil forms a coat over dust particles forming a hard crust and also improves the cohesive resistance of road material. It usually can be applied once every two to three months and re-applied several times per year to maintain its efficiency. Other types of dust suppressant have a high water content to dilution ratio that allows the water to evaporate once applied to the soil and the non-water solution bonds the fine soil particles making them into larger particles; thus making those particles less susceptible to being entrained. Others draw moisture from the environment that acts to keep road surfaces moist, thus holding dust down.

Several studies were performed to evaluate the control effectiveness of dust suppressants. Two of them were performed in the San Joaquin Valley; one in Fresno County by UC Davis, and the other in Merced County by the Desert Research Institute. These two studies provide the best available data to date.

Here's an explanation of the dust suppressant properties as described by the Desert Research Institute[2]:

(1) Salts: these are hygroscopic compounds such as magnesium chloride or calcium chloride. They adsorb water when the relative humidity exceeds about 50%. Water improves the adherence of the soil particles to each

other. Salts are often depleted by precipitation and runoff owing to their high solubility.

(2) Resin or petroleum emulsion: these are non-water-soluble organic compounds that are "emulsified" or suspended in water. When these emulsions are sprayed onto soil, they stick the soil particles together, and eventually harden to form a solid mass. There are several emulsion products based on tree resin, petroleum, or asphalt compounds.

(3) Polymers: these act as adhesives which may be more effective than ordinary resins because their molecular structure is a long chain which in theory may be able to stick to more particles, or bridge larger particle-to-particle gaps.

(4) Surfactants: these reduce water surface tension, allowing available moisture to more effectively wet the particles and aggregates in the surface layer.

(5) Bitumens: these include materials such as asphalt or road oil that effectively pave the surface.

(6) Adhesives: these include lignin sulfonate, a syrupy wood product which creates a sticky but water-soluble layer.

(7) Solid materials: these include a petroleum industry by-product made by mixing recycled materials with earth materials.

Furthermore, unpaved roads and unpaved traffic areas with vehicle trips at and above specific thresholds set in Rule 8081 (Agricultural Sources) of Regulation VIII must meet additional requirements. A vehicle trip, in general, would involve travel along the road to access a field, but not activities that cross the road or use the road for end of row turnarounds. Agricultural unpaved roads and areas typically may have few trips per day during the growing season but have much higher traffic volumes during the harvest season.

Applicability

These practices can be used on all unpaved roads and unpaved equipment and traffic areas.

CMP Category

This practice is applicable to these CMP Categories: Unpaved Roads, and Unpaved Vehicle/Equipment Traffic Areas.

Emission Factor

The current uncontrolled emission factor used by the California Air Resources Board (ARB) is 2.0 lbs PM10 per vehicle mile traveled (VMT)[3]. ARB assumes that all unpaved farm roads in California emit the same levels of PM10 per VMT during all times of the year for all vehicles and conditions[4].

ARB compiled several documents and memoranda that describe the development of this emission factor. The emission factor is based on measurements of unpaved road dust emissions performed in separate projects by the University of California, Davis[5], and the Desert Research Institute (DRI)[2] as mentioned earlier. ARB also developed several methodologies that explain the use of this emission factor in estimating the emissions from unpaved roads. The methodologies are Sections 7.10, 7.10a, and 7.11 for agricultural road of the Emission Inventory Source Category "Road Dust".

Regarding emissions from unpaved equipment and traffic areas, the San Joaquin Valley Air Pollution Control District developed a methodology for assessing PM10 emissions from unpaved traffic area in the San Joaquin Valley using an emission factor and other data identified by ARB. One of the assumptions in the methodology was that there is an average of 10 vehicle trips on unpaved traffic area per day for 240 days of the year (days with no rainfall)[6]. Traffic area includes areas used for parking or storing; shipping, receiving and transfer; and fueling and servicing.

Control Efficiency

The study performed by the Desert Research Institute (DRI) and the study performed by UC Davis in Fresno County examined the effectiveness of several dust suppressants on unpaved roads in Merced County. The following table presents their results.

Table 1: Research Results

	Control Efficiency (%)	
Type of Controls	**UC Davis**	**DRI**
Road mix	99	--
Lignin Sulfonate	99	--
Magnesium chloride	98	--
Water	87 ± 6	--
Oiled road	59 ± 12	93
Graveled	n/a	--
Polymers	--	80
Solid materials*	--	62
Vegetative materials	--	33

*Petroleum based by-products and soils

Rule 8081 (Agricultural Sources) allows an alternative option to comply with some of the requirements in the rule. The alternative option is called a Fugitive

PM10 Management Plan that requires a minimum control efficiency of 50%[7]. Since operations subject to Rule 8081 are required to use dust suppressants that achieve a 50% control effectiveness, a minimum of 50% or greater control efficiency may be assigned accordingly for the unpaved roads and areas subject to Rule 8081.

Emission Reduction Calculation

The calculation involves adding a control efficiency factor to the equations found in ARB's methodologies for unpaved roads and District's methodology for unpaved traffic areas[6].

A. Unpaved Roads

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left(\text{Emission Factor}_{(\text{lbs/VMT})} \times \text{VMT}_{(\text{VMT/ acre})} \times \text{Acreage}_{(\text{acre/year})} \times \text{Control Efficiency}_{(\%)}\right)}{2000_{(\text{lbs/ton})}}$$

Where:

Emission Factor	=	2 lbs per VMT
VMT	=	vehicle mile traveled (crop specific), see Table 2
Acreage	=	parcel acreage for CMP
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 3

Example for Garlic:

$$\text{Emission Reduction} = \frac{(2_{(\text{lbs/VMT})} \times 2.40_{(\text{VMT/acre})} \times 100_{(acre\,/\,year)} \times 87_{(\%)})}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{417.6_{(\text{lbs/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.20_{(\text{tons/yr})}$$

B. Unpaved Vehicle/Equipment Parking and Traffic Areas

$$\text{Emission Reduction}_{(\text{tons/yr})} = \left(\frac{\left(\text{VMT x 240 days x Emission Factor}_{(\text{lbs/VMT})}\text{x Control Efficiency}_{(\%)}\right)}{2000_{(\text{lbs/ton})}}\right)$$

$$\text{VMT} = \left(\frac{\sqrt{\left(\text{Acreage}_{(\text{acre})} \times 43{,}560_{(\text{ft}^2)}\right)}}{5{,}280_{(\text{ft/mile})}}\right)\text{x Vehicle Trips}$$

Where:

VMT	=	vehicle mile traveled
Emission Factor	=	2 lbs per VMT
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 3
Vehicle Trips (VT)	=	10 VT[6], default average value
Acreage	=	acreage of unpaved equipment and traffic area
240 days	=	estimated total days per year of trip traveled on unpaved area[6], default value

Sources of Information

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2. Desert Research Institute, *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Final Report. . Prepared for the California Regional Particulate Air Quality Study. December 1996.
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Table 2: VMT[8] per crop profile

Crop Category	VMT per acre per year
Alfalfa	0.40
Citrus	1.23*
Corn grain and silage	0.40*
Cotton	0.40
Dry Beans, cereal grains, safflower, wheat, and barley	1.40*
Grapes	1.05*
Nut crops	0.49
Onions and garlic	2.40
Tree fruit	1.23*
Sugar Beets	2.40*
Vegetables, tomatoes, melons, and other	2.40*

*Most repeated or averaged VMT value per acre is assigned.

Table 3: Assigned Control Efficiency[2,5]

CMP	Control Efficiency (%)
Chips/mulch	33
Gravel[8]	46
Less than 10 VT	87 (unp. Rd) 60 (unp. Area)
Organic materials/vegetation	33
Paving	98
Polymers	80
Restricted Access	10
Road oil*	76
Sand	33
Speed limit	58 (10mph) 42 (15mph) 3 (25mph)
Water	70

*Note: The control efficiency is the average of DRI's and UC Davis' control efficiency for road oil.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Equipment Changes/Technological Improvements

Description

The practice "Equipment Changes/Technological Improvements" is to modify pieces of equipment or use new machineries to entrain less amount of fugitive particulate matter (PM). PM10 (particulate matter less than 10 microns in size) emissions come from soil being disturbed by the tractors and their implements. This practice does not necessarily reduce the number of passes over the field but rather reduces the amount of PM10 entrained.

For example, a piece of equipment for nut harvesting can be adjusted accordingly so that it does not touch the ground much. Therefore, less dirt is being thrown back into the air. Another example is that a larger or wider piece of equipment can be used to cover more ground area. In this case, there is a potential to reduce the number of field passes.

In order to address air quality concerns, manufacturers and growers are continuing to work on improving equipment and offering new ones that entrains less emissions. Some examples of new changes to harvesting equipment done in 2004 are lengthening of the dirt chain on the pick-up machines so that less dirt gets blown out[1], using a closed air system that returns dust to the ground rather than out to the side of the machine[2], and trying catch-frame technologies that catch nuts when they fall from the tree[3].

Researchers from the University California of Davis continue to evaluate PM10 emissions from using different equipment types and environmental conditions[4]. The results should become available in the near future.

Applicable Crops

This practice can be used for all crop categories.

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and Harvest.

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation and harvest activities per crop type; refer to Tables 1 and 2. The development of the emission factors is described in ARB's methodologies for Emission Inventory Source Category sections 7.4 and 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[5,6].

Control Efficiency

A technical supporting document[7] regarding quantification of agricultural best management practices prepared for the Arizona Department of Environmental Quality provides a control efficiency factor of 50% based on an electrostatically charged fine-mist water spray. Additional literature[8] indicates the possibility to reduce about half of the harvesting field passes by using new technologies. It states that the old equipment would need about six passes to move almond nuts to the middle to be dried while the new equipment could do it with three passes and with less air to move the nuts. An article[2] discusses an umbrella catch-frame equipment used to catch almonds and drop them to the center of the orchard floor to be dried. It eliminates at least one sweeping field pass by replace the shaker and sweeper. In addition, a research study[9] by UC Davis evaluated emissions from almond harvesters and showed in a progress report that the new harvesters produced 42% to 61% less emissions than the old harvesters on a solid set irrigated field.

Based on all of this information, the San Joaquin Valley Air Pollution Control District estimated 50% control efficiency.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. Option 1 (Use when the number of pass reduced is available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 1
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1\text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1\text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{\ (\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10\text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 2
Control Efficiency	=	CMP efficiency to reduce emissions, 50%

Example for Corn:

$$\text{Emission Reduction} = \frac{\left\lfloor 100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 50_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{345_{(\text{lbs})}}{2000_{\ (\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.17\text{ tons/year}$$

B. Harvesting

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, 50%

Example for Corn:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 0.43_{\mathit{lbs\,/\,acre})} \times 50_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.01 \text{ tons/year}$$

Sources of Information

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4. Terry Cassel. *Development of PM10 emission factors for almond harvesting.* In proceedings of the San Joaquin Valley Agricultural Technical Advisory Committee. Fresno, California. 2003.
5. California Air Resources Board, *Section 7.4—Agricultural Land Preparation.* Methods for Assessing Area Source Emissions. January 2003.
6. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation.* Methods for Assessing Area Source Emissions. January 2003.
7. Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.
8. Darla Welles. *A cleaner sweep.* The Porterville Recorder. November 8, 2004.
9. Lowel L. Ashbaugh et al. *Progress Report Comparison of Almond Harvester PM10 Dust Emissions.* Appendix F Test of Almond Harvester Report. November 29, 1999.

Table 1: Emission Factors[5] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 2: Emission Factors[5] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

Table 3: Emission Factors[6] for Harvest Operations

Crop Categories	Harvest Emission Factor (lbs PM10/acre/year)
Alfalfa	0.24
Citrus	0.14
Corn grain and silage	0.43
Cotton	3.37
Dry Beans, cereal grains, safflower, wheat, and barley	3.45
Grapes	0.17
Nut crops	36.50
Onions and garlic	1.68
Tree Fruit	0.14
Sugar Beets	1.69
Vegetables, tomatoes, melons, and other	0.23

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Floor Management

Description

The practice "Floor Management" means to maintain a smooth and flat orchard floor throughout the season. The floor can also be covered with vegetation. Since PM10 emissions come from the soil being disturbed by tractors and their implements, this practice allows for discing passes to be eliminated and with proper calibration of equipment to reduce soil surface disturbance.

For example, some methods of minimizing bumps and dips to stabilize the soil surface are:

- chemical treatment (it should last for a sufficient period to make it possible to reduce the number of passes through the field and keep the number of tractor tracks to a minimum),
- one-pass tillage practices, and
- irrigation (light irrigation will help form a surface crust).

It was found that the efficiency of mechanical harvesters is directly related to the condition of the orchard floor at harvest time. Also, the flatter the orchard floor is kept during the growing season, the easier it is to prepare in the fall[1].

The control effectiveness and air quality benefits of this practice would have to be further evaluated through research studies or literature search.

Applicable Crops

This practice can be used for the Nut Crops category.

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and Harvest.

Emission Factor

The California Air Resources Board compiled several emission factors for land preparation and harvest activities per crop type; see Tables 1 and 3. The development of the emission factors is described in ARB's Methodologies for Emission Inventory Source Category, Sections 7.4 and 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2,3].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates 50% control effectiveness under the CMP category "Land Preparation", and 25% under the CMP category "Harvest" using ARB's information. It is reasonable to assume that maintaining a smooth/flat will reduce the need to float the ground before or after harvest. Therefore, it eliminates field passes needed to float the ground.

Also, harvesting generally involve shaking trees, sweeping nuts, pick up, and hauling. Assuming that emissions from sweeping nuts can be minimized with a smooth floor and/or can be eliminated. Emissions would be minimized greatly since the soil would be more stabilized. There are four basic passes associated with harvest (shake trees, sweep nuts, pick up and haul, and hull nuts). Assuming that the emissions from sweeping pass are eliminated, that's 25% control effectiveness. Please refer to Appendix B2 for the analysis on these control efficiencies.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 1
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1 \text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1 \text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{\ (\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10 \text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor[2], 3.13 lbs/acre/yr
Control Efficiency	=	CMP efficiency to reduce emissions, 50 %

Example:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 3.13_{(\text{lbs/acre})} \times 50_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{156.5_{(\text{lbs})}}{2000_{\ (\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

B. Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor[3], 36.5 lbs/acre/yr
Control Efficiency	=	CMP efficiency to reduce emissions, 25%

Example:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 36.5_{(\text{lbs/acre})} \times 25_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left[912.5_{(\text{lbs/yr})}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.47 \text{ tons/year}$$

Sources of Information

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2. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
3. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003.

Table 1: Emission Factors[2] for Type of Land Preparation Operation

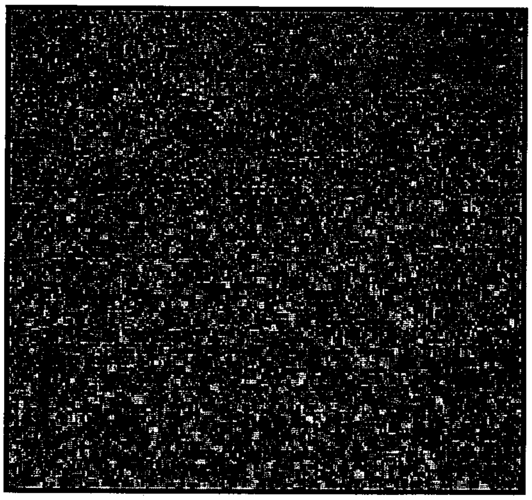
Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Gravel

Description

The practice “Gravel” is to use gravel or other aggregate material as a control measure on unpaved roads and unpaved vehicle/equipment traffic areas to reduce entrainment of fugitive particulate matter (PM) when vehicle pass over the unpaved road or area surface.



Because PM emissions result from the mechanical disturbance of soil by the tires and vehicle, they can be reduced by changing the surface of the road either with “wet suppression” or “chemical stabilization”[1]. Wet suppression keeps the road surface wet to control emissions. Chemical stabilization tries to change the physical characteristics of the surface.

In this case, gravel provides a protection similar to a chemical stabilization. It adds a layer that separates the soil surface from the tires and reduces the amount of particulate matters being suspended in the air. A layer of gravel must be placed at an appropriate depth to minimize emissions.

Unpaved roads and unpaved traffic areas with vehicle trips at and above specific thresholds set in Rule 8081 (Agricultural Sources) of Regulation VIII must meet additional requirements. A vehicle trip, in general, would involve travel along the road to access a field, but not activities that cross the road or use the road for end of row turnarounds. Agricultural unpaved roads and areas typically may have few trips per day during the growing season but have much higher traffic volumes during the harvest season.

Several studies were performed to evaluate the control effectiveness of dust suppressants. Two of them were performed in the San Joaquin Valley; one in Fresno County by UC Davis, and the other in Merced County by the Desert Research Institute. These two studies provide the best available data to date.

Applicability

This practice can be used on all agricultural unpaved roads and unpaved traffic areas.

CMP Category

This practice is applicable to these CMP Categories: Unpaved Roads, and Unpaved Vehicle/Equipment Traffic Areas.

Emission Factor

The current emission factor used by the California Air Resources Board (ARB) is 2.0 lbs PM10 per vehicle mile traveled (VMT)[2]. ARB assumes that all unpaved farm roads in California emit the same levels of PM10 per VMT during all times of the year for all vehicles and conditions[3].

ARB compiled several documents and memoranda that describe the development of this emission factor. The emission factor is based on measurements of unpaved road dust emissions performed in separate projects by the University of California, Davis[4], and the Desert Research Institute (DRI)[5] as mentioned earlier. ARB also developed several methodologies that explain the use of this emission factor in estimating the emissions from unpaved roads. The methodologies are Sections 7.10, 7.10a, and 7.11 for agricultural road of the Emission Inventory Source Category "Road Dust".

Regarding emissions from unpaved equipment and traffic areas, the San Joaquin Valley Air Pollution Control District developed a methodology for assessing PM10 emissions from unpaved traffic area in the San Joaquin Valley using an emission factor and other data identified by ARB. One of the assumptions in the methodology was that there is an average of 10 vehicle trips on unpaved traffic area per day for 240 days of the year (days with no rainfall)[6]. Traffic area includes areas used for parking or storing; shipping, receiving and transfer; and fueling and servicing.

Control Efficiency

A report[7] produced by Sierra Research for the San Joaquin Valley Air Pollution Control District's Regulation VIII provides control efficiencies for different types of dust suppressant. Based on that report, it was estimated a 46% control efficiency for gravel.

Emission Reduction Calculation

See methodology for "Chips/Mulch, Organic Materials, Polymers, Road Oil, and Sand"

Sources of Information

1. USEPA. September 1998. Chapter 13: Emission factors. www.epa.gov/ttn/chief/ap42/ch13/final/c13s02-2.pdf
2. California Air Resources Board, *Section 7.10a: SJV Private Unpaved Road Dust (SJV only) – Farm Roads.* Methods for Assessing Area Source Emissions. May 2004.
3. California Air Resources Board, *Section 7.11: Unpaved Road Dust – Farm Roads.* Methods for Assessing Area Source Emissions. August 1997
4. Air Quality Group, Crocker Nuclear Laboratory, *Evaluation of the Emission of PM10 Particulates from Unpaved Roads in the San Joaquin Valley*, Final Report. University of California, Davis. Prepared for San Joaquin Valley Air Pollution Control District. April 1994.
5. Desert Research Institute, *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Final Report. . Prepared for the California Regional Particulate Air Quality Study. December 1996.
6. San Joaquin Valley Air Pollution Control District, *Assessment of Area Source Emissions from Unpaved Traffic Areas*, March 2003.
7. Sierra Research, *Final BACM Technological and Economic Feasibility Analysis, Sierra Research*. Prepared for the San Joaquin Valley Air Pollution Control District. March 2003.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Green Chop

Description

The practice "Green Chop" means to harvest a forage crop without allowing it to dry in the field.

In a typical situation, harvesting hay includes the use of a mower, a rake, and a baler. First the mower cuts the crop and lays it in a windrow to allow the hay to dry in the field until it reaches an appropriate water content level. Next, a rake moves the windrow to aid the drying process, creates a narrower windrow and /or brings two or more windrows together for a more efficient baling operation. After the raked hay has dried, the baler gathers hay from the windrow and compresses the hay into a denser package called a bale for ease of handling, storing, and feeding.

Green chop involves the green forage being chopped, laid out in a windrow, and loaded immediately into a truck without being left to dry. Then, it is taken to the feed yard. Comparing these two concepts, green chop has the potential to reduce field trips, thus reducing particulate matter emissions.

Applicable Crops

This practice can be used on all crops where combined operations are feasible. These include corn/grain and silage, alfalfa, dry beans/cereal grains/safflower/wheat/barley.

CMP Category

This practice is applicable to the Harvest CMP Category.

Emission Factor

The California Air Resources Board compiled several emission factors for harvest activities per crop type, see Table 2. The development of the emission factors is described in ARB's Methodologies for Emission Inventory Source Category section 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies in Table 1. In a typical situation, harvesting hay involves cutting the crop, allowing it to dry, and compressing into bales. With the practice green chop, the green forage is not allowed to dry and is transported to another area. It was assumed that field trips needed to pack and haul out the crop when dried would be eliminated. Please refer to Appendix B2 for the analysis for these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Alfalfa	10
Corn Grain and Silage	16.5
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	19.87

Emission Reduction Calculation

Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage = parcel acreage for CMP
Emission Factor = harvest emission factor (crop specific), see Table 2
Control Efficiency = CMP efficiency to reduce emissions, see Table 1

Example for Alfalfa:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 0.24_{(\text{lbs/acre})} \times 10_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 2.4_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.0012 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003

Table 2: Emission Factors[1] for Harvest Operations

Crop Categories	Harvest Emission Factor (lbs PM10/acre/year)
Alfalfa	0.24
Corn grain and silage	0.43
Dry Beans, cereal grains, safflower, wheat, and barley	3.45

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Grinding/Chipping/Shredding, No Burning, and Soil Incorporation

Description

The conservation management practices "Grinding/Chipping/Shredding", "No Burning", and "Soil Incorporation" mean to use alternative methods to burning prunings, crop residue, and orchard removal. Any of these techniques can be used. Other possible alternatives are flailing of vegetation instead of tilling, sending prunings to cogeneration/biomass plants, and composting of residue for use as a soil amendment, discing residues and incorporating them into the soil or leaving them on the surface to decompose.

Burning of residues generates particulate matter (PM) emissions, thus eliminating burning reduces emissions. Some of these methods may require additional tillage passes. Soil disturbance generates PM emissions and may offset the full benefit of this practice.

Also, using a new system for farming that does not involve the burning of residue can also assist in reducing PM10 emissions. An example is using the Dried-on-Vines (DOV) technique. Most of the grape varieties are suitable for this harvesting technology. DOV does not use paper tray for laying the grapes on to dry. Instead, the canes are cut and the grapes are allowed to dry on the vines. Therefore, no burning of paper tray is done during harvesting activities. Harvest passes that are needed to take care of paper tray for burning purposes are eliminated this way. There are also harvesters that shred the continuous trays when picking up the raisins. There are biodegrable trays. Therefore the paper trays can be left in the rows. Another example is discing the chips and leaving them at the site for decomposition or using them as a soil amendment.

It is anticipated that more growers will use alternative practices to burning as State laws prohibit burning of field crops, prunings, weed abatement starting in

June 1, 2005; orchard removals in June 1, 2007; and surface harvested prunings and vineyard materials in June 1, 2010[1].

Applicable Crops

This practice can be used for the following crop categories where applicable: citrus, tree fruit, grapes, cotton, and nut crops.

CMP Category

This practice is applicable to the CMP Category "Other" and the CMP Category "Harvest" for grapes.

Emission Factor

ARB compiled a list of emission factors per crop type based on AP-42 values and from a study conducted by B.M. Jenkins[2]. Fuel loading values from AP-42 are also associated with each emission factor. Some of the factors and values were adjusted as needed by the San Joaquin Valley Air Pollution Control District to better reflect the conditions in the San Joaquin Valley[3].

Control Efficiency

This practice eliminates PM10 emissions from burning, but there's at least one field pass needed to chip/shred the brushes or to haul them out. Taking that into consideration, the San Joaquin Valley Air Pollution Control District estimated 90.45% control effectiveness for Citrus, Cotton, Nut Crops, and Tree Fruit, and 96.54% control effectiveness for Alfalfa and Corn under soil incorporation. In addition, the elimination of the burning of raisin trays would result in 100% control effectiveness, and it was assumed that the elimination of the burning of alfalfa seeds would result in 92.9% control effectiveness. Please refer to Attachment A for staff evaluation of these control efficiencies.

Emission Reduction Calculation

"Other" (Ag. burning)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left(\text{Acreage}_{(\text{acre/year})} \times \text{Fuel Loading}_{(\text{ton/ acre})} \times \text{Emission Factor}_{(\text{lbs/ton})} \times \text{Control Efficiency}_{(\%)}\right)}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	acreage listed on the CMP form
Fuel Loading	=	quantity/residue burned in tons per acre, see Table 1
Emission Factor	=	crop specific, see Table 1
Control Efficiency	=	efficiency to reduce emissions, 90.45%

Example for nut crops:

$$\text{Emission Reduction} = \frac{\left(100_{\,(acre/year)} \times 2.8_{(ton/\,acre)} \times 6.6_{(lbs/ton)} \times 90.45_{(\%)}\right)}{2000_{(lbs/ton)}}$$

$$\text{Emission Reduction} = \frac{\left(1671.5_{\,(lbs/year)}\right)}{2000_{(lbs/ton)}}$$

$$\text{Emission Reduction} = 0.84 \text{ tons/year}$$

Sources of Information

1. Official California Legislative information. (2003, September). Bill Number: 705. Retrieved August, 1, 2004 from Official California Legislative Information: http://www.leginfo.ca.gov/pub/bill/sen/sb_0701-0750/sb_705_bill_20030922_chaptered.html
2. Steve Shaw. " Ag burn emission factors." E-mail to Patia Siong. July 30, 2004.
3. Patrick Gaffney, Emission Inventory Branch, California Air Resources Board, Draft Memorandum to Bill Sandman, Colusa County Air Pollution Control District. May 23, 2000.

Table 1: Emission factor[2] for agricultural burning

Crop	PM10 Emission Factor (lbs/ton)	Fuel Loading (ton/acre)
Alfalfa	28.5	0.8
Citrus	5.9	1
Corn grain and silage	11.4	4.2
Cotton	15.9	2.2
Grapes	6.8	10.8
Grapes (raisin trays)	0.78	0.03
Nut crops	6.6	2.8
Tree Fruit	6.5	1.8

Attachment A

District staff performed the following analyses to determine a control efficiency factor for the CMPs "Grinding/Chipping/Shredding", "No Burning", and "Soil Incorporation".

"Grinding/Chipping/Shredding" and "No Burning"
This practice eliminates PM10 emissions from burning, but there's at least one field pass needed to chip/shred the brushes or to haul them out. Taking that into consideration, the District estimates 90.45% control effectiveness.

Calculation formula:
Crop type: Emission Factor x Fuel Load = Emission Factor (lbs/acre)

Citrus: 5.9 x 1 = 5.9
Nut crops: 7 x 1 = 7
Grapes: 4.9 x 2.5 = 12.25
Average = (5.9 + 7 + 12.25) /3 = 8.38 lbs/acre

Using 100 acres = 8.38 lbs/acre x 100 acres = 838 lbs

Burning is eliminated but a pass to haul or handle the brushes/prunings is needed for this practice. So, assigning a Weeding emission factor of 0.8 lb/acre to that pass (80lbs/100 acres) results in 90.45% control efficiency.

Control efficiency: (838-80) x 100 / 838 = 90.45%

"Soil Incorporation"
This practice eliminates PM10 emissions from burning, but there's at least one field pass needed to chip/shred the brushes or to haul them out. Taking that into consideration, the District estimates 96.54% control effectiveness.

Calculation formula:
Crop type: Emission Factor x Fuel Load = Emission Factor (lbs/acre)

Alfalfa: 28.5 x 0.8 = 22.8 (weighted average 21.54)
Corn: 11.4 x 4.2 = 47.88
Average: (21.54 +47.88)/2 = 34.71

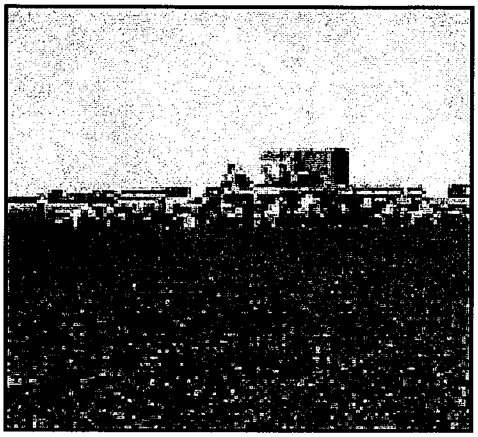
Using 100 acres: 34.71 lbs/acre x 100 acres = 3471

Burning is eliminated but a discing pass is needed for this practice. So, assigning a discing pass emission factor of 1.2 lb/acre to that pass (120lbs/100 acres) results in 96.54% reduction.
Control Efficiency: (3471-120) x 100 / 3471 = 96.54%

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Hand Harvesting

Description



The practice "Hand Harvesting " simply means to harvest by hand. PM10 emissions come from the soil being disturbed by tractors and harvesting machines. Therefore, this practice reduces soil disturbance caused by mechanical activities during harvest.

With this concept, the emissions reduction can be determined using the emission factors developed by the California Air Resources Board (ARB).

Applicable Crops

This practice can be used where practical for the following crop categories: citrus, sugar beet, tree fruit, grapes, vegetables/tomatoes/melons, and onions/garlic.

CMP Category

This practice is applicable to the Harvest CMP Category.

Emission Factor

ARB compiled several emission factors for harvest activities per crop type; see Table 1. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category, section 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates 30% control effectiveness for grapes, 17% for onions/garlic, and 33% for the remaining applicable crops under this CMP.

For Grapes, it was assumed that the emissions associated with mechanical harvesters and half of the trailer activities can be eliminated. Computing these activities with the number of field pass and emission factor, it results in 30% control efficiency.

For other types of crop that can be harvested by hand, the crop onion was used as an example. Mechanical harvest differs from hand harvesting by using a rotary beater and having windrowed passes. Thus, assuming that these activities could emit emissions similar to a discing pass and that the hand harvesting involving a rod weeding emitting emissions similar to a weeding pass, it results in about 33% reduction.

It was assumed that there are three basic activities associated with harvest. They are picking, packing, and hauling activities. Eliminating the mechanical harvesting (associated with picking), it could achieve about 33% control in general as well.

Please refer to Appendix B2 for the analysis on these control efficiencies.

Emission Reduction Calculation for an Agricultural Parcel

Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor (crop specific), see Table 1
Control Efficiency	=	CMP efficiency to reduce emissions, 52% for grapes, 17% for onions/garlic, and 33% for other crop types

Example for vegetables:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 0.23_{(lbs\,/\,acre)} \times 33_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Emission Reduction = 0.004 tons/year

Sources of Information

1. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003

Table 1: Emission Factors[1] for Harvest Operations

Crop Category	Harvest Emission Factor (lbs PM10/acre/yr
Citrus	0.14
Grapes	0.17
Onions and garlic	1.68
Tree Fruit	0.14
Sugar Beets	1.69
Vegetables, tomatoes, melons, and other	0.23

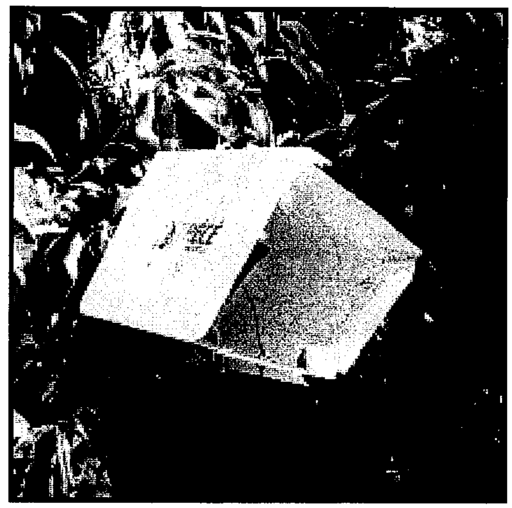
CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Integrated Pest Management

Description

The practice "Integrated Pest Management" (IPM) involves using a combination of techniques to suppress problems such as pests, diseases, and weeds. The techniques[1] are:

- cultural (crop rotation to avoid root worm damage)
- mechanical (cultivation of weeds)
- biological (release of parasitic wasps)
- genetic (planting disease-resistant varieties)
- chemical (using herbicides, insecticides, fungicides)



Some of these techniques provide alternatives to tilling the soil thus reducing the number of passes and causing less soil disturbance. For example, when a grower decides to use biological control to treat insect problem instead of spraying or discing, a tilling pass is eliminated.

The use of IPM is increasing and will likely continue to expand as there are more restrictions and eliminations of chemicals, for example methyl bromide, and as research information for IPM and marketing for environmental products increase[2].

Applicable Crops

This practice can be used on all crop categories.

CMP Category

This practice is applicable to the CMP Categories Land Preparation and "Other".

Emission Factor

The California Air Resources Board compiled several emission factors for land preparation per crop type; see Table 2. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[3].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates several control efficiencies using ARB's information; see Table 1. Five basic management options are used under IPM. They are cultural (i.e.: crop rotation), mechanical (i.e.: mechanical weed removal), biological (i.e.: parasitic wasps), genetic (i.e.: plant disease-resistance), and chemical options (i.e.: fungicides). One can choose to use the latter three options as primary choices over using a cultural or mechanical option. By doing so, it is assumed that several types of field passes can be reduced. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Land Prep. Control Efficiency (%)	"Other" Control Efficiency (%)
Alfalfa	--	8
Citrus and Tree Fruit	--	9
Corn Grain and Silage	12	12
Cotton	19	9
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	--	14
Grapes	--	18
Nut Crops	25	14
Onions and Garlic	--	12
Sugar Beets	--	4
Vegetables, Tomatoes, Melons, and Other	--	4

Emission Reduction Calculation for an Agricultural Parcel

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(2 \text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

2. **Option 2 (Use when the number of pass reduced is not available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Vegetables:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 9.05_{(\text{lbs/acre})} \times 4_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{36.2_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.018 \text{ tons/year}$$

Sources of Information

1. J. Vankirk. July 2000. What is Integrated Pest Management (IPM)? Retrieved November 27, 2002: http://www.colostate.edu/Depts/IPM/CSU%20NIPM%20site/IPM20definition.html

2. U.S. Environmental Protection Agency. n.d. Retrieved January 23, 2003: http://www.epa.gov/cgi-bin/epaprintonly.cgi

3. California Air Resources Board, *Section 7.4—Agricultural Land Preparation.* Methods for Assessing Area Source Emissions. January 2003.

Table 2: Emission Factors[3] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[3] for Land Preparation Operations

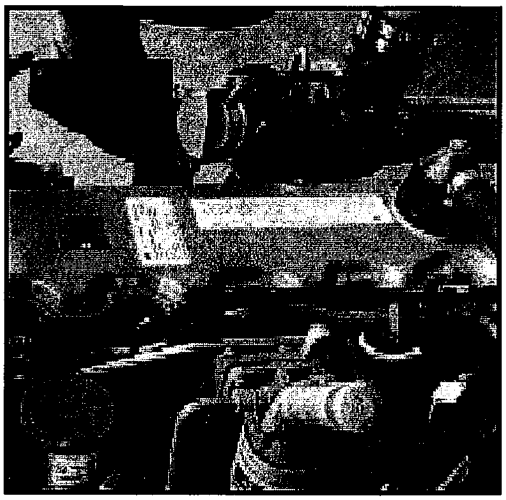
Crop Category	Land Preparation Emission Factor (lbs PM10/acre/yr)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Irrigation Power Units

Description

The practice "Irrigation Power Units" implies using clean burning engines or electric motors.



The types of engines that are allowed to be considered under this practice must emit below the emissions limits as set in the San Joaquin Valley Air Pollution Control District's current rules applicable to engines; for example Rule 4101 (Visible Emissions) and Rule 4702 (Internal Combustion Engines-Phase2).

The control effectiveness and additional air quality benefits of this practice for PM10 emissions would have to be further evaluated through quantitative analysis or literature search.

Applicable Crops

This practice can be used on all crops where it's feasible.

CMP Category

This practice is applicable to the CMP Category "Other".

Emission Factor

Currently, there is no emission factor for fugitive PM10 emissions assigned to this source.

Control Efficiency and Emission Reduction Calculation

There is currently no control efficiency factor assigned to this practice. As information becomes available, it will be added to this methodology. Currently, there is no methodology for calculating the emissions reduction from implementing this CMP.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Mechanical Pruning

Description

The practice "Mechanical Pruning" involves using a machine instead of hand labor to do the pruning. It primarily addresses reducing particulate matter (PM) emissions that are generated from vehicle trips on unpaved roads.

For example, a pruning operation may need several persons for the task depending on the acreage and time allotted for it. It is possible that each person arrives in their own vehicle thus causing several vehicle trips. Because PM emissions result from the mechanical disturbance of soil by the tires, replacing the manual labor with a machine has the potential for reducing the number of vehicle traveled on road.

Applicability

This practice can be used on all agricultural unpaved roads.

CMP Category

This practice is applicable to the CMP Category "Unpaved Roads".

Control Efficiency

The San Joaquin Valley Air Pollution Control District evaluated the reduction of vehicle trips by replacing manual labor with mechanical pruning. It is assumed that about 20 people with five cars would be needed to do a pruning job on a 50 acres tree fruit traveling on about ten miles of unpaved road per year. It is assumed that the number of car/trips would be reduced because fewer individuals would be needed for mechanical pruning. Associating the emission factors with the number of miles traveled on unpaved road to these numbers results in 55% control effectiveness. Please refer to Attachment A for staff evaluation of this control effectiveness.

Emission Factor and Emission Reduction Calculation

See methodology for "Chips/Mulch, Organic Materials, Polymers, Road Oil, and Sand".

Attachment A

This CMP involves reducing the number of vehicle trips by replacing manual labor with a machine. Based on data[1] provided by the agriculture industry to ARB and Sierra Research for the estimation of unpaved roads emission factor, it was assumed that about 20 persons with five cars would be needed to do a pruning job on a 50 acres (tree fruit) with about 10 miles of unpaved road traveled to a low five people with two cars with one mile traveled (nut crops on 75 acres):

Tree fruit:

manual pruning: 10 mile / 5 cars = 2 miles /car
5 cars x 2 miles x 2 lbs/VMT = 20 lbs
mechanical pruning: 2 cars x 2 miles x 2 lbs = 8 lbs

Nut crops:

manual pruning: 1 mile / 2 cars = 0.5 mile/car
2 cars x 0.5 mile x 2 lbs/VMT = 2 lbs
mechanical pruning: 1 car x 0.5 mile x 2 lbs = 1 lbs

Tree fruit Control Effectiveness = 1 - (8/20) = 0.6 = 60%
Nut crops Control Effectiveness = 1 - (1/2) = 0.5 = 50%

Average Control Efficiency = (60 + 50) /2 = 55 %

Sources of information

1. San Joaquin Valley Air Pollution Control District, *Reference 12: Detailed Documentation for Fugitive Dust and Ammonia Emission Inventory Changes for the SJVUAPCD Particulate Matter SIP*, for SJVUAPCD 2003 PM10 Plan. June 2003.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Mulching

Description

The practice "Mulching " means to apply or leave plant residue or other material to soil surface.

Since particulate matter emissions come from the soil being disturbed, mulch can assist in binding soil together by being an added protective layer. This layer will help reduce soil movement in wind events and conserve soil moisture. In addition, large plant residues can assist in reducing weed competition thereby reducing tillage passes and soil compaction.

Some examples of mulch that can be applied are organic material, gypsum, lime, and humus. Pre-plant ground covers or plastic mulch, such as the ones used for vegetables, are also included under this conservation management practice. The soil is protected from the wind so less particulate matters are entrained.

Applicable Crops

This practice can be used on all crops where it's feasible. These include corn/grain and silage, vegetables/tomatoes/melons, grapes, dry beans/cereal grains/safflower/wheat/barley, and onion/garlic.

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and "Other".

Emission Factor

The California Air Resources Board compiled several emission factors for land preparation and harvest activities per crop type; see Table 2. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category, Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

ARB developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[2]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12.

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates several control efficiencies under the CMP category "Land Preparation" using ARB's information; see Table 1 below. It is reasonable to assume that this practice could potentially reduce at least one discing pass that would be needed to control weeds and soil moisture. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies under "Land Preparation"

Crop Category	Control Efficiency (%)
Corn Grain and Silage	12
	--
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	7
Grapes	21
Onions and Garlic	18
Vegetables, Tomatoes, Melons, and Other	13

A technical supporting document[3] regarding quantification of agricultural best management practices prepared for the Arizona Department of Environmental Quality provides some control efficiencies based on the percent of surface cover. Based on this information, the District estimated a 32.5 % control effectiveness under the CMP category "Other" for preventing windblown dust.

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. Option 1 (Use when the number of pass reduced is available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(1 \text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(1 \text{ weeding pass} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left(2_{\ (\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.10 \text{ tons/year}$$

Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Corn:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 12_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{82.8_{(\text{lbs})}}{2000_{\ (\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.04 \text{ tons/year}$$

C. "Other" (windblown PM)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage = parcel acreage for CMP
Emission Factor = windblown PM emission factor[3], 13.56 lbs/acre/year
Control Efficiency = CMP efficiency to reduce emissions, 32.5 %

Example:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 32.5_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 440.7_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.22 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
2. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
3. Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.

Table 2: Emission Factors[1] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[1] for Land Preparation Operations

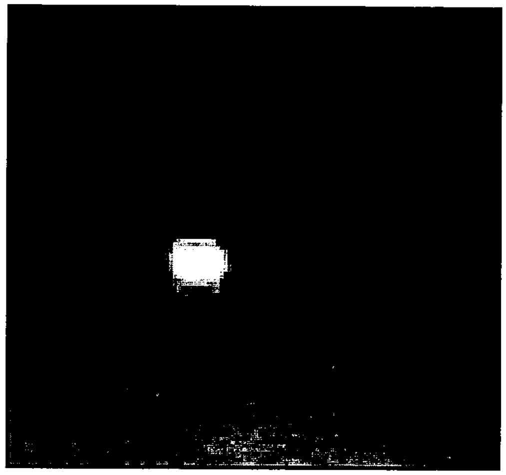
Crop Category	Land Preparation Emission Factor (lbs PM10/acre/yr
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Onions and garlic	6.5
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Night Farming/Night Harvesting

Description

The practice "Night Farming" or "Night Harvesting" means to conduct operations at night.



PM10 emissions come from the soil being disturbed by tractors and their implements. Minimizing emissions from soil disturbance can be achieved by reducing the number of passes over the field and/or by reducing the amount of particulate matters being entrained. However, this practice does not necessarily reduce the number of field pass.

Moisture generally increases after sunset and is higher around sunrise depending on the season and individual's irrigation schedule. Moisture causes soil to crust, and therefore PM10 emissions are not easily transported into the air.

As an added benefit, studies have shown that pesticides work much better when applied at night, especially for the ones that benefit from a high moisture level to enable rapid uptake into the plant[1].

Harvesting at night, when products are the coolest, is common for sweet corn and is gaining in use for the cantaloupe and grape industries.

There would be a trade off between poor atmospheric dispersion and particulate matter emissions generated from wind movement. Although the particulate matter emissions production would be less at night due to lower wind speeds and higher humidity, the dispersion of emissions would be poor due to extreme surface based atmospheric inversions and low speeds[2]. Air quality benefits of this practice as an alternative to daytime activities would have to be further evaluated.

Applicable Crops

This practice can be used for the following crop categories:

- Corn/grain and silage,
- Cotton,
- Alfalfa
- Vegetables, tomatoes, melons, and other
- Sugar beets,
- Tree fruit,
- Grapes,
- Dry beans, cereal grains, safflower, wheat, barley,
- Onions and garlic
- Nut crops

CMP Category

This practice is applicable to these CMP Categories: Land Preparation, Harvest, and "Other".

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation and harvest activities per crop type, refer to Tables 1and 2. The development of the emission factors is described in ARB's methodologies for Emission Inventory Source Category sections 7.4 and 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[3,4].

ARB developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[5]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12.

Control Efficiency

A technical supporting document[3] regarding quantification of agricultural best management practices prepared for the Arizona Department of Environmental Quality contains an estimate value of 30% control. It was applied in their evaluation for reducing windblown dust from planting based on soil moisture. One assumption used was the application of water to the soil prior to planting.

Irrigation is a good source of moisture which can impact PM10 emissions. Humidity is higher at daybreak, during spring, and after precipitation or irrigation.

However, the CMP "Night farming" may not necessarily imply irrigation prior to activity. Therefore, the 30% assumption could not be assigned.

In addition, based on meteorological activities during nighttime it would reasonable to assume that there would be a trade off between poor dispersion of emission and emission production from night farming. Although the emission production would be less at night due to lower wind speeds and higher humidity, the dispersion would be poor due to extreme surface based inversions and low wind speeds. Inversion involves warmer air moving above cooler air thus trapping that cooler dense air. The cooler air is trapped because it can't rise through the less dense warm air above it. Strong inversion keeps pollutants trapped at the location.

No additional data could be found in the literature search on which to base a control efficiency factor for night farming. Therefore, the San Joaquin Valley Air Pollution Control District estimated a minimal of 10% control effectiveness under CMP categories Land Preparation and Harvest, and 5% under the CMP Category "Other". The PM10 emissions from soil disturbance would be greater during land preparation and harvest activities than cultural practices.

Emission Reduction Calculation

A. Land Preparation and Other

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 1
Control Efficiency	=	CMP efficiency to reduce emissions, 10% under Land Prep. And 5% under Other

Example for Corn:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 6.9_{(\text{lbs/acre})} \times 10_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{69_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.035 \text{ tons/year}$$

B. Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor (crop specific), see Table 2
Control Efficiency	=	CMP efficiency to reduce emissions, 10 %

Example for Corn:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 0.43_{(\text{lbs/acre})} \times 10_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 4.3_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.002 \text{ tons/year}$$

DRAFT

Sources of Information

1. Jim Bauder, *Night Farming—Really!,* Montana State University Communications Services. January 2001. http://www.montana.edu/wwwpb/ag/baudr218.html
2. Evan Shipp. " Need info for night farming." E-mail to Patia Siong. September 1, 2004.
3. California Air Resources Board, *Section 7.4—Agricultural Land Preparation.* Methods for Assessing Area Source Emissions. January 2003.
4. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation.* Methods for Assessing Area Source Emissions. January 2003.

Table 1: Emission Factors[3] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

Table 2: Emission Factors[4] for Harvest Operations

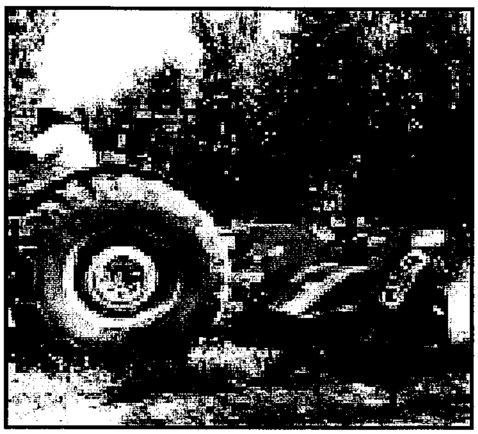
Crop Categories	Harvest Emission Factor (lbs PM10/acre/year)
Alfalfa	0.24
Citrus	0.14
Corn grain and silage	0.43
Cotton	3.37
Dry Beans, cereal grains, safflower, wheat, and barley	3.45
Grapes	0.17
Nut crops	36.50
Onions and garlic	1.68
Tree Fruit	0.14
Sugar Beets	1.69
Vegetables, tomatoes, melons, and other	0.23

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Non-Tillage/Chemical Tillage

Description

The practice "Non-Tillage/Chemical Tillage" involves cultivation that eliminates weeds through chemical or mechanical means with none or very minimal soil tillage. With less soil disturbance, there are less PM10 emissions.



An example is using pre-emergent or contact herbicides. The use of herbicides allows growers to spray them on weeds instead of discing them where they reside without damaging nearby crops. Other examples are hand-weeding and using a flail mower that cuts the weeds instead of using an implement that would actually till the soil. Also, in general, this practice reduces soil compaction and stabilizes soil through elimination or reduction of soil tillage passes.

Applicable Crops

This practice can be used for the following crop categories where applicable: Tree fruit, Grapes, Nut crops, and Alfalfa.

CMP Category

This practice is applicable to these CMP Categories: Land Preparation and "Other".

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation activities per crop type; refer to Table 2. The development of the emission factors is described in ARB's methodologies for Emission Inventory Source Category section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies under the CMP category "Land Preparation" using ARB's information; see Table 1 below.

A study[2] conducted in Oregon found that reducing spring tillage in one year out of a 3-year crop rotation in combination with weed controls (high to no herbicide application) eliminated the weed nightshade by 90 to 95% compared with conventional tillage. It was noted that no spring tillage could be believed to provide 70% weed control. It is reasonable to assume that this CMP reduces one discing or weeding pass since there would be minimum tillage or no tillage for weeds. Please refer to Appendix B for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Alfalfa	8
Citrus and Tree Fruit	30
Grapes	17
Nut Crops	25

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(2 \text{ weeding passes} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Nut Crops:

$$\text{Emission Reduction} = \frac{\left\lfloor 100_{(\text{acre/year})} \times 3.13_{(\text{lbs/acre})} \times 25_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{78.25_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.04 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
2. Western Region Integrated Pest Management Report 2000: New Tillage Practices Challenge Pernicious Weeds. Retrieved November 27, 2002: http://www.colostate.edu/Depts/IPM/%20NIPM%2020site/WRIPMR2000/WRIPM2000.html

Table 2: Emission Factors[1] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[1] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/yr
Alfalfa	4
Tree fruits	0.07
Grapes	1.82
Nut crops	3.13

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Organic Practices

Description

"Organic Practices " carries the same denotation as defined by the California Certified Organic Farmers. It means to use biological, cultural, and/or mechanical control methods to develop biological diversity and promote ecological balance[4]. For example, in organic farming, growers are required to have a crop rotation which can include a cover crop to provide soil erosion control; to use mulching or hand weeding for weed controls; and to use traps or repellent for pests control.

Particulate matter emissions come from the soil being disturbed by tractors and their implements. Some of the organic practices provide alternatives to tilling the soil thus reducing the number of passes and causing less soil disturbance; and also provide soil coverage reducing windblown particulate matters. Under this type of farming system, it reduces the use of chemicals and soil disturbance associated with conventional agricultural practices. For example, when a grower decides to do hand weeding instead of a discing pass, mechanical tillage usually done with a sled or rolling cultivator is eliminated.

Environmental regulations and pressure from the U. S. Food Industry stimulates consumers' interest in organic products. The establishment of a voluntary partnership in California known as BIOS (Biologically Integrated Orchard Systems) is one form of an active effort in conjunction with research studies to find solutions to water problems with organic farming. It was estimated that as much as 10% of California's cropland acreage could be organic by 2025[5].

The control effectiveness for reducing particulate matter and additional air quality benefits of this practice would have to be further evaluated through research studies or literature search.

Applicable Crops

This practice can be used on all crop categories where applicable.

CMP Category

This practice is applicable to these CMP Categories: "Other".

Emission Factor

The California Air Resources Board compiled several emission factors for land preparation activities per crop type; see Table 2. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category, Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies in Table 1. This practice could potentially reduce soil disturbance due to less tillage used for weed management. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Alfalfa	9
Citrus/Tree fruit	14
Corn Grain and Silage	17
Cotton	18
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	16
Grapes	38
Nut Crops	4
Onions and Garlic	18
Sugar Beets	5
Vegetables, Tomatoes, Melons, and Other	18

Emission Reduction Calculation

"Other"

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(2 \text{ weeding passes} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

2. **Option 2 (Use when the number of pass reduced is not available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Nut Crops:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 3.13_{(\text{lbs/acre})} \times 4_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{12.52_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.006 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
2. California Certified Organic Farmers. Manual Two: USDA Requirements for Organic Producers. December 2001.
3. Sean L. Swezey, Janet C. Broome. August 2001. Growth Predicted in Biological Integrated and Organic Farming in California. Retrieved March 12, 2003: http://panna.igc.org/resources/gpc/gpc_200108.11.2.07.dv.html

Table 2: Emission Factors[1] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[1] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Grapes	1.82
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Paving

Description

The practice "Paving" is to pave unpaved roads and unpaved vehicle/equipment traffic areas to reduce entrainment of fugitive particulate matter (PM) emissions when vehicles pass over the unpaved road or area surface.

Because PM emissions result from the mechanical disturbance of soil by the tires and vehicle, they can be reduced by changing the surface of the road either with "wet suppression" or "chemical stabilization"[1]. Wet suppression keeps the road surface wet to control emissions. Chemical stabilization tries to change the physical characteristics of the surface.

In this case, paving changes the soil surface by providing a permanent protection from the tires and eliminates the amount of particulate matters being suspended in the air.

Unpaved roads and unpaved traffic areas with vehicle trips at and above specific thresholds set in Rule 8081 (Agricultural Sources) of Regulation VIII must meet additional requirements. A vehicle trip, in general, would involve travel along the road to access a field, but not activities that cross the road or use the road for end of row turnarounds. Agricultural unpaved roads and areas typically may have few trips per day during the growing season but have much higher traffic volumes during the harvest season.

Several studies were performed to evaluate the control effectiveness of dust suppressants. Two of them were performed in the San Joaquin Valley; one in Fresno County by UC Davis[2], and the other in Merced County by the Desert Research Institute[3]. These two studies provide the best available data to date.

Applicability

This practice can be used on all agricultural unpaved roads and unpaved traffic areas.

CMP Category

This practice is applicable to these CMP Categories: Unpaved Roads, and Unpaved Vehicle/Equipment Traffic Areas.

Control Efficiency

The study[3] performed by the Desert Research Institute (DRI) in Merced County and the study[2] performed by UC Davis in Fresno County examined the effectiveness of several dust suppressants on unpaved roads in Merced County.

No result is available for paving as a control measure, but it is reasonable to assume that vehicle trips on paved roads will cause very minimal soil disturbance. Therefore, 98% control effectiveness can be assigned for paving unpaved roads or areas.

Emission Factor and Emission Reduction Calculation

See methodology for "Chips/Mulch, Organic Materials, Polymers, Road Oil, and Sand".

Sources of information

1. USEPA. September 1998. Chapter 13: Emission factors. www.epa.gov/ttn/chief/ap42/ch13/final/c13s02-2.pdf
2. Air Quality Group, Crocker Nuclear Laboratory, *Evaluation of the Emission of PM10 Particulates from Unpaved Roads in the San Joaquin Valley*, Final Report. University of California, Davis. Prepared for San Joaquin Valley Air Pollution Control District. April 1994.
3. Desert Research Institute, *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Final Report. . Prepared for the California Regional Particulate Air Quality Study. December 1996.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Permanent Crops

Description

The practice "Permanent Crops" is to establish a permanent crop that is not replanted annually. It can be done by planting or maintaining perennial plants throughout a crop field.

Since emissions come from the soil being disturbed, a permanent crop provides protection from wind erosion by shielding the soil with vegetation and providing a type of wind barrier. This reduces windblown particulate matter emissions from soil erosion.

Applicable Crops

This practice can be used for the following crop categories: Citrus, Grapes, Tree fruit, and Nut crops.

CMP Category

This practice is applicable to the CMP Category "Other".

Emission Factor

ARB developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[1]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12. Currently, there is no emission factor assigned to this source.

Control Efficiency and Emission Reduction Calculation

There is currently no control efficiency assigned to this practice and no methodology for calculating the emissions reduction from implementing this CMP.

Sources of Information

1. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Method for Precision Farming

Description

The practice "Precision Farming" means to manage or treat a selective area of the field using a precision farming method. There are several methods of performing this practice. It can involve using an overlap reduction technology (e.g.: a global positioning system (GPS), pass markers), variable rate application technology, and petiole and/or soil sampling.

Reducing particulate emissions from soil disturbance can be achieved by reducing the number of passes over the field. This practice does not necessarily reduce the number of field pass but reduces the level of activities on the field by identifying the specific areas of need, thus there is less soil disturbance.

GPS uses satellites to map the field, calculate position in the field and identify the area that needs fertilizer, thus only treating that area rather than the entire field. The pass markers use a similar concept. The treated area could be just two acres in size while the entire field is ten acres. Therefore, only two acres will be disturbed.

Another use of GPS is to reduce overlap when preparing the field and performing several operations at one time such as listing beds, seeding, cultivating or harvesting[4]. When forming beds and coming back in between them, one of the benefits is the outside shanks not pulling any soil or disturbing the soil from the already established beds as the tractor goes through.

Variable rate application technology is the use of machines and systems used for applying a regulated rate of materials at a specific time and location and can be used in conjunction with GPS. Petiole/soil sampling is a method of identifying a treatment with the assistance of laboratory testing.

In regards to overlap reduction technology, while some systems are already in use, there are systems being tested and demonstrated in the field in the San Joaquin Valley by manufacturers to develop California based economic statistics[4]. The data may be able to provide information that can be used to better estimate emissions reductions in terms of passes/operations reduced.

Applicable Crops

This practice can be used for the following crop categories:

- Corn/grain and silage,
- Cotton,
- Alfalfa
- Vegetables, tomatoes, melons, and other
- Sugar beets,
- Grapes,
- Dry beans, cereal grains, safflower, wheat, barley,
- Onions and garlic
- Nut crops

CMP Category

This practice is applicable to the CMP Category Land Preparation.

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation activities per crop type; refer to Table 1. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

Several manufacturers and research facilities evaluated the use of traditional foam markers versus GPS and reported that the field overlap rate drops to about 5% with GPS versus foam marker[6] to as low as 1.5% with an experienced driver[6], and that typical farming operation tends to overlap operations by 10 to 20%[4]. Other field tests also showed 2% overlap with GPS[7], thus 8% drop from 10%. In addition, controlling the pathway for on-field traffic assists in using a no-till management[8].

Based on this information, the San Joaquin Valley Air Pollution Control District estimates 15% control effectiveness for precision farming.

Emission Reduction Calculation

Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right) \times \text{Acreage}_{(\text{acre/year})}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	= number of field passes reduced
Emission Factor	= operation specific, see Table 1
Acreage	= acreage listed on the CMP form

Example:

$$\text{Emission Reduction} = \frac{\left[\left[\left(1 \text{ discing pass} \times 1.2_{(\text{lbs/acre-pass})}\right) + \left(2 \text{ weeding passes } \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left[\left[\left(1.2_{(\text{lbs/acre})}\right) + \left(1.6_{(\text{lbs/acre})}\right)\right] \times 100_{(\text{acre/year})}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left[\left(2.8_{(\text{lbs/acre})}\right) \times 100_{(\text{acre/year})}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.14 \text{ tons/year}$$

2. **Option 2 (Use when the number of pass reduced is not available)**

$$\text{Emission Reduction}_{(\text{tons/yr})} = \text{Acreage}_{(\text{acre})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}$$

Where:

Acreage	= acreage listed on the CMP form
Emission Factor	= land preparation emission factor, see Table 2
Control Efficiency	= efficiency to reduce emissions, 15%

Example for Corn:

$$\text{Emission Reduction} = 100_{(\text{acre})} \times 6.9_{(\text{lbs/acre})} \times 15_{(\%)}$$

$$\text{Emission Reduction} = \frac{103.5_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.051 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
2. Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.
3. Jim Bauder, *Night Farming—Really!,* Montana State University Communications Services. January 2001. http://www.montana.edu/wwwpb/ag/baudr218.html
4. Willard Thompson, *Straight Ahead*, no date www.rinconpublishing.com/past_features/gps_tractors.html
5. Tom Pilarski et al, *The Demeter System for Automated Harvesting*, Robotics Institute Carnie Mellon University, no date.
6. Jess Lowenberg-DeBoer, *GPS Based Guidance Systems for Agriculture*, Purdue University, October 1999.
7. Barry Ward, Corn - Crop Observation and Recommendation Network. October 14-October 20, 2002. http://corn.osu.edu/archive/2002/oct/02-35.html
8. Department of Primary Industries and Fisheries, Queensland Government, Precision farming in the northern grains region- Soil compaction and controlled traffic farming, May 2004. http://www.dpi.qld.gov.au/fieldcrops/3166.html

Table 1: Emission factors for land preparation operations

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 2: Emission factors for land preparation operations

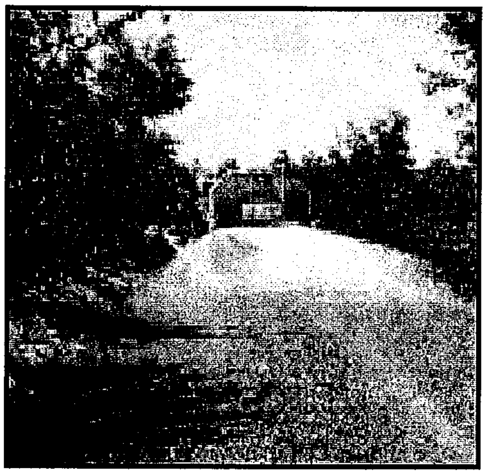
Crop Categories	Land Preparation Emission Factor
Alfalfa	4
Citrus	0.07
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	5.3*
Grapes	1.64*
Nut crops	3.13
Onions and garlic	6.5
Tree Fruit	0.07
Sugar Beets	22.8
Vegetables, tomatoes, melons, and other	9.3*

* Average land preparation emission factor

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Pre-Harvest Soil Preparation

Description



The practice "Pre-Harvest Soil Preparation" means to apply a light amount of water or stabilizing material to soil prior to harvest whenever possible. Moisture causes soil to crust, and therefore PM10 emissions are not easily transported into the air from being disturbed by machinery or wind.

This practice does not necessarily reduce the number of passes, but may reduce the amount of PM10 being entrained.

Researchers at the University of California, Davis, are currently investigating the impacts of different types of farming conditions, such as moisture content, in orchards in relation to PM10 emissions.

Applicable Crops

This practice can be used on the following crop categories where applicable: tree fruit, grapes, onion/garlic, and nut crops.

CMP Category

This practice is applicable to the CMP Category Harvest.

Emission Factor

The California Air Resources Board compiled several emission factors for harvest activities per crop type; see Table 1. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category Section 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates several control efficiencies in Table 1.

For example, harvesting nut crops generally involves shaking trees, sweeping nuts, picking up the nuts, and hauling. Emissions from the first activity, shaking trees, can be minimized since the soil would be more stabilized. It is reasonable to assume that applying an amount of water before harvest will add moisture to the floor and also provide a surface crust. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Alfalfa	7
Citrus/Tree Fruit	10
Corn Grain and Silage	5
Cotton	12
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	5
Grapes	10
Nut Crops	6
Onions and Garlic	10
Sugar Beets	10
Vegetables, Tomatoes, Melons, and Other	2

Emission Reduction Calculation for an Agricultural Parcel

Harvesting

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor (crop specific), see Table 2
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for nut crops:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 36.5_{(\mathit{lbs/acre})} \times 6_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 2190_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 1.1 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003

Table 2: Emission Factors[1] for Harvest Operations

Crop Categories	Harvest Emission Factor (lbs PM10/acre/year)
Alfalfa	0.24
Citrus	0.14
Corn grain and silage	0.43
Cotton	3.37
Dry Beans, cereal grains, safflower, wheat, and barley	3.45
Grapes	0.17
Nut crops	36.50
Onions and garlic	1.68
Tree Fruit	0.14
Sugar Beets	1.69
Vegetables, tomatoes, melons, and other	0.23

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Reduced Pruning

Description

The practice "Reduced Pruning" is the reduction of pruning, topping, or hedging. It can be accomplished by pruning in alternate years or less frequently. There is less soil disturbance due to less vehicle travel on road.

In addition, it is anticipated that more growers will use alternative practices to burning as State law prohibits burning of fieldcrops, prunings; weed abatement starting in June 1, 2005; orchard removals in June 1, 2007; and surface harvested prunings and vineyard materials in June 1, 2010[1].

Applicable Crops

This practice can be used for the Nut Crops and Citrus Crop Categories.

CMP Category

This practice is applicable to the CMP Category "Other".

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation activities per crop type; refer to Table 1. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated 9% control effectiveness for Citrus, and 6% for Nut Crops for potentially reducing half of the number of passes used for pruning. Please refer to Appendix B2 for the analysis on these control efficiencies.

Emission Reduction Calculation for an Agricultural Parcel

Land Preparation

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 2
Control Efficiency	=	CMP efficiency to reduce emissions, 9% or 6%

Example for Nut Crops:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 3.13_{(\text{lbs/acre})} \times 6_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{18.78_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.009 \text{ tons/year}$$

Sources of Information

1. Official California Legislative information. (2003, September). Bill Number: 705. Retrieved August, 1, 2004 from Official California Legislative Information: http://www.leginfo.ca.gov/pub/bill/sen/sb_0701-0750/sb_705_bill_20030922_chaptered.html
2. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.

Table 1: Emission Factors[2] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

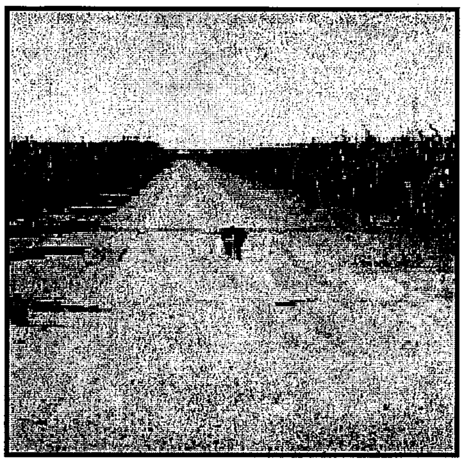
Table 2: Emission Factors[2] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/year)
Citrus	0.07
Nut crops	3.13

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Restricted Access

Description



The practice "Restricted Access" means to restrict public access to private roads and areas. That can be achieved by installing a line with a no-trespassing sign or by placing any other type of physical restriction across the road to discourage the use of it. Because particulate matter emissions result from the mechanical disturbance of soil by the tires and vehicle, no access will discourage the unnecessary use of the unpaved road and reduces emissions.

With this concept, it is reasonable to assume that none to very minimal PM emissions would result from the mechanical disturbance of soil by the tires and vehicle on those unpaved roads and areas during non-agricultural activity.

The emissions reduction can then be estimated using the emission factors and data developed by the California Air Resources Board (ARB).

Applicability

This practice can be used on all agricultural unpaved roads and unpaved equipment and traffic areas.

CMP Category

This practice is applicable to these CMP Categories: Unpaved Roads, and Unpaved Vehicle/Equipment Traffic Areas.

Emission Factor

The current emission factor used by the California Air Resources Board (ARB) is 2.0 lbs of PM10 per vehicle mile traveled (VMT)[1]. ARB assumes that all unpaved farm roads in California emit the same levels of PM10 per VMT during all times of the year for all vehicles and conditions[2].

ARB compiled several documents and memoranda that describe the development of this emission factor and PM10 emissions from unpaved road.

The emission factor is based on measurements of unpaved road dust emissions performed in separate projects by the University of California, Davis[3], and the Desert Research Institute (DRI)[4] as mentioned earlier. ARB also developed several methodologies that explain the use of this emission factor in estimating the emissions from unpaved roads. The methodologies are Sections 7.10, 7.10a, and 7.11 for agricultural road of the Emission Inventory Source Category "Road Dust".

Regarding emissions from unpaved equipment and traffic areas, the San Joaquin Valley Air Pollution Control District developed a methodology for assessing PM10 emissions from unpaved traffic area in the San Joaquin Valley using an emission factor and other data identified by ARB. One of the assumptions in the methodology was that there is an average of 10 vehicle trips on unpaved traffic area per day for 240 days of the year (days with no rainfall)[5]. Traffic area includes areas used for parking or storing; shipping, receiving and transfer; and fueling and servicing.

Control Efficiency

ARB's methodology Section 7.10a discusses PM10 emissions from private unpaved road in the San Joaquin Valley. To list a few type of sources, this methodology includes travel from irrigation canals as well as non-production travel on agricultural roads. It is pointed out that, through discussion with stakeholders, traffic on private unpaved road would be assumed to be 10% of the total traffic on all agricultural and non-agricultural unpaved roads due to the complexity in collecting traffic data from these roads. Therefore, a control efficiency of 10% would be assumed for eliminating traffic on these roads under this CMP. Please refer to Attachment A for staff analysis of this control effectiveness.

Emission Factor and Emission Reduction Calculation

See methodology for "Chips/Mulch, Organic Materials, Polymers, Road Oil, and Sand".

Sources of information

1. California Air Resources Board, *Section 7.10a: SJV Private Unpaved Road Dust (SJV only) – Farm Roads.* Methods for Assessing Area Source Emissions. May 2004.
2. California Air Resources Board, *Section 7.11: Unpaved Road Dust – Farm Roads.* Methods for Assessing Area Source Emissions. August 1997
3. Air Quality Group, Crocker Nuclear Laboratory, *Evaluation of the Emission of PM10 Particulates from Unpaved Roads in the San Joaquin Valley*, Final Report. University of California, Davis. Prepared for San Joaquin Valley Air Pollution Control District. April 1994.

4. Desert Research Institute, *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Final Report. . Prepared for the California Regional Particulate Air Quality Study. December 1996.

5. San Joaquin Valley Air Pollution Control District, *Assessment of Area Source Emissions from Unpaved Traffic Areas*, March 2003.

Attachment A

District staff evaluated the documents listed under the section Sources of Information of the main methodology report, and estimated 10% control efficiency for the CMP Restricted Access based on the data available.

Tables 1 and 2 show Vehicle Miles Travel (VMT) information provided by the Air Resources Board (ARB) as supporting information for the 2003 PM10 Plan. The information was collected from stakeholders and used for this analysis as well.

Table 1: Summary VMT per crop type[1]

crop type	VMT/acre/yr	reported (VMT/acres/yr)
grapes (all)	0.38	15/40
citrus	1.23	98/80
tree fruit	1.24	62/50
tree and citrus fruit	1.23	average of citrus and tree fruit
nut crops	0.49	37/75
cotton large	0.4	64/160
cotton small	2.4	156/65
existing ARB	4.38	175/40

Table 2: Detailed VMT per crop type[1]

crop type	annual VMT/acre		annual vehicle trips/farm	
	implements	all vehicles	implements	all vehicles
cotton small	0.196	2.4	34	262
Cotton large	0.1	0.4	16	64
grapes	0.0625	0.388	6	91
tree fruit	0.277	1.97	n/a	n/a
nut crop	0.091	0.493	n/a	n/a
citrus fruit	0	1.23	0	296

Table 3: Analysis of Control Efficiency for Restricted Access

crops	VMT/acre/yr	VMT/acre/day	max VT (private + public)	mileage with 75 VT daily	emissions with 75 VT daily	public VT	mileage with 10 VT daily	emissions with 10 VT daily	reduced VT CE%	emissions CE %
	a	b= a / 365 days	c	d = b/c	e = c x d x 2	f	g = d x f	h = g x 2	I= 1- (g/b)	
grapes (all)	15	0.04	75	0.00	0.08	7.5	0.00	0.01	10.00	10.00
citrus	98	0.27	75	0.00	0.54	7.5	0.03	0.05	10.00	10.00
tree fruit	62	0.17	75	0.00	0.34	7.5	0.02	0.03	10.00	10.00
nut crops	37	0.10	75	0.00	0.20	7.5	0.01	0.02	10.00	10.00
cotton large	64	0.18	75	0.00	0.35	7.5	0.02	0.04	10.00	10.00
cotton small	156	0.43	75	0.01	0.85	7.5	0.04	0.09	10.00	10.00
existing ARB	175	0.48	75	0.01	0.96	7.5	0.05	0.10	10.00	10.00

Note:

-VT: vehicle trip
-CE: control efficiency
-Public VT: public vehicle trips to be eliminated. It was assumed a 10% usage based on ARB methodology section 7.10a SJV private unpaved road dust.
-ARB stated that it was not possible to collect information regarding mileage of private unpaved roads and the amount of vehicle traffic on these roads. Therefore, through discussions with stakeholders, it was decided that an initial estimate of private unpaved road traffic would be assumed to be 10% of the total traffic on all unpaved roads.
-10% agrees with the information provided by stakeholders for the 50acre/tree fruit, 56 miles for staff and 6 miles for non-staff. The extra 6 miles is about 10%.

Sources of information

1. San Joaquin Valley Air Pollution Control District, *Reference 12: Detailed Documentation for Fugitive Dust and Ammonia Emission Inventory Changes for the SJVUAPCD Particulate Matter SIP*, for SJVUAPCD 2003 PM10 Plan. June 2003.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Shed Packing Crops

Description

The practice "Shed Packing" means to pack commodities in a covered or closed area instead of field packing.

It requires the farm workers to place the goods collectively in large containers or bins and then to transport them to the shed or house where the packing is done. Packing done out in the field involves more frequent transport of materials, such as cartons, in and out of the field, and the use of harvesters, if feasible, to accommodate field packing. Field packing has farm workers picking and packing the commodity for shipment to market in the field, and is widespread for vegetable crops and table grapes. Workers walk behind a conveyor belt that moves slowly through the field, they then pick and place the goods on a belt so that packers riding on the machine can wrap and pack them. Comparing field packing to shed packing, the latter has a potential of reducing soil disturbance caused by harvesters and the number of field and road trips.

Many California vegetable crops have shifted from shed to field packing over the last twenty years and more recently with San Joaquin Valley melons. But also at the same time, growth in fresh-cut, and ready-to-eat bagged produce creates a rise in shed packing[1].

Applicable Crops

This practice can be used for the following crop categories where applicable: vegetables, tomatoes, melons, and other; and onions and garlic.

CMP Category

This practice is applicable to the "Harvest" CMP Category.

Emission Factor

The California Air Resources Board compiled several emission factors for harvest activities per crop type; see Table 1. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category, Section 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated 13% control effectiveness for Onions and Garlic, and 11% for Vegetables, etc.

Using onions and garlic, the main harvest activities are digging, topping, undercutting, windrowing, and hauling; thus a total of five practices. Shed packing will most likely reduce the hauling activities by some number. Hauling makes about 20% of the emissions based on this. Therefore, by reducing hauling activity, it showed that in general 11% or 13% of the harvest emissions would be eliminated. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Onions and Garlic	13
Vegetables, Tomatoes, Melons, and Other	11

Emission Reduction Calculation for an Agricultural Parcel

Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage = parcel acreage for CMP
Emission Factor = harvest emission factor (crop specific), see Table 2
Control Efficiency = CMP efficiency to reduce emissions, see Table 1

Example for Vegetables:

$$\text{Emission Reduction} = \frac{\left\lfloor 100_{(\text{acre/year})} \times 0.23_{(lbs\,/\,acre)} \times 11_{(\%)} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left\lfloor 2.53_{(\text{lbs/yr})} \right\rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.0012 \text{ tons/year}$$

Sources of Information

1. Roberta Cook, University of California Davis. In Proceedings September 10-12, 1998. California Vegetables and Citrus: Production Trends and Implications for Labor Demand. Retrieved September 24, 2004.
2. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003

Table 2: Emission Factors for Harvest Operations

Crop Category	Harvest Emission Factor (lbs PM10/acre/yr
Onions and garlic	1.68
Vegetables, tomatoes, melons, and other	0.23

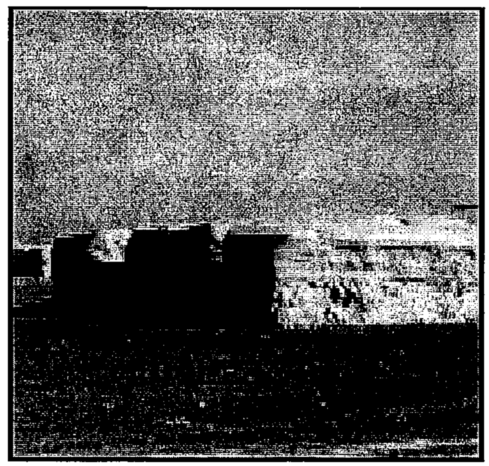
CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Shuttle system/Larger carrier

Description

The practice "Shuttle system/Larger carrier " means to haul multiple or larger trailers/bins per trip to reduce the frequency of bulk movement of commodities from the field. This is applicable to the smaller types of load that can be increased in loading capacity. This reduces field passes, which in turn reduces particulate matter emissions.

Possible carriers are boll buggies, cotton modules versus trailers, bankout wagons, multiple trailers, or gondolas. For example, a boll buggy sits at the end of the row and can be filled up several times more than a regular load. When filled, it then can be hauled away. This can eliminate the number of trips that a driver does when hauling the regular smaller loads of cotton back and forth. This concept also works for cotton modules. They have a greater holding capacity than trailers.



Applicable Crops

This practice can be used for the following crop categories where applicable: corn/grain and silage, cotton, vegetables/tomatoes, melons, sugar beets, tree fruit, grapes, dry beans/cereal grains/safflower/wheat/barley, onion/garlic, and nut crops.

CMP Category

This practice is applicable to the Harvest CMP Category.

Emission Factor

ARB compiled several emission factors for harvest activities per crop type; see Table 2. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category Section 7.5 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates several control efficiencies; see Table 1. For several crops, it is assumed that in general there are three basic steps: picking/cutting, collecting/packing, and hauling. It is assumed that with a higher loading capacity or extended transportation mode, it could reduce about half of the field trips done by the harvest carriers. For example, a 2-ton gondola (considered a standard size) can be replaced by a 4 or 6-ton gondola; thus reducing about half of the trailer trips. With these assumptions, the control efficiency can range from 10% to 17% or more control efficiency. Please refer to Appendix B2 for the analysis on these control efficiencies.

For grapes using just the grapes raisin for calculation purposes, it is assumed that a standard 2-ton gondolas can be replaced by up to 6-ton gondolas. Using a 4-ton gondola as an average size, it can reduce 50% of the trips, thus reducing the trailer activity by 50%. This results in an overall 16% control efficiency.

For alfalfa, bales are picked up with a balewagon that moves the bales from the field and get roadsided in stack. A conversion kit attached to the standard balewagon to handle about 1000 bales can be added too. Also, there is a system in which an accumulator attached to the rear of the baler can stack several bales and drop them directly on the ground to be picked up on a semitruck or wagon (rather than making individual bale and leaving individual bale on ground). Assuming that the activities associated with alfalfa harvest is cut alfalfa, turned and windrowed using a rake, and baling. So assuming that 50% more bales can be picked with this type of system, thus reducing 50% of these baling passes. Overall it produces a 17% emissions reduction.

For cotton, since a boll buggy/ cotton module can carry a load of five to six times more than a trailer, the activity "build module" and "hauling" can be reduced by 80%. For Pima variety, two harvest pick-ups are required but there is more acreage in Upland variety, so for calculation purposes the second harvest pick-up is not counted and the emissions is allocated to the other operations.

The same assumption is used for the other crop categories. It is assumed that the harvest operations will also have a 3-step process in which half of the trips used for hauling will be eliminated.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Alfalfa	17
Citrus and Tree Fruit	17
Corn Grain and Silage	17
Cotton	40
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	20
Grapes	16
Nut Crops	10
Onions and Garlic	17
Sugar Beets	17
Vegetables, Tomatoes, Melons, and Other	17

Emission Reduction Calculation for an Agricultural Parcel

Harvest

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	harvest emission factor (crop specific), see Table 2
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Tree fruit:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 0.14_{(lbs\,/\,acre)} \times 17_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 2.38_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.001 \text{ tons/year}$$

Sources of Information

1. California Air Resources Board, *Section 7.5—Agricultural Harvest Preparation*. Methods for Assessing Area Source Emissions. January 2003

Table 2: Emission Factors[1] for Harvest Operations

Crop Category	Harvest Emission Factor (lbs PM10/acre/yr)
Citrus	0.14
Corn grain and silage	0.43
Cotton	3.37
Dry Beans, cereal grains, safflower, wheat, and barley	3.45
Grapes	0.17
Nut crops	36.50
Onions and garlic	1.68
Tree Fruit	0.14
Sugar Beets	1.69
Vegetables, tomatoes, melons, and other	0.23

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Soil Amendments

Description

The practice " Soil Amendments" infers to applying organic or chemical materials to the soil.

Since emissions come from the soil being disturbed, soil amendments provide protection from wind erosion by adding moisture and allowing soil to form bigger clods. This reduces windblown particulate matter emissions from soil erosion.

A method example for applying organic materials is to use a conservation tillage system which involves leaving up to 30% of the soil covered with previous crop residue and continuing working with the soil in that state.

Low residue crops are crops such as most vegetable crops that produce very small amounts of above-ground residue that decay rapidly. The lack of residue cover after these crops are harvested leaves the soil vulnerable to wind erosion until the next crop is established[1].

Based on a research study that evaluated different types of organic amendments to address reducing wind erosion, it was found that wheat straw provided the best control at about 40%[1].

Applicable Crops

This practice can be used for the following crop categories where applicable: cotton, citrus, and grapes.

CMP Category

This practice is applicable to the CMP Category "Other".

Emission Factor

ARB developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[2]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12.

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates 20% control effectiveness for reducing windblown dust.

A research study[1] evaluated the control effectiveness of different types of organic amendments to address reducing wind erosion. It was found that wheat straw provided the best control at about 40%[1] in the high wind condition found in the Columbia Plateau. Another study[3] evaluated synthetic gypsum as an erosion control. It was conducted to analyze the efficiency of gypsum in reducing soil sealing thus increasing water infiltration in soil. Test was conducted on silt loam soil on a corn/soybean crop rotation with till versus no till farming operation with gypsum. Even though, no evaluation of PM emissions reduction was conducted, results show that infiltration rates effectively increased on the tilled plots with gypsum application and that gypsum does keep the soil agglomerated. Based on these studies, District staff assumed a 20% control efficiency factor (half of the 40% control above).

Emission Reduction Calculation for an Agricultural Parcel

"Other" (windblown PM)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	windblown PM emission factor[2], 13.56 lbs/acre/year
Control Efficiency	=	CMP efficiency to reduce emissions, 20%

Example:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 20_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 271.2_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.14 \text{ tons/year}$$

Sources of Information

1. "Farming with the Wind." Best Management practices for Controlling Wind Erosion and Air Quality on Columbia Plateau Croplands. USDA-National Resources Conservation Service, Conservation Districts, and the AG service Industry. Northwest Columbia Plateau Wind Erosion Air Quality Project. n.d., http://pnwsteep.wsu.edu/winderosion, (January 21, 2003).(chapter 6)
2. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
3. *Erosion Control by Amending Soil with Synthetic Gypsum.* B.H. Wallace, L.D. Norton, and R. Woodward. http://topsoil.nserl.purdue.edu/nserlweb/isco99/pdf/ISCOdisc/SustainingTheGlobalFarm/P183-Saxton.pdf

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Speed Limits

Description

The practice "Speed Limits" is to comply with speed equal to or lower than 25 mph. This can be achieved by posting speed limits on or around the operation.

Fugitive particulate matter (PM) becomes entrained when vehicles pass over the unpaved road or area surface and can also be suspended by natural winds. Dust emissions are a function of speed, meaning reducing speed reduces fugitive particulate matter emissions. There is a linear relationship between speed and emissions; therefore, reducing speed to 25 mph or even 15 mph will result in proportional emission reductions[7].

Unpaved roads and unpaved traffic areas with vehicle trips at and above specific thresholds set in Rule 8081 (Agricultural Sources) of Regulation VIII must meet additional requirements[1]. A vehicle trip, in general, would involve travel along the road to access a field, but not activities that cross the road or use the road for end of row turnarounds. Agricultural unpaved roads and areas typically may have few trips per day during the growing season but have much higher traffic volumes during the harvest season.

Several studies were performed to evaluate the effectiveness of dust controls. UC Davis performed a study in Fresno County and also evaluated speed limit as a control. This study provides the best available data to date for the San Joaquin Valley. Using the emission factor and equation developed by the Air Resources Board and the United States Environmental Protection Agency, it is possible to estimate the control effectiveness of speed reduction.

Applicability

This practice can be used on all unpaved roads and unpaved equipment and traffic areas.

CMP Category

This practice is applicable to these CMP Categories: Unpaved Roads, and Unpaved Vehicle/Equipment Traffic Areas.

Emission Factor

The current emission factor used by the California Air Resources Board (ARB) is 2.0 lbs PM10 per vehicle mile traveled (VMT)[2]. ARB assumes that all unpaved farm roads in California emit the same levels of PM10 per VMT during all times of the year for all vehicles and conditions[3].

ARB compiled several documents and memoranda that describe the development of this emission factor. The emission factor is based on measurements of unpaved road dust emissions performed in separate projects by the University of California, Davis[4], and the Desert Research Institute (DRI)[5] as mentioned earlier. ARB also developed several methodologies that explain the use of this emission factor in estimating the emissions from unpaved roads. The methodologies are Sections 7.10, 7.10a, and 7.11 for agricultural road of the Emission Inventory Source Category "Road Dust".

Regarding emissions from unpaved equipment and traffic areas, the San Joaquin Valley Air Pollution Control District developed a methodology for assessing PM10 emissions from unpaved traffic area in the San Joaquin Valley using an emission factor and other data identified by ARB. One of the assumptions in the methodology was that there is an average of 10 vehicle trips on unpaved traffic area per day for 240 days of the year (days with no rainfall)[6]. Traffic area includes areas used for parking or storing; shipping, receiving and transfer; and fueling and servicing.

Control Efficiency

The study performed by UC Davis in Fresno County examined speed reduction and found that reducing speed from 25 mph to 10 mph achieved 58% ± 3 control effectiveness and 42% ± 35 control effectiveness from 25 mph to 15 mph. For example, because the emissions from unpaved roads are directly proportional to vehicle speed, if the speed is reduced to 12.5 mph, the effectiveness of the control is more than doubled from 36% to 87%[7].

The San Joaquin Valley Air Pollution Control District performed an analysis for comparison using equations developed by Sierra Reseach[6]. The analysis evaluated different speed scenarios using weight and speed factors and resulted in similar results. Therefore, a control effectiveness of 81% will be used for reducing speed to 5 mph, 58% for reducing speed to 10 mph, 42% for reducing speed to 15 mph, and 3% for reducing speed to 25 mph from the baseline speed 25.9 mph as used for the emission factor[7]. Please refer to Attachment A for staff analysis of this control effectiveness.

Emission Factor and Emission Reduction Calculation

See methodology for "Chips/Mulch, Organic Materials, Polymers, Road Oil, and Sand".

Sources of information

1. San Joaquin Valley Air Pollution Control District, Compliance Division, *Regulation VIII—Criteria for Developing and Evaluating Fugitive PM10 Management Plans (FPMP),* October 2002.
2. California Air Resources Board, *Section 7.10a: SJV Private Unpaved Road Dust (SJV only) – Farm Roads.* Methods for Assessing Area Source Emissions. May 2004.
3. California Air Resources Board, *Section 7.11: Unpaved Road Dust – Farm Roads.* Methods for Assessing Area Source Emissions. August 1997
4. Air Quality Group, Crocker Nuclear Laboratory, *Evaluation of the Emission of PM10 Particulates from Unpaved Roads in the San Joaquin Valley*, Final Report. University of California, Davis. Prepared for San Joaquin Valley Air Pollution Control District. April 1994.
5. Desert Research Institute, *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Final Report. . Prepared for the California Regional Particulate Air Quality Study. December 1996.
6. San Joaquin Valley Air Pollution Control District, *Assessment of Area Source Emissions from Unpaved Traffic Areas*, March 2003.
7. Sierra Research, *Final BACM Technological and Economic Feasibility Analysis, Sierra Research.* Prepared for the San Joaquin Valley Air Pollution Control District. March 2003.

Attachment A

District staff evaluated the documents listed under the section Sources of Information of the main methodology report, and estimated several control efficiencies based on speed for the CMP Speed Limit.

Tables 1, 2, and 3 present information used in an appendix[1] to the 2003 PM10 Plan. The tables contain factors that change depending on speed, weight of the vehicle, and the number of wheels on the vehicle. Changing these factors impacts the emissions emitted. Thus, District staff used these factors to estimate the control efficiencies for this CMP.

Table 1: Effect of Speed on Emissions[1]

Speed (mph)	Baseline speed	Effect
a	b	c = a/b
25.9	25.9	1.0000
25	25.9	0.9653
20	25.9	0.7722
15	25.9	0.5792
10	25.9	0.3861
5	25.9	0.1931

Table 2: Effect of Weight on Emissions[1]

Weight (lbs)	Weight (tons)	Weight factor	Effect
	a	b	c = a x b
6,000	3	n/a	1
10,000	5	$(5/3)^{0.7}$	1.430
20,000	10	$(10/3)^{0.7}$	2.323

Table 3: Effect of the Number of Wheels on the Vehicle[1]

Number of Wheels	Weight Factor	Effect
a	b	c= a x b
4	n/a	1
8	$(8/4)^{0.5}$	1.414
12	$(12/4)^{0.5}$	1.732

Table 4: Calculated Emissions Reduction with Different Speed Limit

Scenario	Type of vehicle	Weight (lbs)	Speed (mph)	EF (lbs/VMT)	Speed effect	Weight Effect	Wheels Effect	Emissions (lbs/VMT)	% Control Efficiency
				a	b	c	d	axbxcxd	
1	truck	6,000	25.9	2	1	1	1	2.000	
	truck	6,000	25	2	0.9653	1	1	1.931	
									3
2	truck	6,000	25.9	2	1	1	1	2.000	
	truck	6,000	20	2	0.7722	1	1	1.544	
									23
3	truck	6,000	25.9	2	1.0000	1	1	2.000	
	truck	6,000	15	2	0.5792	1	1	1.158	
									42
4	truck	6,000	25.9	2	1.0000	1	1	2.000	
	truck	6,000	10	2	0.3861	1	1	0.772	
									61
5	truck	6,000	25.9	2	1.0000	1	1	2.000	
	truck	6,000	5	2	0.1931	1	1	0.386	
									81

Notes:

-The calculated control efficiency for speed reduced to 10 mph corresponds closely with the UC Davis finding of 58 +/- 3 from 25 mph to 10 mph. Therefore, the 58% control efficiency will be used.

-The calculated control efficiency for speed reduced to 15 mph corresponds closely with the UC Davis finding of 42+/- 35 from 25 mph to 15 mph.

Sources of information

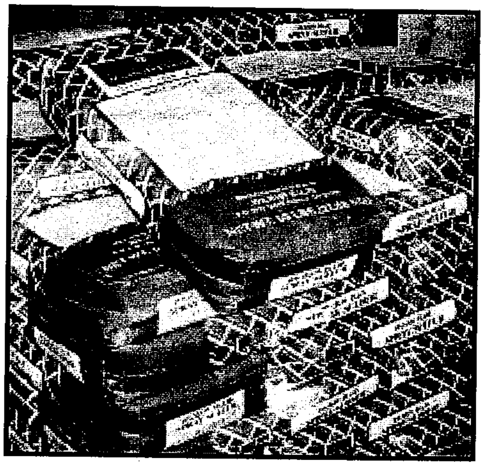
1. San Joaquin Valley Air Pollution Control District, *Appendix G: Exhibit C Supplemental BACM Analysis*, for SJVUAPCD 2003 PM10 Plan. December 2003.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Sulfur-Reduction of Dusting

Description

The practice " Sulfur: Reduction or Elimination of Dusting" means to reduce or eliminate the application of sulfur in the powder form. Reducing it can potentially reduce particulate matter emissions from being windblown.



Sulfur is the leading pesticide used in California Agriculture[2] and is an effective tool for managing powdery mildew. However, sulfur in the powder form is also a concern for water quality because it drifts to other areas and can affect people and other crops.

The California Winegrape Pest Management Alliance is a partnership between the California winegrape community and the Department of Pesticide Regulation, and has established Best Management Practices to address sulfur application.

Examples of alternative control methods[2] are:

- Using a trellis system or using canopy thinning techniques. A properly opened canopy provides conditions less conducive to mildew and other diseases, potentially enabling lower sulfur application rates and fewer applications.
- Applying wettable sulfur or other low-risk fungicide sprays that are less prone to drift.
- Applying sulfur application when the wind speed is lower than 10 miles per hour.

Applicable Crops

This practice can be used for the Grapes crop category.

CMP Category

This practice is applicable to these CMP Category "Other".

Emission Factor

The California Air Resources Board (ARB) compiled several emission factors for land preparation activities per crop type; refer to Table 1. The development of the emission factors is described in ARB's methodology for Emission Inventory Source Category Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[1].

Control Efficiency

There is currently no control efficiency factor assigned to this practice. As information becomes available, it will be added to this methodology. Based on literature[2], wettable sulfur is typically applied at rates two to three times lower than dusting sulfur, therefore it can potentially reduce the number of field passes. The control effectiveness and additional air quality benefits of this practice would have to be further evaluated through research studies or literature search.

Emission Reduction Calculation

Currently, there is no methodology for calculating the emissions reduction from implementing this CMP.

Sources of Information

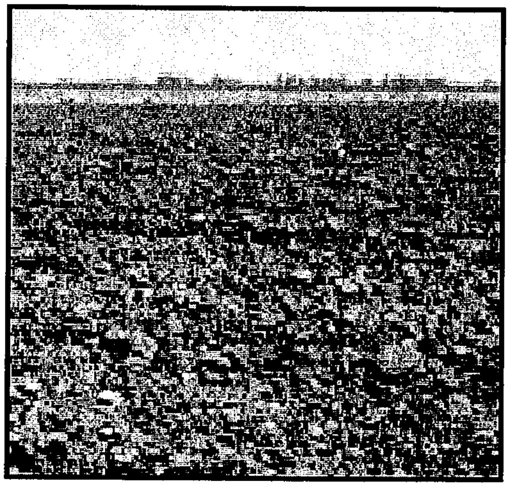
1. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.
2. California Association of Winegrape Growers. n.d. BMPs for Sulfur in Winegrapes. Retrieved August 22, 2004: http://www.cawg.orp/pma/ed-grower_bmps.htm

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Surface Roughening

Description

The practice "Surface Roughening" is to leave the soil surface (when fallow) rough by leaving it stand with clods or to prepare beds in a perpendicular orientation to the prevailing wind direction when practical. It can be used in the San Joaquin Valley especially during the high wind period from March to June to reduce particulate emissions from being windblown.



Soil surface aggregates (random roughness) and ridges (oriented roughness) can reduce soil loss by wind erosion[2]. Soil erosion by winds occurs (1) when wind velocity is strong enough to set off soil movement, (2) when soil particles are small enough to erode, and (3) when the soil surface is not protected by crop canopy, residue, and/or roughness. Flat and standing crop residues, crop canopy, wind barriers and soil surface roughness are among the most important factors reduce wind velocity at the surface.

Researchers conducted wind tunnel studies to evaluate the effect of ridges and aggregates on soil erosion by wind, and soil losses from different surfaces. The results based on that study was that ridges reduce wind erosion more effectively than random roughness[2].

In addition, there is a research study[3] that evaluated management practices to address wind erosion in the Northwest Columbia Plateau in the Idaho/Washington/Oregon area with windblown dust problem. The study indicated that established beds or ridges have higher potential in reduction erosion than cover crop and than a disked or packed ground.

Applicable Crops

This practice can be used on all crop categories.

CMP Category

This practice is applicable to these CMP Category "Other".

Emission Factor

ARB developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[1]. The emission factors are contained in the methodology for Emission Inventory Source Category section 7.12.

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates 64% control effectiveness based on the following findings. Table 2-4 in the report called Fugitive Dust Handbook[4] developed for Western Regional Air Partnership provides a list of published control efficiencies. It identifies control efficiencies for surface roughening with a range from 15% to 64% based on a study conducted by Grantz et al. The study evaluated control efficiency for using rocks or soil aggregates to increase soil surface.

Another study[5] by Grantz et al. evaluated a different type of soil erosion control in the Antelope Valley and found about 54% control effectiveness at around 78 inches above ground and 71% at around height 8 inches in height.

In "Farming with the Wind. Best Management practices for Controlling Wind Erosion and Air Quality on Columbia Plateau Croplands", testing results showed that bed ridge has higher control efficiency than cover crop and disc/pack[3].

Emission Reduction Calculation

"Other" (windblown dust)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\lfloor \text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	windblown PM emission factor[1], 13.56 lbs/acre/year
Control Efficiency	=	CMP efficiency to reduce emissions, 64%

Example:

$$\text{Emission Reduction} = \frac{\lfloor 100_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 64_{(\%)} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\lfloor 867.84_{(\text{lbs/yr})} \rfloor}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.43 \text{ tons/year}$$

Sources of Information

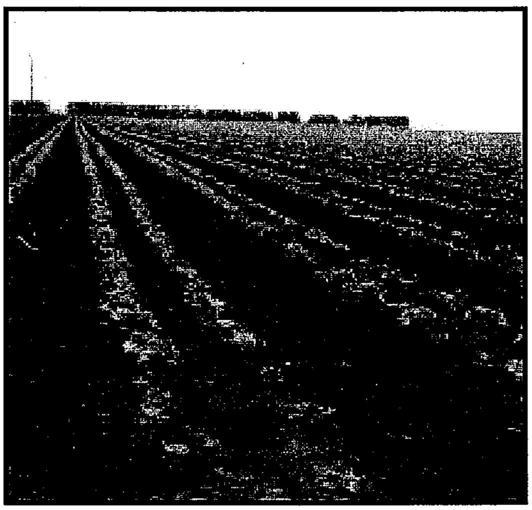
1. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
2. Ali Saleh and D.W. Fryrear. *Draft Appendix O: Soil Roughness for the Revised Wind Erosion Equation RWEQ.* n.d.
3. "Farming with the Wind." Best Management practices for Controlling Wind Erosion and Air Quality on Columbia Plateau Croplands, Chapter 6. USDA-National Resources Conservation Service, Conservation Districts, and the AG service Industry. Northwest Columbia Plateau Wind Erosion Air Quality Project. n.d., http://pnwsteep.wsu.edu/winderosion, January 21, 2003.
4. WRAP Fugitive Dust Handbook, Countess Environmental, prepared for Western Governors' Association, November 15, 2004. www.ndep.nv.gov/baqp/WRAP/final-handbook.pdf
5. Wind Fences: A Review of Dust Control Effectiveness", final report, MRI, October 16, 2000.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Time of Planting

Description

The practice "Time of Planting " means to plant either earlier or later than typically done. Time of Planting is planting when moisture is high and earlier or later in the season to minimize bare soil exposure to winds in-between farming operations. It assists in reducing the time the land is being left idle and when it's being tilled, thus reducing the time bare land can be subject to windblown dust. It may also assists in reducing days of high PM10 emissions by distributing them to periods when there is less particulate matter concentration.



The highest percentage of PM concentrations from agricultural land preparation activities is found around March and between the months of October and December[1].

For example, there are early season varieties available for tomatoes, sugar beets, vegetables, and tree crops that can be grown. Meteorological condition is one main factor that dictates how early or late a certain crop can be planted.

Applicable Crops

This practice can be used on all crops categories.

CMP Category

This practice is applicable to the Land Preparation CMP Category.

Emission Factor

ARB developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[1]. The emission factors are contained in the methodology for Emission Inventory Source Category Section 7.12.

Control Efficiency

An appendix[2] based on information provided by the Virginia Department of Conservation and Recreation indicates that surface roughening established during construction activities can be achieved by using tracking (depression formed by tires tracks), grooving (series of ridges and depression), or stair-stepping (grading method creating stair steps). When properly performed, this practice can result in up to 18% control that may be taken for the time between establishment of surface roughening and seeding

However, no data was found on evaluating reduction of PM10 emissions from farmed land based on the duration of bare soil and the time of planting. Therefore, there is currently no control efficiency factor assigned to this practice. As information becomes available, it will be added to this methodology.

Emission Reduction Calculation

Currently, there is no methodology for calculating the emissions reduction from implementing this CMP.

Sources of Information

1. California Air Resources Board, *Section 7.12—Windblown Dust Agricultural Lands.* Methods for Assessing Area Source Emissions. July 1997.
2. Virginia Department of Conservation and Recreation. Appendix Surface Roughening. May 22, 2002.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for: Track Out Control

Description

The practice "Track Out Control" involves minimizing any and all material that adheres to and agglomerates on all vehicles and equipment from unpaved roads and falls onto a paved public road or the paved shoulder of a paved public road.

Track Out control measure on unpaved roads and unpaved vehicle/equipment traffic areas assist in reducing entrainment of fugitive particulate matter (PM) when vehicle pass over the unpaved road or area surface and onto traffic areas. This can be accomplished by maintaining sufficient length of paved/graveled interior roads to allow mud and dirt to drop off vehicles before exiting the site; or use of a grizzly to dislodge debris from tires and undercarriage of vehicles leaving site.

As information becomes available on the emission inventory and emission factor for this source of fugitive PM10 emissions, it will be added to this methodology.

Applicability

This practice can be used on all agricultural unpaved roads and unpaved equipment and traffic areas.

CMP Category

This practice is applicable to these CMP Categories: Unpaved Roads, and Unpaved Vehicle/Equipment Traffic Areas.

Emission Factor and Control Efficiency

Currently, there is no emission factor and control efficiency assigned to this CMP.

Emission Reduction Calculation

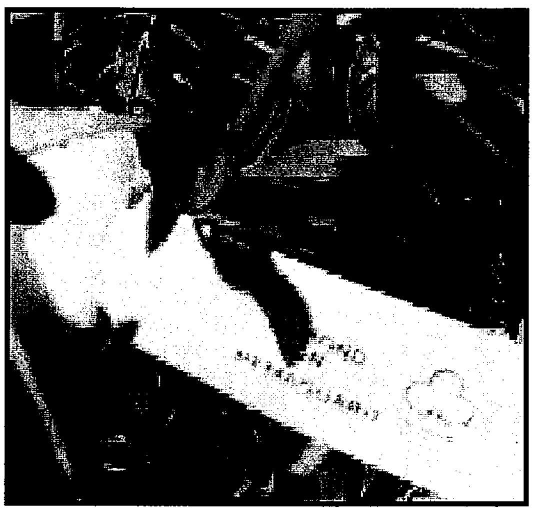
Currently, there is no methodology for calculating emissions reduction from implementing this CMP.

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Transgenic Crops

Description

The practice "Transgenic Crops " means to use genetically modified organisms (GMOs) or transgenic crops such as "herbicide-ready". Because these types of crop are tolerant to certain things such as herbicides, drought, and pest, they reduce the need for tillage or cultivation operations, thus reducing soil disturbance and number of field passes. This practice also reduces the amount of pesticide drift that can potentially occur using conventional pesticide application methods.



Some examples of transgenic crops include genetically altered seed, nematode resistant rootstock and grafting, the use of Bt-Cotton and Bt-Corn, and pest resistant varieties.

Currently, a number of transgenic crop varieties have been de-regulated from commercial use in the United States, and a small fraction of them are in California. The largest portion of California's current transgenic agricultural acreage is planted in Bt cotton[1]. The percentage of acreage planted to transgenic crop decreased in 2000.

Applicable Crops

This practice can be used on the following crops where it's feasible: alfalfa, corn/grain and silage, cotton, vegetables/tomatoes/melons, dry beans/cereal grains/safflower/wheat/barley, sugar beets, and onion/garlic.

CMP Category

This practice is applicable to the CMP Categories Land Preparation and "Other".

Emission Factor

The California Air Resources Board compiled several emission factors for land preparation and harvest activities per crop type, see Table 2. The development of the emission factors is described in ARB's Methodologies for Emission Inventory Source Category, section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies using ARB's information; see Table 1 below. Because transgenic crops are tolerant to certain things such as herbicides, drought, and pest, they reduce the need for tillage or cultivation operations, thus reducing soil disturbance and number of field passes. It is assumed that transgenic eliminates at least one weeding pass. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Land Preparation Control Efficiency (%)	"Other" Control Efficiency (%)
Alfalfa	2	8
Corn Grain and Silage	12	12
Cotton	9	9
Dry Beans, Cereal Grains, Safflower, Wheat, and Barley	4	14
Onions and Garlic	12	--
Vegetables, Tomatoes, Melons, and Other	6	--

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation and "Other"

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(2 \text{ weeding passes} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Onions and Garlic:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.5_{(\text{lbs/acre})} \times 12_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{78_{(\text{lbs})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.04 \text{ tons/year}$$

Sources of Information

1. Chapter 3: Transgenic Crop Plants and the Environment: Benefits and Risks. N.d. http: www.ccst.ucr.edu/gmf/FB_Ch3.pdf
2. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.

Table 1: Emission Factors[2] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 2: Emission Factors[2] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre)
Alfalfa	4
Corn grain and silage	6.9
Cotton	8.9
Dry Beans, cereal grains, safflower, wheat, and barley	4.45
Onions and garlic	6.5
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Transplanting

Description

The practice " Transplanting" means to plant crop already in a growth state. It reduces soil disturbance and the number of passes compared to using direct seeding.

The equipment used for seeding and transplanting may disturb the soil differently. Typically, the machine used for transplanting creates a hole in the planting beds, and the transplants (which roots are already wrapped with soil) are dropped. On the other hand, the machine used for seeding creates a furrow in the planting bed. The seeds are dropped in the furrow. Then the machine covers them with soil. This process may create more disturbance than the one used for transplanting.

In addition, because the transplants are already at a later stage of growing, it reduces the number of field passes that would be needed to cultivate plant growth from seeds.

Using the processing tomato industry to observe a popularity of transplanting, a nursery that caters to the west side of the San Joaquin Valley estimates that transplants are used on about 40%[1] of the states' processing tomato acreage, and transplanting may increase as seed cost rises. Two other reasons for using transplants are savings in water usage and decline in weed competition.

Applicable Crops

This practice can be used where it's feasible for the vegetables/tomatoes/melons crop category, and the onion/garlic crop category.

CMP Category

This practice is applicable to the Land Preparation CMP Category.

Emission Factor

The California Air Resources Board compiled several emission factors for land preparation per crop type; see Table 2. The development of the emission factors is described in ARB's Methodology for Emission Inventory Source Category, Section 7.4 for agricultural operations.

The emission factors were based on operation specific emission factors developed by the University of California, Davis, and on background information such as the number of field passes and crop calendars (seasons) compiled with the assistance of farmers and agricultural experts[2].

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimated several control efficiencies under the CMP category "Land Preparation" using ARB's information; see Table 1 below. In addition to the description of the CMP above, less field passes would be needed since the plant would already be in an early stage of growth. Therefore, it was assumed that transplanting reduces weeding passes. Please refer to Appendix B2 for the analysis on these control efficiencies.

Table 1: Control Efficiencies

Crop Category	Control Efficiency (%)
Onions and Garlic	12
Vegetables, Tomatoes, Melons, and Other	6

Emission Reduction Calculation for an Agricultural Parcel

A. Land Preparation

1. **Option 1 (Use when the number of pass reduced is available)**

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\sum\left(\text{Pass} \times \text{Emission Factor}_{(\text{lbs/ acre-pass})}\right)\right] \times \text{Acreage}_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

Where:

Pass	=	number of field passes reduced per acre per year
Emission Factor	=	emission factor for type of pass (operation specific), see Table 2
Acreage	=	parcel acreage for CMP

Example:

$$\text{Emission Reduction} = \frac{\left[\left(2 \text{ weeding passes} \times 0.8_{(\text{lbs/acre-pass})}\right)\right] \times 100_{(\text{acre/year})}}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.08 \text{ tons/year}$$

2. Option 2 (Use when the number of pass reduced is not available)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	land preparation emission factor (crop specific), see Table 3
Control Efficiency	=	CMP efficiency to reduce emissions, see Table 1

Example for Onions and Garlic:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 6.5_{(\text{lbs/acre})} \times 12_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{78_{(\text{lbs})}}{2000\ _{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.04 \text{ tons/year}$$

Sources of Information

1. Dan Bryant. February 2, 2002. Vegetable transplants at full speed. Retrieved September 29, 2004: http://westernfarmpress.com/mag/farming_vegetable_transplants_full/
2. California Air Resources Board, *Section 7.4—Agricultural Land Preparation*. Methods for Assessing Area Source Emissions. January 2003.

Table 2: Emission Factors[2] for Type of Land Preparation Operation

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM10/ acre-pass)
Chisel	Discing	1.2
Disc	Discing	1.2
Disc & Furrow-out	Discing	1.2
Disc & Roll	Discing	1.2
Finish Disc	Discing	1.2
Harrow Disc	Discing	1.2
Land Preparation, Gen.	Discing	1.2
Mulch Beds	Discing	1.2
Plow	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Stubble Disc	Discing	1.2
Unspecified Operation	Discing	1.2
3 Wheel Plane	Land planing	12.5
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level	Land planing	12.5
Level	Land planing	12.5
Level (new vineyard)	Land planing	12.5
Plane	Land planing	12.5
Subsoil	Ripping	4.6
Subsoil-deep chisel	Ripping	4.6
Bed Preparation	Weeding	0.8
List	Weeding	0.8
List & Fertilize	Weeding	0.8
Listing	Weeding	0.8
Roll	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Shape Beds	Weeding	0.8
Shape Beds & Roll	Weeding	0.8
Shaping	Weeding	0.8
Spring Tooth	Weeding	0.8
Terrace	Weeding	0.8

Table 3: Emission Factors[2] for Land Preparation Operations

Crop Category	Land Preparation Emission Factor (lbs PM10/acre/yr
Onions and garlic	6.5
Vegetables, tomatoes, melons, and other	9.05

CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Water Application

Description

The practice "Water Application" means to use water as a control measure on unpaved roads and unpaved vehicle/equipment traffic areas to reduce the entrainment of fugitive particulate matter less than 10 micron in size (PM10). The emissions on these roads and areas result from the mechanical disturbance of soil by the tires and vehicle.

Water increases soil particle mass by binding to them and also adds surface tension forces. Even after water has evaporated, the cohesion of water and particles remains due to the formation of aggregates and surface crusts[4]. Watering is a practice already in use for agricultural purposes to reduce the spread of dust mites in vineyards, orchards, row and field crops.

Unpaved roads and unpaved traffic areas with vehicle trips at and above specific thresholds set in Rule 8081 (Agricultural Sources) of Regulation VIII must meet additional requirements. A vehicle trip, in general, would involve travel along the road to access a field, but not activities that cross the road or use the road for end of row turnarounds. Agricultural unpaved roads and areas typically may have few trips per day during the growing season but have much higher traffic volumes during the harvest season.

Several studies were performed to evaluate the control effectiveness of dust suppressants. Two of them were performed in the San Joaquin Valley; one in Fresno County by UC Davis, and the other in Merced County by the Desert Research Institute. These two studies provide the best available data to date.

Applicability

This practice can be used on all agricultural unpaved roads and unpaved equipment and traffic areas.

CMP Category

This practice is applicable to these CMP Categories: Unpaved Roads, and Unpaved Vehicle/Equipment Traffic Areas.

Emission Factor

The current emission factor used by the California Air Resources Board (ARB) is 2.0 lbs PM10 per vehicle mile traveled (VMT)[1]. ARB assumes that all unpaved farm roads in California emit the same levels of PM10 per VMT during all times of the year for all vehicles and conditions[2].

ARB compiled several documents and memoranda that describe the development of this emission factor. The emission factor is based on measurements of unpaved road dust emissions performed in separate projects by the University of California, Davis[3], and the Desert Research Institute (DRI)[4] as mentioned earlier. ARB also developed several methodologies that explain the use of this emission factor in estimating the emissions from unpaved roads. The methodologies are Sections 7.10, 7.10a, and 7.11 for agricultural road of the Emission Inventory Source Category "Road Dust".

Regarding emissions from unpaved equipment and traffic areas, the San Joaquin Valley Air Pollution Control District developed a methodology for assessing PM10 emissions from unpaved traffic area in the San Joaquin Valley using an emission factor and other data identified by ARB. One of the assumptions in the methodology was that there is an average of 10 vehicle trips on unpaved traffic area per day for 240 days of the year (days with no rainfall)[5]. Traffic area includes areas used for parking or storing; shipping, receiving and transfer; and fueling and servicing.

Control Efficiency

The San Joaquin Valley Air Pollution Control District evaluated the reports for the UC Davis and Desert Research Institute research studies and other available data and found that 70% control effectiveness for water application would be appropriate. Therefore, a control efficiency of 70% will be assigned for applying water on unpaved roads and unpaved traffic areas subject to Rule 4550 (CMPs). Please refer to Attachment A for staff's evaluation of this control effectiveness value.

Emission Factor and Emission Reduction Calculation

See methodology for "Chips/Mulch, Organic Materials, Polymers, Road Oil, and Sand".

Sources of information

1. California Air Resources Board, *Section 7.10a: SJV Private Unpaved Road Dust (SJV only) – Farm Roads.* Methods for Assessing Area Source Emissions. May 2004.
2. California Air Resources Board, *Section 7.11: Unpaved Road Dust – Farm Roads.* Methods for Assessing Area Source Emissions. August 1997
3. Air Quality Group, Crocker Nuclear Laboratory, *Evaluation of the Emission of PM10 Particulates from Unpaved Roads in the San Joaquin Valley*, Final Report. University of California, Davis. Prepared for San Joaquin Valley Air Pollution Control District. April 1994.
4. Desert Research Institute, *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Final Report. . Prepared for the California Regional Particulate Air Quality Study. December 1996.
5. San Joaquin Valley Air Pollution Control District, *Assessment of Area Source Emissions from Unpaved Traffic Areas*, March 2003.

Attachment A

District staff: Hector Guerra, Patia Siong

District staff evaluated several documents, and based on the data available it was agreed that one application of water per day could result in an overall 70% control effectiveness under the CMP Program.

The documents reviewed are the following:

1. *Evaluation of the Emission of PM10 Particulates from Unpaved Roads in the San Joaquin Valley*, UC Davis, Crocker Nuclear Laboratory, Robert Flocchini et al., April 1994.
2. *Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads*, Desert Research Institute, December 1996.
3. *Regulation VIII-Criteria for Developing and Evaluating Fugitive PM10 Management Plans*, District, October 2002.
4. *Suggested Water Treatment Levels for Unpaved Roads,* no author, April 2002. Provided by R. Isom and D. Tristao.
5. *Particulate Emission Measurements from Controlled Construction Activities,* Midwest Research Institute, April 2001.

Below are the reviews of the documents.

I. UC Davis results:

Treatment	PM10 Reduction Efficiency	Time of measurement after treatment
Water	87% ± 6% 77%	2hrs and 6 hrs after 22.3 hrs after

a. Comments:

1. No vehicle trip number is provided. It is assumed that one test equals one vehicle trip. About two tests were conducted for each dust suppressant. The vehicle used for this study is a three-fourth ton cargo van with four wheels traveling at 25 mph.
2. The report does not address the frequency of application but does note that the amount of use on a road after application and deterioration of application needs further evaluation.

3. The study indicates that treatments were field tested shortly after application but reduction efficiencies over longer periods of time will be needed.
4. "Watering a road proved to be fairly effective in reducing emissions by an average of 87% ± 6% for a one day period under typical San Joaquin Valley summer conditions (dry and hot)." Page 52
5. The author notes that watering a road and driving on it reduces its potential for PM10 emissions. However, the report does not indicate what the minimum or maximum number of vehicle trips is before water loses its efficiency.

II. Desert Research Institute (DRI) results:

DRI did not evaluate water as a dust suppressant, but evaluated petroleum emulsion/polymer mixture, polymer emulsion, road oils, and biocatalysts with an average of 14 vehicle trips per day.

III. Fugitive PM10 Management Plan (FPMP) finding:

The document states that the FPMP must be designed and implemented to achieve a PM10 control efficiency of a least 50%. The District found water as an accepted control and provided a recommended application rate to meet the 50% requirement.

Accepted Control	Application Rate	Threshold/Time
Water	• 1/day • 2/day • 3/day	• ∠150 VT/day • 151 to 225 VT/day • 226 to 300 VT/day

IV. *Suggested Water Treatment Levels for Unpaved Roads* finding:

This document provides information such as soil textures and their potential for PM10 emissions. Findings from the UC Davis research were also referenced. The document concludes that wetting unpaved roads once per day would be sufficient to maintain greater than 50% PM10 control.

V. Midwest Research Institute finding:

This research evaluated water as a control measure on unpaved roads at construction sites. Water was applied once before each test. One test lasted about one hour with about 70 trips. The equipment used was a scraper traveling at about 11mph. The report discusses loss of moisture content with time after watering and its control efficiency. It shows a decay rate of 12.40% per hour for PM10 and about 70% control efficiency for one test (based on the data referenced by Sierra Research for Regulation VIII analysis.)

IV. General comments:

- It is undetermined as to how many vehicle trips after water is applied that water remains effective at 87% control efficiency.
- It is most likely that growers will water at least once per day and every day during harvest season and also have less than 10 vehicle trips per day during non-harvest season.
- The average control efficiency is 72% using the Midwest Research Institute research as a worst-case scenario. Applying a 12.40% decay rate to UC Davis' control efficiency of 87% provides 87% control for hour #1, 76.21% control for hour #2, 66.76% control for hour #3, and 58.48% control for hour #4.
- The average control efficiency is 69% using 87% as the maximum control efficiency and 50% as an acceptable minimum control efficiency. This is for only one vehicle trip and would continue to decline over time and due to vehicle trips.

Therefore, one application of water is necessary, and an overall 70% control effectiveness should be assigned for water until further evaluation or additional information becomes available.

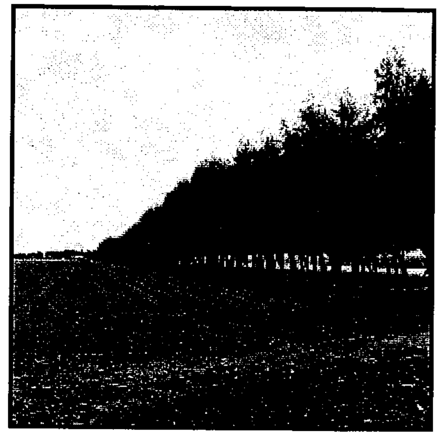
CONSERVATION MANAGEMENT PRACTICE

Emission Reduction Calculation Methodology for Wind Barrier

Description

The practice "Wind Barrier" involves establishing a boundary that disrupts the erosive flow of wind over unpaved roads and areas. Wind barrier reduces the particulate matters emissions typically stirred up in the process due to winds.

The effectiveness of a barrier depends on the height, density, orientation, and length. For instance, it was found that wind barrier reduces wind speeds up to 30 times their height downwind[1], and that the sheltered area is defined as ten times the height on the leeward side and two times the height on the windward side of the barrier[2]. The maximum benefit of using this practice is when the barriers are perpendicular as possible to the prevailing wind direction.



Examples of barrier are continuous board fences, trees, shrubs, conifers, burlap fences, crate walls, bales of hay, etc. A basic requirement is to have a continuous row of barriers. The longer it is, the better protection it provides.

The Natural Resources Conservation Service has a conservation reserve program that addresses reduction of soil erosion from winds and already has developed recommendations on the specifics of wind barrier labeled as windbreak or shelterbelt in their documents. Further information on designs such as types of windbreak and spacing can be found in their practice standard documents[2].

There is a research study[3] that evaluated management practices to address wind erosion in the Northwest Columbia Plateau in the Idaho/Washington/Oregon area with windblown dust problem. With findings available from research studies and the emission factors developed by the California Air Resources Board, it is possible to estimate a control efficiency factor.

Applicable Crops

This practice can be used on the following crop categories where applicable: corn grain and silage, cotton, vegetables/tomatoes/melons/other, sugar beets, dry beans/cereal grains/safflower/wheat/barley, onions and garlic, and nut crops.

CMP Category

This practice is applicable to the CMP category "Other".

Emission Factor

ARB developed emission factors for windblown dust from agricultural lands. The emission factors are based on a wind erosion equation (WEQ) that was developed by the United States Department of Agriculture-Agricultural Research Service that was then revised by ARB to address the conditions in the San Joaquin Valley Air Basin[4]. The emission factors are contained in the methodology for Emission Inventory Source Category Section 7.12.

Control Efficiency

The San Joaquin Valley Air Pollution Control District estimates an average control effectiveness of 30% for preventing windblown dust based on the finding of several sources [5,6,7] that evaluated soil erosion in regards to dust controls.

It was assumed that the minimum barrier density used for wind erosion control is 40%[2] as recommended by the Natural Resources Conservation Service practice standard. This can be achieved using trees or deciduous shrubs from 10 to 25 feet in height spaced about 5 to 10 feet in single row.

A technical supporting document[5] regarding quantification of agricultural best management practices prepared for the Arizona Department of Environmental Quality provides a number of control efficiencies based on several findings:

- A report by Sierra Research assigned a 25% control efficiency for trees,
- A report by Bilbro and Stout showed up to 32.5% control efficiency using a wind fence made from plastic pipe with density of 12% to 75%, and
- A report by Grantz showed control efficiency from 54% to 71%.

Another report conducted by Midwest Research Institute indicates that wind fences in the Antelope Valley can be used effectively to capture saltating sand during high wind events (20 to 47 mph) in the range of 60 to 90%[7] control effectiveness. The report refers to a study that shows PM10 emissions being directly proportioned to the amount of saltating particles thus implying that control of PM10 emissions is possible with wind fences at certain height above ground.

The report also refers to another study conducted in California that found a simultaneous reduction in the mass of particles 38 micrometers (as compared to sand sized particles) and below, which indicates a possible reduction in the emission of particles in the size range of 0 to 15 micrometers.

Emission Reduction Calculation for an Agricultural Parcel

"Other" (windblown PM)

$$\text{Emission Reduction}_{(\text{tons/year})} = \frac{\left[\text{Acreage}_{(\text{acre/year})} \times \text{Emission Factor}_{(\text{lbs/acre/year})} \times \text{Control Efficiency}_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

Where:

Acreage	=	parcel acreage for CMP
Emission Factor	=	windblown PM emission factor[4], 13.56 lbs/acre/year
Control Efficiency	=	CMP efficiency to reduce emissions, 30%

Example:

$$\text{Emission Reduction} = \frac{\left[100_{(\text{acre/year})} \times 13.56_{(\text{lbs/acre/year})} \times 30_{(\%)}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = \frac{\left[406.8_{(\text{lbs/yr})}\right]}{2000_{(\text{lbs/ton})}}$$

$$\text{Emission Reduction} = 0.20 \text{ tons/year}$$

Sources of information

1. Mike Kuhns. Windbreak Benefits and Design. Utah State University Extension. June 1998.
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Appendix C

CMP Control Efficiencies and Emissions Factors

Table 1: Control Effiencies for CMP Alternate Tillage

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f		h= g/d x 100
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00		
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00		
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00		
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.50	0.25	0.30		
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00		
		SUBTOTAL	2		1.00	1.20	1.20			0.25	0.30		
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00		
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00		
	TOTAL							2.64		0.25	0.30	2.34	11%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00		
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00		
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.50	0.25	0.30		
		SUBTOTAL	1		0.50	1.20	0.60			0.25	0.30		
	TOTAL							0.83	0.00	0.25	0.30	0.53	36%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		1.00	0.02	0.25		
		SUBTOTAL	1		0.02	12.50	0.25			0.02	0.25		
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00		
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00		
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00		
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.50	0.38	0.45		
		SUBTOTAL	1		0.75	1.20	0.90			0.38	0.45		
	TOTAL							1.54		0.40	0.70	0.84	45%
	Weighted average							1.82		0.90		1.31	28%

Table 2: Control Effiencies for CMP Application Efficiency

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)			Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)						
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.56	1.20	0.67		0.00	0.00	0.00			
		make border	1	Discing	0.28	1.20	0.33		1.00	0.28	0.33			
		fertilizer .5	0.5	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		finish disc and harrow	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		SUBTOTAL	4.5		1.25	1.20	1.50			0.28	0.33			
	Land Maintenance	chisel field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		laser lever field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		plant	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		irrigate	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		weed winter	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		SUBTOTAL	5		0.20	12.50	2.50			0.00	0.00			
	TOTAL							4.00		0.28	0.33			8%
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			

		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		1.00	0.80			12%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.00	0.00	0.00			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		make ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		irrigate	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		close ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate 4x	4	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	12		2.00	0.80	1.60			1.00	0.80			
	TOTAL							8.90		1.00	0.80			9%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc and roll	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.07	12.50	0.88		0.50	0.04	0.44			
		fertilize 3x	3	Land Planing	0.02	12.50	0.29		0.00	0.00	0.00			
		irrigate 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		pest 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		SUBTOTAL	32		0.25	12.50	3.13			0.04	0.44			
	TOTAL							3.13		0.04	0.44			14%
sugar beet	disc	disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.00	0.00			
	land plane	triplane 2x	2	Land Planing	1.00	12.50	12.50		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	12.50	12.50			0.00	0.00			
	subsoil deep chisel		1	ripping	1.00	4.60	4.60		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	4.60	4.60			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	corrugate	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		flood	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		precision plant and shape	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			

		herbicide 3x ground	3	Discing	0.02	12.50	0.29		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		mechanical thin	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize 2x inject	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		irrigate 12x	12	Discing	0.09	12.50	1.15		0.00	0.00	0.00			
		work ends 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		SUBTOTAL	26		0.20	12.50	2.50			0.00	0.00			
	TOTAL							22.80		1.00	0.80			4%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
	GRAND TOTAL							~~13.00~~		2.00	1.60			12%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	95,887	10%

garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	322	10%
Safflower	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		1.00	0.80	3.70	16,542	18%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.50	0.60	3.10	559,711	16%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		1.00	0.80	9.20	18,806	8%
	WEIGHTED AVERAGE							4.45				3.81		14%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			

		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		1.00	0.80	11.95	28,887	6%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		1.00	0.14	0.11			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.14	0.11			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		0.14	0.11	5.59	90,137	2%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		1.00	0.67	0.53			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.67	0.53			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			

		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		0.67	0.53	9.57	228,250	5%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.03	0.01	0.08			
		SUBTOTAL	1		0.20	12.50	2.50			0.01	0.08			
	Unspecified		1	Discing	5.00	1.20	6.00		0.00	0.00	0.00			
		SUBTOTAL	1		5.00	1.20	6.00			0.00	0.00			
								8.50		0.01	0.08	8.43	81,409	1%
	WEIGHTED AVERAGE							9.05				8.67		4%

Table 3: Control Effiencies for CMP Baling/Large Balers

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB)								
					Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
				a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	haylage 2x	2	4.67	0.01	0.05		0.50	2.33	0.03			
		hay 7x	7	16.33	0.01	0.19		0.00	0.00	0.00			
		SUBTOTAL	9	21.00		0.24			2.33	0.03			
	TOTAL						0.24			0.03			11%
Dry Beans	cut beans		1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL	1	1.00									
	windrow		1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL	1	1.00									
	harvest		1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL	1	1.00		1.75							
	TOTAL			3.00			1.75		0.00	0.00	1.75	95,887	0%
garbanzo			1	1.00	1.68	1.68		0.00	0.00	0.00			
		SUBTOTAL	1	1.00		1.68			0.00	0.00			
	TOTAL						1.68			0.00	1.68	322	0%
Safflower			1	1.00	5.80	5.80		0.25	0.25	1.45			
		SUBTOTAL	1	1.00		5.80			0.25	1.45			
	TOTAL						5.80			1.45		16,542	25%
Wheat			1	1.00	3.73	3.73		0.25	0.25	0.93			
		SUBTOTAL	1	1.00		3.73			0.25	0.93			
	TOTAL						3.73			0.93	2.80	559,711	25%
rice	combine		1	0.01	3.29	0.03		0.25	0.00	0.01			
		SUBTOTAL	1	0.01									
	chop straw		1	0.50	3.29	1.65		0.00	0.00	0.00			
		SUBTOTAL	1	0.50		1.68							
	TOTAL			0.51			1.68		0.00	0.01	1.67	18,806	0.5%
	WEIGHTED AVERAGE						3.45				2.55		26%

Table 4: Control Effiencies for CMP Bed Row Size

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
~~Citrus~~/Tree fruit	Unspecified	discing 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		subsoil	1	Discing	0.01	1.20	0.01		1.00	0.01	0.01			
		level ground	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		irrigate	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		fertilizer 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		weed discing 3x	3	Discing	0.02	1.20	0.02		0.00	0.00	0.00			
		soil amendments	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		SUBTOTAL	11		0.06	1.20	0.07			0.01	0.01			
	TOTAL							0.07		0.01	0.01			9%
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		1.00	0.80			12%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.00	0.00	0.00			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			

		make ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		irrigate	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		close ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate 4x	4	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	12		2.00	0.80	1.60			1.00	0.80			
	TOTAL							8.90		1.00	0.80			9%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc and roll	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.07	12.50	0.88		0.50	0.04	0.44			
		fertilize 3x	3	Land Planing	0.02	12.50	0.29		0.00	0.00	0.00			
		irrigate 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		pest 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		SUBTOTAL	32		0.25	12.50	3.13			0.04	0.44			
	TOTAL							3.13		0.04	0.44			14%
sugar beet	disc	disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.00	0.00			
	land plane	triplane 2x	2	Land Planing	1.00	12.50	12.50		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	12.50	12.50			0.00	0.00			
	subsoil deep chisel		1	ripping	1.00	4.60	4.60		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	4.60	4.60			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	corrugate	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		flood	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		precision plant and shape	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		herbicide 3x ground	3	Discing	0.02	12.50	0.29		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		mechanical thin	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize 2x inject	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		irrigate 12x	12	Discing	0.09	12.50	1.15		0.00	0.00	0.00			
		work ends 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		SUBTOTAL	26		0.20	12.50	2.50			0.00	0.00			
	TOTAL							22.80		1.00	0.80			4%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			

		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
	GRAND TOTAL							~~13.00~~		2.00	1.60			12%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	TOTAL							2.64		1.00	0.80	1.84	192,980	30%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.12	0.06	0.07			
		SUBTOTAL	1		0.50	1.20	0.60			0.06	0.07			
	TOTAL							0.83		0.06	0.07	0.76	75,895	9%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.50	0.10	0.08			
		SUBTOTAL	1		0.20	0.80	0.16			0.10	0.08			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.00	0.00	0.00			
		SUBTOTAL	1		0.75	1.20	0.90			0.00	0.00			
	TOTAL							1.54		0.10	0.08	1.46	303,035	5%
	Weighted average							1.82		1.16		1.50		18%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			

	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	95,887	10%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	322	10%
Safflower	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		1.00	0.80	3.70	16,542	18%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.50	0.60	3.10	559,711	16%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		1.00	0.80	9.20	18,806	8%
	WEIGHTED AVERAGE							4.45				3.81		14%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			

		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		1.00	0.80	11.95	28,887	6%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		1.00	0.14	0.11			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.14	0.11			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		0.14	0.11	5.59	90,137	2%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		1.00	0.67	0.53			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.67	0.53			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		0.67	0.53	9.57	228,250	5%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.03	0.01	0.08			
		SUBTOTAL	1		0.20	12.50	2.50			0.01	0.08			
	Unspecified		1	Discing	5.00	1.20	6.00		0.00	0.00	0.00			
		SUBTOTAL	1		5.00	1.20	6.00			0.00	0.00			
								8.50		0.01	0.08	8.43	81,409	1%
	WEIGHTED AVERAGE							9.05				8.67		4%

Table 5: Control Effiencies for CMP Chemigation/Fertigation

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)								
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.56	1.20	0.67		0.00	0.00	0.00			
		make border	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		fertilizer .5	0.5	Discing	0.14	1.20	0.17		0.50	0.07	0.08			
		finish disc and harrow	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		SUBTOTAL	4.5		1.25	1.20	1.50			0.07	0.08			
	Land Maintenance	chisel field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		laser lever field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		plant	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		irrigate	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		weed winter	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		SUBTOTAL	5		0.20	12.50	2.50			0.00	0.00			
	TOTAL							4.00		0.07	0.08			2%
Citrus	Unspecified	discing 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		subsoil	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		level ground	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		irrigate	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		fertilizer 2x	2	Discing	0.01	1.20	0.01		0.50	0.01	0.01			
		weed discing 3x	3	Discing	0.02	1.20	0.02		0.00	0.00	0.00			
		soil amendments	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		SUBTOTAL	11		0.06	1.20	0.07			0.01	0.01			
	TOTAL							0.07		0.01	0.01			9%
Corn	List and Fertilize		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			

		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.50	0.05	0.05			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		SUBTOTAL	11		1.00	1.20	1.20			0.05	0.05			
	TOTAL							6.90		0.05	0.05			1%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.00	0.00	0.00			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		make ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		irrigate	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		close ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate 4x	4	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	12		2.00	0.80	1.60			1.00	0.80			
	TOTAL							8.90		1.00	0.80			9%
Almonds	float	laser lever field	1	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.03	12.50	0.39		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.03	12.50	0.39		0.00	0.00	0.00			
		disc and roll	1	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.14	12.50	1.76		0.50	0.07	0.88			
		fertilize 3x	1	Land Planing	0.02	12.50	0.20		0.50	0.01	0.10			
		irrigate 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		pest 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		SUBTOTAL	16		0.25	12.50	3.13			0.08	0.98			
	TOTAL							3.13		0.08	0.98			31%

sugar beet	disc	disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.00	0.00			
	land plane	triplane 2x	2	Land Planing	1.00	12.50	12.50		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	12.50	12.50			0.00	0.00			
	subsoil deep chisel		1	ripping	1.00	4.60	4.60		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	4.60	4.60			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	corrugate	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		flood	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize	1	Discing	0.01	12.50	0.10			0.00	0.00			
		precision plant and shape	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		herbicide 3x ground	3	Discing	0.02	12.50	0.29		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		mechanical thin	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize 2x inject	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		irrigate 12x	12	Discing	0.09	12.50	1.15		0.00	0.00	0.00			
		work ends 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		SUBTOTAL	26		0.20	12.50	2.50			0.00	0.00			
	TOTAL							22.80		1.00	0.80			3.5%
onions	list		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		0.50	0.40			6%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			

		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		0.50	0.40			6%
	GRAND TOTAL							~~13.00~~		1.00	0.80			6%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.50	0.10	0.08			
		SUBTOTAL	1		0.20	0.80	0.16			0.10	0.08			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	TOTAL							2.64		0.10	0.08	2.56	192,980	3%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	TOTAL							0.83		0.00	0.00	0.83	75,895	0%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.50	0.10	0.08			
		SUBTOTAL	1		0.20	0.80	0.16			0.10	0.08			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.00	0.00	0.00			
		SUBTOTAL	1		0.75	1.20	0.90			0.00	0.00			
	TOTAL							1.54		0.10	0.08	1.46	303,035	5%
	Weighted average							1.82		0.20		1.75		4%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			

	TOTAL							7.70		0.50	0.40	7.30	95,887	5%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	TOTAL							7.70		0.50	0.40	7.30	322	5%
Safflower	list		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		0.50	0.40	4.10	16,542	9%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.50	0.03	0.31			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.03	0.31			
	TOTAL							3.70		0.03	0.31	3.39	559,711	8%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		0.50	0.40	9.60	18,806	4%
	WEIGHTED AVERAGE							4.45				4.12		7%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			

		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		0.50	0.40	12.35	28,887	3%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		0.50	0.07	0.06			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.07	0.06			
	disc	disc 2x	2	Discing	0.29	1.20	0.34		0.00	0.00	0.00			
		disc 2x	2	Discing	0.29	1.20	0.34		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		furrow out	1	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		irrigate 5x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		0.07	0.06	5.64	90,137	1%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		0.50	0.33	0.27			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.33	0.27			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			

	Land Maintenance	triplane	2	Discing	0.04	12.50	0.56		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.28		0.00	0.00	0.00			
		irrigate furrow	0	Discing	0.00	12.50	0.00		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.28		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.11	12.50	1.39		0.00	0.00	0.00			
		SUBTOTAL	9		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		0.33	0.27	9.83	228,250	3%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Unspecified		1	Discing	5.00	1.20	6.00		0.00	0.00	0.00			
		SUBTOTAL	1		5.00	1.20	6.00			0.00	0.00			
								8.50		0.00	0.00	8.50	81,409	0%
	WEIGHTED AVERAGE							9.05				8.87		2%

Table 6: Control Effiencies for CMP Conservation Irrigation

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.56	1.20	0.67		0.00	0.00	0.00			
		make border	1	Discing	0.28	1.20	0.33		0.66	0.18	0.22			
		fertilizer .5	0.5	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		finish disc and harrow	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		SUBTOTAL	4.5		1.25	1.20	1.50			0.18	0.22			
	Land Maintenance	chisel field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		laser lever field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		plant	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		irrigate	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		weed winter	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		SUBTOTAL	5		0.20	12.50	2.50			0.00	0.00			
	TOTAL							4.00		0.18	0.22			6%
Citrus/Tree fruit	Unspecified	discing 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		subsoil	1	Discing	0.01	1.20	0.01		1.00	0.01	0.01			
		level ground	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		irrigate	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		fertilizer 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		weed discing 3x	3	Discing	0.02	1.20	0.02		0.00	0.00	0.00			
		soil amendments	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		SUBTOTAL	11		0.06	1.20	0.07			0.01	0.01			
	TOTAL							0.07		0.01	0.01			9%
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			

		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		1.00	0.80			12%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.00	0.00	0.00			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		make ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		irrigate	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		close ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate 4x	4	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	12		2.00	0.80	1.60			1.00	0.80			
	TOTAL							8.90		1.00	0.80			9%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc and roll	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.07	12.50	0.88		0.50	0.04	0.44			
		fertilize 3x	3	Land Planing	0.02	12.50	0.29		0.00	0.00	0.00			
		irrigate 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		pest 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		SUBTOTAL	32		0.25	12.50	3.13			0.04	0.44			
	TOTAL							3.13		0.04	0.44			14%
sugar beet	disc	disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			

		SUBTOTAL	4		1.00	1.20	1.20			0.00	0.00			
	land plane	triplane 2x	2	Land Planing	1.00	12.50	12.50		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	12.50	12.50			0.00	0.00			
	subsoil deep chisel		1	ripping	1.00	4.60	4.60		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	4.60	4.60			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	corrugate	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		flood	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		precision plant and shape	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		herbicide 3x ground	3	Discing	0.02	12.50	0.29		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		mechanical thin	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize 2x inject	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		irrigate 12x	12	Discing	0.09	12.50	1.15		0.00	0.00	0.00			
		work ends 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		SUBTOTAL	26		0.20	12.50	2.50			0.00	0.00			
	TOTAL							22.80		1.00	0.80			4%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			

		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
	GRAND TOTAL							~~13.00~~		2.00	1.60			12%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	TOTAL							2.64		1.00	0.80	1.84	192,980	30%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.12	0.06	0.07			
		SUBTOTAL	1		0.50	1.20	0.60			0.06	0.07			
	TOTAL							0.83		0.06	0.07	0.76	75,895	9%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.50	0.10	0.08			
		SUBTOTAL	1		0.20	0.80	0.16			0.10	0.08			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.00	0.00	0.00			
		SUBTOTAL	1		0.75	1.20	0.90			0.00	0.00			
	TOTAL							1.54		0.10	0.08	1.46	303,035	5%
	Weighted average							1.82		1.16		1.50		18%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	95,887	10%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			

	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	322	10%
Safflower	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		1.00	0.80	3.70	16,542	18%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.50	0.60	3.10	559,711	16%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		1.00	0.80	9.20	18,806	8%
	WEIGHTED AVERAGE							4.45				3.81		14%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			

		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		1.00	0.80	11.95	28,887	6%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		1.00	0.14	0.11			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.14	0.11			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		0.14	0.11	5.59	90,137	2%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		1.00	0.67	0.53			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.67	0.53			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			

		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		0.67	0.53	9.57	228,250	5%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.03	0.01	0.08			
		SUBTOTAL	1		0.20	12.50	2.50			0.01	0.08			
	Unspecified		1	Discing	5.00	1.20	6.00		0.00	0.00	0.00			
		SUBTOTAL	1		5.00	1.20	6.00			0.00	0.00			
								8.50		0.01	0.08	8.43	81,409	1%
	WEIGHTED AVERAGE							9.05				8.67		4%

Table 7: Control Effiencies for CMP Conservation Tillage

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	2		1.00	1.20	1.20			1.00	1.20			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		2.00	2.40			35%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		1.00	1.33	1.60			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			1.33	1.60			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			

	Seed bed preparation	list beds	1	Weeding	0.18	0.80	0.15		1.00	0.18	0.15			
		make ditch	1	Weeding	0.18	0.80	0.15		1.00	0.18	0.15			
		spray and incorporate herbicide	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00			
		irrigate	0	Weeding	0.00	0.80	0.00		0.00	0.00	0.00			
		close ditch	1	Weeding	0.18	0.80	0.15		1.00	0.18	0.15			
		cultivate preplant	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00			
		plant	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.18	0.80	0.15		1.00	0.18	0.15			
		cultivate 4x	4	Weeding	0.73	0.80	0.58		0.50	0.36	0.29			
		SUBTOTAL	11		2.00	0.80	1.60			1.09	0.87			
	TOTAL							8.90		2.42	2.47			28%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc and roll	1	Land Planing	0.01	12.50	0.10		1.00	0.01	0.10			
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.07	12.50	0.88		0.00	0.00	0.00			
		fertilize 3x	3	Land Planing	0.02	12.50	0.29		0.00	0.00	0.00			
		irrigate 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		pest 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		SUBTOTAL	32		0.25	12.50	3.13			0.01	0.10			
	TOTAL							3.13		0.01	0.10			3%
sugar beet	disc	disc 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60			
	land plane	triplane 2x	2	Land Planing	1.00	12.50	12.50		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	12.50	12.50			0.00	0.00			
	subsoil deep chisel		1	ripping	1.00	4.60	4.60		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	4.60	4.60			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	Land Maintenance	corrugate	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		flood	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		precision plant and shape	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		herbicide 3x ground	3	Discing	0.02	12.50	0.29		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		mechanical thin	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize 2x inject	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		irrigate 12x	12	Discing	0.09	12.50	1.15		0.00	0.00	0.00			

		work ends 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		SUBTOTAL	26		0.20	12.50	2.50			0.00	0.00			
	TOTAL							22.80		0.50	0.60			3%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		1.00	0.20	0.24			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.20	0.24			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		0.20	0.24			4%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20			
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		1.00	1.20			18%
	GRAND TOTAL							~~13.00~~		1.20	1.44			11%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		SUBTOTAL	2		1.00	1.20	1.20			0.50	0.60			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	TOTAL							2.64		0.50	0.60	2.04	192,980	23%

grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.50	0.25	0.30			
		SUBTOTAL	1		0.50	1.20	0.60			0.25	0.30			
	TOTAL							0.83		0.25	0.30	0.53	75,895	36%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.50	0.38	0.45			
		SUBTOTAL	1		0.75	1.20	0.90			0.38	0.45			
	TOTAL							1.54		0.38	0.45	1.09	303,035	29%
	Weighted average							1.82		1.13		1.34		26%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	discing		1	Discing	2.00	1.20	2.40		1.00	2.00	2.40			
		SUBTOTAL	1		2.00	1.20	2.40			2.00	2.40			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		2.00	2.40	5.30	95,887	31%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	discing		1	Discing	2.00	1.20	2.40		1.00	2.00	2.40			
		SUBTOTAL	1		2.00	1.20	2.40			2.00	2.40			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		2.00	2.40	5.30	322	31%
Safflower	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.50	0.50	0.60			
		SUBTOTAL	1		1.00	1.20	1.20			0.50	0.60			

	TOTAL							4.50		0.50	0.60	3.90	16,542	13%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.50	0.60	3.10	559,711	16%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		1.00	1.20	8.80	18,806	12%
	WEIGHTED AVERAGE							4.45				3.58		19%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.60			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			

	TOTAL							12.75		0.00	0.60	12.15	28,887	5%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.00	0.00			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		1.00	0.17	0.20			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.17	0.20			
	TOTAL							5.70		0.17	0.20	5.50	90,137	4%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.00	0.00			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		1.00	2.50	3.00			
		SUBTOTAL	4		5.00	1.20	6.00			2.50	3.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		2.50	3.00	7.10	228,250	30%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Unspecified		1	Discing	5.00	1.20	6.00		0.50	2.50	3.00			
		SUBTOTAL	1		5.00	1.20	6.00			2.50	3.00			
								8.50		2.50	3.00	5.50	81,409	35%
	WEIGHTED AVERAGE							9.05				6.80		25%
Tree fruit	Unspecified	discing 2x	2	Discing	0.18	1.20	0.22		0.50	0.09	0.11			
		subsoil	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		level ground	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			

		fertilizer 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00				
		weed discing 3x	3	Discing	0.27	1.20	0.33		0.00	0.00	0.00				
		soil amendments	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00				
		SUBTOTAL	11		0.06	1.20	1.20			0.09	0.11				
	TOTAL							1.20		0.09	0.11				9%

Table 8: Control Effiencies for CMP Continuous Tray/Dried-on-Vines

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB)								
					Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
				a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
grapes-raisin	machine harvest		1	0.01	0.65	0.01		0.00	0.00	0.00			
		SUBTOTAL	1	0.01									
	trailer activity	turn and roll	1	0.08	0.65	0.05		1.00	0.08	0.05			
		box and shake	1	0.08	0.65	0.05		0.00	0.00	0.00			
		haul to packer	1	0.08	0.65	0.05		0.00	0.00	0.00			
		SUBTOTAL	3	0.25		0.17							
	TOTAL			0.26			0.17		0.08	0.05	0.12	192,980	32%

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)								
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1	0.8	0.80			1.00	0.80			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.2	0.8	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.6	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1	1.2	1.20			0.00	0.00			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.5	0.25			0.00	0.00			
	TOTAL							2.64		1.00	0.80	1.84	192,980	30%

Table 9: Control Effiencies for CMP Cover Crops

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)								
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.17		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.03	12.50	0.35		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.03	12.50	0.35		1.00	0.03	0.35			
		disc and roll	1	Land Planing	0.01	12.50	0.17		0.00	0.00	0.00			
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.13	12.50	1.56		0.50	0.06	0.78			
		fertilize 3x	3	Land Planing	0.04	12.50	0.52		0.00	0.00	0.00			
		irrigate 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		pest 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		SUBTOTAL	18		0.25	12.50	3.13			0.09	1.13			
	TOTAL							3.13		0.09	1.13			36%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		SUBTOTAL	2		1.00	1.20	1.20			0.50	0.60			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	TOTAL							2.64		0.50	0.60	2.04	192,980	23%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.50	0.25	0.30			
		SUBTOTAL	1		0.50	1.20	0.60			0.25	0.30			
	TOTAL							0.83		0.25	0.30	0.53	75,895	36%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			

	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.50	0.38	0.45			
		SUBTOTAL	1		0.75	1.20	0.90			0.38	0.45			
	TOTAL							1.54		0.38	0.45	1.09	303,035	29%
	Weighted average							1.82		1.13		1.34		26%
Citrus	Unspecified	discing 2x	2	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		level ground	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		irrigate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		fertilizer 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		weed discing 3x	3	Discing	1.50	1.20	1.80		0.33	0.50	0.59			
		soil amendments	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	11		0.06	1.20	6.60			1.50	1.79			
	TOTAL							6.60		1.50	1.79			27%

Table 10: Control Effiencies for CMP Floor Management

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)			Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Control Efficiency (%)
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)				
					a	b	c = a x b	d	e	f = a x e	g = b x f	h= g/d x 100
Almonds	float	laser lever field	1	Land Planing	0.04	12.50	0.52		0.00	0.00	0.00	
		subsoil 2x	2	Land Planing	0.08	12.50	1.04		1.00	0.08	1.04	
		disc 2x	2	Land Planing	0.08	12.50	1.04		0.50	0.04	0.52	
		disc and roll	1	Land Planing	0.04	12.50	0.52		0.00	0.00	0.00	
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		weed 9x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		fertilize 3x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		irrigate 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		pest 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		SUBTOTAL	6		0.25	12.50	3.13			0.13	1.56	
	TOTAL							3.13		0.13	1.56	50%

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB)			Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Control Efficiency (%)
					Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)				
				a	b	c = a x b	d	e	f = a x e	g = b x f	h= g/d x 100
Almonds		shake trees	1	1.00	9.13	9.13		0.00	0.00	0.00	
		sweep nuts	1	1.00	9.13	9.13		1.00	1.00	9.13	
		hand rake	0	0.00	9.13	0.00		0.00	0.00	0.00	
		pick up and haul	1	1.00	9.13	9.13		0.00	0.00	0.00	
		hull nuts	1	1.00	9.13	9.13		0.00	0.00	0.00	
		SUBTOTAL	4	4.00					1.00	9.13	
	TOTAL						36.50		1.00	9.13	25%

Table 11: Control Effiencies for CMP Green Chop

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB)								
					Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
				a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	haylage 2x	0	0.00	0.011	0.000		0.00	0.00	0.00			
		hay 7x	7	21.00	0.011	0.240		0.10	2.10	0.02			
		SUBTOTAL	7	21		0.240			2.10	0.02			
	TOTAL						0.24			0.02			10.00%
Corn		cut	1	0.33	0.43	0.14		0.0	0.0	0.0			
		haul	1	0.33	0.43	0.14		0.5	0.2	0.1			
		pack	1	0.33	0.43	0.14		0.0	0.0	0.0			
		SUBTOTAL	3	1.00		0.43			0.17	0.07			
	TOTAL						0.43			0.07			16.67%
Dry Beans	cut beans		1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL	1	1.00									
	windrow		1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL	1	1									
	harvest		1	1.00	0.58	0.58		0.50	0.50	0.29			
		SUBTOTAL	1	1		1.75							
	TOTAL			3.00			1.75		0.50	0.29	1.46	95,887	16.7%
garbanzo			1	1.0	1.7	1.7		0.2	0.2	0.3			
		SUBTOTAL	1	1		1.7			0.17	0.28			
	TOTAL						1.68			0.28	1.40	322	16.5%
Safflower			1	1.0	5.8	5.8		0.2	0.2	1.0			
		SUBTOTAL	1	1		5.8			0.17	0.96			
	TOTAL						5.80			0.96		16,542	16.5%
Wheat			1	1.0	3.7	3.7		0.2	0.2	0.6			
		SUBTOTAL	1	1		3.7			0.17	0.62			
	TOTAL						3.73			0.62	3.11	559,711	16.5%
rice	combine		1	0.01	3.29	0.03		0.00	0.00	0.00			
		SUBTOTAL	1	0.01									
	chop straw		1	0.50	3.29	1.65		0.17	0.08	0.27			
		SUBTOTAL	1	0.5		1.68							
	TOTAL			0.51			1.68		0.08	0.27	1.41	18,806	16.2%
	WEIGHTED AVERAGE						3.45				2.76		19.87%

Table 12: Control Effiencies for CMP Hand harvesting

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
				a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Citrus	hand pick	pick	1	0.33	0.14	0.05		1.00	0.33	0.05			
		pack	1	0.33	0.14	0.05		0.00	0.00	0.00			
		haul	1	0.33	0.14	0.05		0.00	0.00	0.00			
		SUBTOTAL	3	1.00	0.00	0.14			0.33	0.05			
	TOTAL						0.14			0.05			33%
Corn		cut	1	0.33	0.43	0.14		1.00	0.33	0.14			
		haul	1	0.33	0.43	0.14		0.00	0.00	0.00			
		pack	1	0.33	0.43	0.14		0.00	0.00	0.00			
		SUBTOTAL	3	1.00		0.43			0.33	0.14			
	TOTAL						0.43			0.14			33%
onions	top	top	1	1.00	0.56	0.56		1.00	1.00	0.56			
	undercut	dig	1	1.00	0.56	0.56		0.00	0.00	0.00			
	windrow	haul/sell	1	1.00	0.56	0.56		0.00	0.00	0.00			
		SUBTOTAL	3	3.00		1.68			1.00	0.56			
	TOTAL						1.68			0.56			33%
garlic	top	top	1	1.00	0.56	0.56		0.00	0.00	0.00			
	undercut	dig	1	1.00	0.56	0.56		0.00	0.00	0.00			
	windrow	haul/sell	1	1.00	0.56	0.56		0.00	0.00	0.00			
		SUBTOTAL	3	3.00		1.68			0.00	0.00			
	TOTAL						1.68			0.00			0%
							3.36			0.56			17%
grapes-raisin	machine harvest		1	0.01	0.65	0.01		1.00	0.01	0.01			
		SUBTOTAL	1	0.01									
	trailer activity	turn and roll	1	0.08	0.65	0.05		0.00	0.00	0.00			
		box and shake	1	0.08	0.65	0.05		0.50	0.04	0.03			
		haul to packer	1	0.08	0.65	0.05		0.00	0.00	0.00			
		SUBTOTAL	3	0.25		0.17							

	TOTAL			0.26			0.17		0.05	0.03	0.14	192,980	20%
grapes-table	machine harvest		1	0.01	0.65	0.01		1.00	0.01	0.01			
		SUBTOTAL	1	0.01									
	trailer activity		1	0.25	0.65	0.16		0.33	0.08	0.05			
		SUBTOTAL	1	0.25		0.17							
	TOTAL			0.26			0.17		0.09	0.06	0.11	75,895	36%
grapes-wine	machine harvest		1	0.01	0.65	0.01		1.00	0.01	0.01			
		SUBTOTAL	1	0.01									
	trailer activity		1	0.25	0.65	0.16		0.33	0.08	0.05			
		SUBTOTAL	1	0.25		0.17							
	TOTAL			0.26			0.17		0.09	0.06	0.11	303,035	36%
	WEIGHTED AVERAGE						0.17				0.12		30%
lettuce			1	1.00	0.08	0.08		0.33	0.33	0.03			
		SUBTOTAL	1	1.00		0.08			0.33	0.03			
	TOTAL						0.08			0.03	0.05	28,887	33%
melon			1	1.00	0.55	0.55		0.33	0.33	0.18			
	TOTAL		1	1.00			0.55		0.00	0.18	0.37	90,137	33%
tomatoes	machine harvest	open harvest lane	1	0.33	0.15	0.05		0.00	0.00	0.00			
		harvest	1	0.33	0.15	0.05		1.00	0.33	0.05			
		in field hauling	1	0.33	0.15	0.05		0.00	0.00	0.00			
		SUBTOTAL	3	1.00		0.15			0.33	0.05			
	TOTAL						0.15			0.05	0.10	228,250	33%
vegetables			1	1.00	0.15	0.15		0.33	0.33	0.05			
	TOTAL		1	1.00			0.15		0.00	0.05	0.10	81,409	33%
	WEIGHTED AVERAGE						0.23				0.15		33%

Table 13: Control Effiencies for CMP Integrated Pest Management (CMP Category Other)

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.56	1.20	0.67		0.00	0.00	0.00			
		make border	1	Discing	0.28	1.20	0.33		1.00	0.28	0.33			
		fertilizer .5	0.5	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		finish disc and harrow	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		SUBTOTAL	4.5		1.25	1.20	1.50			0.28	0.33			
	Land Maintenance	chisel field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		laser lever field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		plant	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		irrigate	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		weed winter	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		SUBTOTAL	5		0.20	12.50	2.50			0.00	0.00			
	TOTAL							4.00		0.28	0.33			8%
Citrus/Tree fruit	Unspecified	discing 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		subsoil	1	Discing	0.01	1.20	0.01		1.00	0.01	0.01			
		level ground	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		irrigate	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		fertilizer 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		weed discing 3x	3	Discing	0.02	1.20	0.02		0.00	0.00	0.00			
		soil amendments	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		SUBTOTAL	11		0.06	1.20	0.07			0.01	0.01			
	TOTAL							0.07		0.01	0.01			9%
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			

	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		1.00	0.80			12%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.00	0.00	0.00			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		make ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		irrigate	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		close ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate 4x	4	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	12		2.00	0.80	1.60			1.00	0.80			
	TOTAL							8.90		1.00	0.80			9%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.02	12.50	0.20		0.00	0.00	0.00			
		disc and roll	1	Land Planing	0.01	12.50	0.10		0.00	0.00	0.00			

		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.07	12.50	0.88		0.50	0.04	0.44			
		fertilize 3x	3	Land Planing	0.02	12.50	0.29		0.00	0.00	0.00			
		irrigate 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		pest 7x	7	Land Planing	0.05	12.50	0.68		0.00	0.00	0.00			
		SUBTOTAL	32		0.25	12.50	3.13			0.04	0.44			
	TOTAL							3.13		0.04	0.44			14%
sugar beet	disc	disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.00	0.00			
	land plane	triplane 2x	2	Land Planing	1.00	12.50	12.50		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	12.50	12.50			0.00	0.00			
	subsoil deep chisel		1	ripping	1.00	4.60	4.60		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	4.60	4.60			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	corrugate	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		flood	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		precision plant and shape	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		herbicide 3x ground	3	Discing	0.02	12.50	0.29		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		mechanical thin	1	Discing	0.01	12.50	0.10		0.00	0.00	0.00			
		fertilize 2x inject	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		irrigate 12x	12	Discing	0.09	12.50	1.15		0.00	0.00	0.00			
		work ends 2x	2	Discing	0.02	12.50	0.19		0.00	0.00	0.00			
		SUBTOTAL	26		0.20	12.50	2.50			0.00	0.00			
	TOTAL							22.80		1.00	0.80			4%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			

	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
	GRAND TOTAL							13.00		2.00	1.60			12%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	TOTAL							2.64		1.00	0.80	1.84	192,980	30%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.12	0.06	0.07			
		SUBTOTAL	1		0.50	1.20	0.60			0.06	0.07			
	TOTAL							0.83		0.06	0.07	0.76	75,895	9%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			

	spring tooth		1	Weeding	0.20	0.80	0.16		0.50	0.10	0.08			
		SUBTOTAL	1		0.20	0.80	0.16			0.10	0.08			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.00	0.00	0.00			
		SUBTOTAL	1		0.75	1.20	0.90			0.00	0.00			
	TOTAL							1.54		0.10	0.08	1.46	303,035	5%
	Weighted average							1.82		1.16		1.50		18%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	95,887	10%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	322	10%
Safflower	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		1.00	0.80	3.70	16,542	18%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			

		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.50	0.60	3.10	559,711	16%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		1.00	0.80	9.20	18,806	8%
	WEIGHTED AVERAGE							4.45				3.81		14%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			

		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		1.00	0.80	11.95	28,887	6%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		1.00	0.14	0.11			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.14	0.11			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		0.14	0.11	5.59	90,137	2%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		1.00	0.67	0.53			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.67	0.53			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		0.67	0.53	9.57	228,250	5%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.03	0.01	0.08			
		SUBTOTAL	1		0.20	12.50	2.50			0.01	0.08			
	Unspecified		1	Discing	5.00	1.20	6.00		0.00	0.00	0.00			
		SUBTOTAL	1		5.00	1.20	6.00			0.00	0.00			
								8.50		0.01	0.08	8.43	81,409	1%

	WEIGHTED AVERAGE						9.05				8.67		4%

Table 14: Control Effiencies for CMP Integrated Pest Management (CMP Category Land Preparation)

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)						
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f	h= g/d x 100
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80	
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80	
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00	
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00	
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00	
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00	
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00	
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00	
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00	
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00	
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00	
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00	
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00	
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00	
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00	
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00	
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00	
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00	
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00	
		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00	
	TOTAL							6.90		1.00	0.80	12%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.50	0.67	0.80	
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00	
		SUBTOTAL	3		4.00	1.20	4.80			0.67	0.80	
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00	
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00	
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00	
		make ditch	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00	
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00	
		irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00	
		close ditch	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00	
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13	
		plant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13	

		uncap beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13	
		cultivate 4x	4	Weeding	0.67	0.80	0.53		1.00	0.67	0.53	
		SUBTOTAL	12		2.00	0.80	1.60			1.17	0.93	
	TOTAL							8.90		1.83	1.73	19%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.17		0.00	0.00	0.00	
		subsoil 2x	2	Land Planing	0.03	12.50	0.35		0.00	0.00	0.00	
		disc 2x	2	Land Planing	0.03	12.50	0.35		0.00	0.00	0.00	
		disc and roll	1	Land Planing	0.01	12.50	0.17		0.00	0.00	0.00	
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		weed 9x	9	Land Planing	0.13	12.50	1.56		0.50	0.06	0.78	
		fertilize 3x	3	Land Planing	0.04	12.50	0.52		0.00	0.00	0.00	
		irrigate 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		pest 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00	
		SUBTOTAL	18		0.25	12.50	3.13			0.06	0.78	
	TOTAL							3.13		0.06	0.78	25%

Table 15: Control Effiencies for CMP Mulching under Land Preparation

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		1.00	0.80			12%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			

		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20			
	TOTAL							6.50		1.00	1.20			18%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20			
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		1.00	1.20			18%
	GRAND TOTAL							~~13.00~~		2.00	2.40			18%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.50	0.25	0.30			
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.25	0.30			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	TOTAL							2.64		0.25	0.30	2.34	192,980	11%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.50	0.25	0.30			
		SUBTOTAL	1		0.50	1.20	0.60			0.25	0.30			
	TOTAL							0.83		0.25	0.30	0.53	75,895	36%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.50	0.38	0.45			
		SUBTOTAL	1		0.75	1.20	0.90			0.38	0.45			

	TOTAL							1.54		0.38	0.45	1.09	303,035	29%
	Weighted average							1.82		0.88		1.44		21%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		0.50	0.40	7.30	95,887	5%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		0.50	0.40	7.30	322	5%
Safflower	list		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		0.50	0.40	4.10	16,542	9%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		0.50	0.25	0.30			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.25	0.30			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.25	0.30	3.40	559,711	8%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			

	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		0.00	0.00	10.00	18,806	0%
	WEIGHTED AVERAGE							4.45				4.14		7%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20			
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		1.00	1.20	11.55	28,887	9%
melon	plow		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20			
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.00	0.00			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			

		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		1.00	1.20	4.50	90,137	21%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.00	0.00			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		1.00	0.04	0.50			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.04	0.50			
	TOTAL							10.10		0.04	0.50	9.60	228,250	5%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Unspecified		1	Discing	5.00	1.20	6.00		0.50	2.50	3.00			
		SUBTOTAL	1		5.00	1.20	6.00			2.50	3.00			
								8.50		2.50	3.00	5.50	81,409	35%
	WEIGHTED AVERAGE							9.05				7.88		13%

Table 16: Control Effiencies for CMP Non-tillage/Chemical tillage

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)								
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.56	1.20	0.67		0.00	0.00	0.00			
		make border	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		fertilizer .5	0.5	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		finish disc and harrow	1	Discing	0.28	1.20	0.33		1.00	0.28	0.33			
		SUBTOTAL	4.5		1.25	1.2	1.50			0.28	0.33			
	Land Maintenance	chisel field	1	Land Planing	0.0	12.5	0.5		0.0	0.0	0.0			
		laser lever field	1	Land Planing	0.0	12.5	0.5		0.0	0.0	0.0			
		plant	1	Land Planing	0.0	12.5	0.5		0.0	0.0	0.0			
		irrigate	1	Land Planing	0.0	12.5	0.5		0.0	0.0	0.0			
		weed winter	1	Land Planing	0.0	12.5	0.5		0.0	0.0	0.0			
		SUBTOTAL	5		0.2	12.5	2.5			0.00	0.00			
	TOTAL							4.00		0.28	0.33			8%
Citrus	Unspecified	discing 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		subsoil	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		level ground	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		irrigate	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		fertilizer 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		weed discing 3x	3	Discing	0.02	1.20	0.02		1.00	0.02	0.02			
		soil amendments	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00			
		SUBTOTAL	10		0.06	1.2	0.07			0.02	0.02			
	TOTAL							0.07		0.02	0.02			30%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.17		0.00	0.00	0.00			
		subsoil 2x	2	Land Planing	0.03	12.50	0.35		0.00	0.00	0.00			
		disc 2x	2	Land Planing	0.03	12.50	0.35		0.00	0.00	0.00			

		disc and roll	1	Land Planing	0.01	12.50	0.17		0.00	0.00	0.00			
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		weed 9x	9	Land Planing	0.13	12.50	1.56		0.50	0.06	0.78			
		fertilize 3x	3	Land Planing	0.04	12.50	0.52		0.00	0.00	0.00			
		irrigate 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		pest 7x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00			
		SUBTOTAL	18		0.25	12.5	3.13			0.06	0.78			
	TOTAL							3.125		0.06	0.78			25%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1	0.8	0.80			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.50	0.10	0.08			
		SUBTOTAL	1		0.2	0.8	0.16			0.10	0.08			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.6	0.23			0.00	0.00			
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1	1.2	1.20			0.00	0.00			
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.5	0.25			0.00	0.00			
	TOTAL							2.64		0.10	0.08	2.56	192,980	3%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.6	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.50	0.25	0.30			
		SUBTOTAL	1		0.5	1.2	0.60			0.25	0.30			
	TOTAL							0.83		0.25	0.30	0.53	75,895	36%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.02	12.5	0.25			0.00	0.00			
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00			
		SUBTOTAL	1		0.2	0.8	0.16			0.00	0.00			
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00			
		SUBTOTAL	1		0.05	4.6	0.23			0.00	0.00			
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		0.50	0.38	0.45			
		SUBTOTAL	1		0.75	1.2	0.90			0.38	0.45			
	TOTAL							1.54		0.38	0.45	1.09	303,035	29%
	Weighted average							1.82		0.73		1.51		17%

Table 17: Control Effiencies for CMP Organic Practices

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f		h= g/d x 100
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.63	1.20	0.75		0.00	0.00	0.00		
		make border	1	Discing	0.31	1.20	0.38		1.00	0.31	0.38		
		finish disc and harrow	1	Discing	0.31	1.20	0.38		0.00	0.00	0.00		
		SUBTOTAL	4		1.25	1.20	1.50			0.31	0.38		
	Land Maintenance	chisel field	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00		
		laser lever field	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00		
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00		
		weed winter	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00		
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00		
	TOTAL							4.00		0.31	0.38		9%
Citrus/Tree fruit	Unspecified	discing 2x	2	Discing	0.02	1.20	0.02		0.50	0.01	0.01		
		subsoil	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		level ground	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		weed discing 3x	3	Discing	0.03	1.20	0.03		0.00	0.00	0.00		
		SUBTOTAL	7		0.06	1.20	0.07			0.01	0.01		
	TOTAL							0.07		0.01	0.01		14%
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00		
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	2		1.00	1.20	1.20			1.00	1.20		
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00		
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00		
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00		
	Stubble disc	chisel 2x	2	Discing	0.22	1.20	0.27		0.00	0.00	0.00		
		disc stubble 2x	2	Discing	0.22	1.20	0.27		0.00	0.00	0.00		
		weed control post/pre emergent	1	Discing	0.11	1.20	0.13		0.00	0.00	0.00		
		plant	1	Discing	0.11	1.20	0.13		0.00	0.00	0.00		
		cultivate 2x	2	Discing	0.22	1.20	0.27		0.00	0.00	0.00		
		pest control	1	Discing	0.11	1.20	0.13		0.00	0.00	0.00		
		SUBTOTAL	9		1.00	1.20	1.20			0.00	0.00		
	TOTAL							6.90		1.00	1.20		17%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		1.00	1.33	1.60		
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00		
		SUBTOTAL	3		4.00	1.20	4.80			1.33	1.60		
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	Seed bed preparation	list beds	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00		
		make ditch	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00		

		spray and incorporate herbicide	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00		
		close ditch	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00		
		cultivate preplant	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00		
		plant	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00		
		uncap beds	1	Weeding	0.18	0.80	0.15		0.00	0.00	0.00		
		cultivate 4x	4	Weeding	0.73	0.80	0.58		0.00	0.00	0.00		
		SUBTOTAL	11		2.00	0.80	1.60			0.00	0.00		
	TOTAL							8.90		1.33	1.60		18%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.14		0.00	0.00	0.00		
		subsoil 2x	2	Land Planing	0.02	12.50	0.27		0.00	0.00	0.00		
		disc 2x	2	Land Planing	0.02	12.50	0.27		0.00	0.00	0.00		
		disc and roll	1	Land Planing	0.01	12.50	0.14		1.00	0.01	0.14		
		prune 4x	0	Land Planing	0.00	12.50	0.00		0.00	0.00	0.00		
		weed 9x	9	Land Planing	0.10	12.50	1.22		0.00	0.00	0.00		
		fertilize 3x	1	Land Planing	0.01	12.50	0.14		0.00	0.00	0.00		
		pest 7x	7	Land Planing	0.08	12.50	0.95		0.00	0.00	0.00		
		SUBTOTAL	23		0.25	12.50	3.13			0.01	0.14		
	TOTAL							3.13		0.01	0.14		4%
sugar beet	disc	disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00		
		disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00		
		SUBTOTAL	4		1.00	1.20	1.20			0.00	0.00		
	land plane	triplane 2x	2	Land Planing	1.00	12.50	12.50		0.00	0.00	0.00		
		SUBTOTAL	2		1.00	12.50	12.50			0.00	0.00		
	subsoil deep chisel		1	ripping	1.00	4.60	4.60		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	4.60	4.60			0.00	0.00		
	Stubble disc		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	Land Maintenance	corrugate	1	Discing	0.02	12.50	0.21		0.00	0.00	0.00		
		precision plant and shape	1	Discing	0.02	12.50	0.21		0.00	0.00	0.00		
		herbicide 3x ground	3	Discing	0.05	12.50	0.63		0.00	0.00	0.00		
		cultivate 2x	2	Discing	0.03	12.50	0.42		0.00	0.00	0.00		
		mechanical thin	1	Discing	0.02	12.50	0.21		0.00	0.00	0.00		
		fertilize 2x inject	2	Discing	0.03	12.50	0.42		0.00	0.00	0.00		
		work ends 2x	2	Discing	0.03	12.50	0.42		0.00	0.00	0.00		
		SUBTOTAL	12		0.20	12.50	2.50			0.00	0.00		
	TOTAL							22.80		1.00	1.20		5%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00		
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00		
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00		
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00		
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00		
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00		
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00		
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00		
	disc and roll		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	TOTAL							6.50		1.00	1.20		18%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00		
	Chisel		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		

		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	shape beds.		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	TOTAL							6.50		1.00	1.20		18%
	GRAND TOTAL							13.00		2.00	2.40		18%
grapes-raisin	Terrace		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00		
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00		
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00		
	Disc &Furrow-out	disc middles/incorporate	1	Discing	0.50	1.20	0.60		1.00	0.50	0.60		
		cover crop	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00		
		SUBTOTAL	2		1.00	1.20	1.20			0.50	0.60		
	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00		
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00		
	TOTAL							2.64		0.50	0.60	2.04	23%
grapes-table	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00		
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00		
	Disc &Furrow-out		1	Discing	0.50	1.20	0.60		0.25	0.13	0.15		
		SUBTOTAL	1		0.50	1.20	0.60			0.13	0.15		
	TOTAL							0.83		0.13	0.15	0.68	18%
grapes-wine	level (new vineyard)		1	Land Planing	0.02	12.50	0.25		0.00	0.00	0.00		
		SUBTOTAL	1		0.02	12.50	0.25			0.00	0.00		
	spring tooth		1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	0.80	0.16			0.00	0.00		
	subsoil		1	ripping	0.05	4.60	0.23		0.00	0.00	0.00		
		SUBTOTAL	1		0.05	4.60	0.23			0.00	0.00		
	Disc &Furrow-out		1	Discing	0.75	1.20	0.90		1.00	0.75	0.90		
		SUBTOTAL	1		0.75	1.20	0.90			0.75	0.90		
	TOTAL							1.54		0.75	0.90	0.64	58%
	Weighted average							1.82		1.38		1.12	38%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	Chisel		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00		
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00		
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	TOTAL							7.70		1.00	1.20	6.50	16%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	Chisel		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00		
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00		
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	TOTAL							7.70		1.00	1.20	6.50	16%
Safflower	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		

		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	Stubble disc		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	TOTAL							4.50		1.00	1.20	3.30	27%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60		
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00		
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60		
	Land Maintenance	pull borders	1	Land Planing	0.07	12.50	0.83		0.00	0.00	0.00		
		plant	1	Land Planing	0.07	12.50	0.83		0.00	0.00	0.00		
		pull tail/close ditch	1	Land Planing	0.07	12.50	0.83		0.00	0.00	0.00		
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00		
	TOTAL							3.70		0.50	0.60	3.10	16%
rice	Chisel		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00		
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00		
	roll		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00		
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00		
	TOTAL							10.00		1.00	1.20	8.80	12%
	WEIGHTED AVERAGE							4.45				3.73	16%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		1.00	0.50	0.60		
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00		
		SUBTOTAL	2		1.00	1.20	1.20			0.50	0.60		
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00		
	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00		
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00		
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00		
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00		
	shape beds and roll	laser level	1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		bed shape/prep	1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		minimum tillage	1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		precision plant	1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		cultivate and fertilizer	1	Weeding	0.20	0.80	0.16		0.00	0.00	0.00		
		SUBTOTAL	5		1.00	0.80	0.80			0.00	0.00		
	TOTAL							12.75		0.50	0.60	12.15	5%
melon	plow		1	Discing	1.00	1.20	1.20		1.00	1.00	1.20		
		SUBTOTAL	1		1.00	1.20	1.20			1.00	1.20		
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00		
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00		
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00		
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00		
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00		
		SUBTOTAL	7		1.00	0.80	0.80			0.00	0.00		

	disc	disc 2x	2	Discing	0.29	1.20	0.34		0.00	0.00	0.00		
		disc 2x	2	Discing	0.29	1.20	0.34		0.00	0.00	0.00		
		border/crosscheck	1	Discing	0.14	1.20	0.17		0.00	0.00	0.00		
		back-fill furrow	1	Discing	0.14	1.20	0.17		0.00	0.00	0.00		
		furrow out	1	Discing	0.14	1.20	0.17		0.00	0.00	0.00		
		SUBTOTAL	7		1.00	1.20	1.20			0.00	0.00		
	TOTAL							5.70		1.00	1.20	4.50	21%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00		
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00		
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00		
		SUBTOTAL	3		2.00	0.80	1.60			0.00	0.00		
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.50	1.25	1.50		
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00		
		SUBTOTAL	4		5.00	1.20	6.00			1.25	1.50		
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.56		0.00	0.00	0.00		
		cultibate 2x	1	Discing	0.02	12.50	0.28		0.00	0.00	0.00		
		open ditch	1	Discing	0.02	12.50	0.28		0.00	0.00	0.00		
		close ditch and drag	5	Discing	0.11	12.50	1.39		0.00	0.00	0.00		
		SUBTOTAL	9		0.20	12.50	2.50			0.00	0.00		
	TOTAL							10.10		1.25	1.50	8.60	15%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00		
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00		
	Unspecified		1	Discing	5.00	1.20	6.00		0.50	2.50	3.00		
		SUBTOTAL	1		5.00	1.20	6.00			2.50	3.00		
								8.50		2.50	3.00	5.50	35%
	WEIGHTED AVERAGE							9.05				7.39	18%

Table 18: Control Effiencies for CMP Pre-Harvest Soil Preparation

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB)								
					Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
				a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	haylage 2x	2	4.67	0.011	0.053		0.30	1.40	0.02			
		hay 7x	7	16.33	0.011	0.187		0.00	0.00	0.00			
		SUBTOTAL	9	21		0.240			1.40	0.02			
	TOTAL						0.24			0.02			7%
Citrus/Tree fruit	hand pick	pick	1	0.33	0.14	0.05		0.30	0.10	0.01			
		pack	1	0.33	0.14	0.05		0.00	0.00	0.00			
		haul	1	0.33	0.14	0.05		0.00	0.00	0.00			
		SUBTOTAL	3	1	0	0.14			0.10	0.01			
	TOTAL						0.14			0.01			10%
Corn		cut	1	0.33	0.43	0.14		0.2	0.1	0.0			
		haul	1	0.33	0.43	0.14		0.0	0.0	0.0			
		pack	1	0.33	0.43	0.14		0.0	0.0	0.0			
		SUBTOTAL	3	1.00		0.43			0.05	0.02			
	TOTAL						0.43			0.02			5%
Cotton		harvest 1st pick	1	0.2	3.4	0.7		0.3	0.1	0.2			
		harvest 2nd pick	1	0.2	3.4	0.7		0.3	0.1	0.2			
		build module and tarp	1	0.2	3.4	0.7		0.0	0.0	0.0			
		haul and gin cotton	1	0.2	3.4	0.7		0.0	0.0	0.0			
		compress cotton	1	0.2	3.4	0.7		0.0	0.0	0.0			
		SUBTOTAL	5	1		3.4			0.12	0.40			
	TOTAL						3.37			0.40			12%
Almonds		shake trees	1	0.80	9.13	7.30		0.00	0.00	0.00			
		sweep nuts	1	0.80	9.13	7.30		0.30	0.24	2.19			
		hand rake	1	0.80	9.13	7.30		0.00	0.00	0.00			
		pick up and haul	1	0.80	9.13	7.30		0.00	0.00	0.00			
		hull nuts	1	0.80	9.13	7.30		0.00	0.00	0.00			

		SUBTOTAL		5	4		36.50			0.24	2.19			
	TOTAL							36.5		0.24	2.19			6%
sugar beet	top	dig and top		2	1.3	0.8	1.1		0.2	0.2	0.2			
	dig	haul		1	0.7	0.8	0.6		0.0	0.0	0.0			
		SUBTOTAL		3	2		1.7			0.20	0.17			
	TOTAL							1.69			0.17			10%
onions	top	top		1	1.0	0.6	0.6		0.3	0.3	0.2			
	undercut	dig		1	1.0	0.6	0.6		0.0	0.0	0.0			
	windrow	haul/sell		1	1.0	0.6	0.6		0.0	0.0	0.0			
		SUBTOTAL		3	3		1.7			0.30	0.17			
	TOTAL							1.68			0.17			10%
garlic	top	top		1	1.0	0.6	0.6		0.3	0.3	0.2			
	undercut	dig		1	1.0	0.6	0.6		0.0	0.0	0.0			
	windrow	haul/sell		1	1.0	0.6	0.6		0.0	0.0	0.0			
		SUBTOTAL		3	3		1.7			0.30	0.17			
	TOTAL							1.68			0.17			10%
								3.36			0.34			10%
grapes-raisin	machine harvest			1	0.01	0.65	0.01		0.00	0.00	0.00			
		SUBTOTAL		1	0.01									
	trailer activity	turn and roll		1	0.08	0.65	0.05		0.00	0.00	0.00			
		box and shake		1	0.08	0.65	0.05		0.00	0.00	0.00			
		haul to packer		1	0.08	0.65	0.05		0.00	0.00	0.00			
		SUBTOTAL		3	0.25		0.17							
	TOTAL				0.26			0.17		0.00	0.00	0.17	192,980	0%
grapes-table	machine harvest			1	0.01	0.65	0.01		0.00	0.00	0.00			
		SUBTOTAL		1	0.01									
	trailer activity			1	0.25	0.65	0.16		0.15	0.04	0.02			
		SUBTOTAL		1	0.25		0.17							
	TOTAL				0.26			0.17		0.04	0.02	0.15	75,895	14%
grapes-wine	machine harvest			1	0.01	0.65	0.01		0.00	0.00	0.00			
		SUBTOTAL		1	0.01									
	trailer activity			1	0.25	0.65	0.16		0.15	0.04	0.02			
		SUBTOTAL		1	0.25		0.17							
	TOTAL				0.26			0.17		0.04	0.02	0.15	303,035	14%
	WEIGHTED AVERAGE							0.17				0.15		10%
Dry Beans	cut beans			1	1.00	0.58	0.58		0.30	0.30	0.18			
		SUBTOTAL		1	1.00									
	windrow			1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL		1	1									
	harvest			1	1.00	0.58	0.58		0.00	0.00	0.00			

		SUBTOTAL	1	1		1.75						
	TOTAL			3.00			1.75		0.30	0.18	1.58	95,887	10%
garbanzo			1	1.0	1.7	1.7		0.2	0.2	0.3			
		SUBTOTAL	1	1		1.7			0.15	0.25			
	TOTAL						1.68			0.25	1.43	322	15%
Safflower			1	1.0	5.8	5.8		0.0	0.0	0.0			
		SUBTOTAL	1	1		5.8			0.00	0.00			
	TOTAL						5.80			0.00		16,542	0%
Wheat			1	1.0	3.7	3.7		0.0	0.0	0.0			
		SUBTOTAL	1	1		3.7			0.00	0.00			
	TOTAL						3.73			0.00	3.73	559,711	0%
rice	combine		1	0.01	3.29	0.03		0.15	0.00	0.00			
		SUBTOTAL	1	0.01									
	chop straw		1	0.50	3.29	1.65		0.00	0.00	0.00			
		SUBTOTAL	1	0.5		1.68							
	TOTAL			0.51			1.68		0.00	0.00	1.68	18,806	0%
	WEIGHTED AVERAGE						3.45				3.28		5%
lettuce			1	1.0	0.1	0.1		0.0	0.0	0.0			
		SUBTOTAL	1	1		0.1			0.00	0.00			
	TOTAL						0.080			0.000	0.08	28,887	0%
melon			1	1.00	0.55	0.55		0.00	0.00	0.00			
	TOTAL		1	1			0.55		0.00	0.00	0.55	90,137	0%
tomatoes	machine harvest	open harvest lane	1	0.3	0.15	0.1		0.0	0.0	0.0			
		harvest	1	0.3	0.15	0.1		0.0	0.0	0.0			
		in field hauling	1	0.3	0.15	0.1		0.0	0.0	0.0			
		SUBTOTAL	3	1		0.150			0.00	0.00			
	TOTAL						0.150			0.000	0.15	228,250	0%
vegetables			1	1.00	0.15	0.15		0.15	0.15	0.02			
	TOTAL		1	1			0.15		0.00	0.02	0.13	81,409	15%
	WEIGHTED AVERAGE						0.23				0		2%

Table 19: Control Effiencies for CMP Reduced Pruning

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB): Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Control Efficiency (%)
					a	b	c = a x b	d	e	f = a x e	g = b x f		h = g/d x 100
Citrus/Tree fruit	Unspecified	discing 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		subsoil	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		level ground	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		irrigate	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		fertilizer 2x	2	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		weed discing 3x	3	Discing	0.02	1.20	0.02		0.33	0.01	0.01		
		soil amendments	1	Discing	0.01	1.20	0.01		0.00	0.00	0.00		
		SUBTOTAL	11		0.06	1.20	0.07			0.01	0.01		
	TOTAL							0.07		0.01	0.01		9%
Almonds	float	laser lever field	1	Land Planing	0.01	12.50	0.09		0.00	0.00	0.00		
		subsoil 2x	2	Land Planing	0.01	12.50	0.18		0.00	0.00	0.00		
		disc 2x	2	Land Planing	0.01	12.50	0.18		0.00	0.00	0.00		
		disc and roll	1	Land Planing	0.01	12.50	0.09		0.00	0.00	0.00		
		prune 4x	4	Land Planing	0.03	12.50	0.37		0.50	0.01	0.18		
		weed 9x	9	Land Planing	0.07	12.50	0.83		0.00	0.00	0.00		
		fertilize 3x	1	Land Planing	0.01	12.50	0.09		0.00	0.00	0.00		
		irrigate 7x	7	Land Planing	0.05	12.50	0.64		0.00	0.00	0.00		
		pest 7x	7	Land Planing	0.05	12.50	0.64		0.00	0.00	0.00		
		SUBTOTAL	34		0.25	12.50	3.13			0.01	0.18		
	TOTAL							3.13		0.01	0.18		6%

Table 20: Control Effiencies for CMP Shed Packing

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB)								
					Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
				a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
onions	top	top	1	1.0	0.6	0.6		0.0	0.0	0.0			
	undercut	dig	1	1.0	0.6	0.6		0.0	0.0	0.0			
	windrow	haul/sell	1	1.0	0.6	0.6		0.4	0.4	0.2			
		SUBTOTAL	3	3		1.7			0.35	0.20			
	TOTAL						1.68			0.20			12%
garlic	top	top	1	1.0	0.6	0.6		0.0	0.0	0.0			
	undercut	dig	1	1.0	0.6	0.6		0.0	0.0	0.0			
	windrow	haul/sell	1	1.0	0.6	0.6		0.4	0.4	0.2			
		SUBTOTAL	3	3		1.7			0.40	0.22			
	TOTAL						1.68			0.22			13%
							3.36			0.42			13%
lettuce			1	1.0	0.1	0.1		0.1	0.1	0.0			
		SUBTOTAL	1	1		0.1			0.07	0.01			
	TOTAL						0.080			0.005	0.07	28,887	7%
melon			1	1.00	0.55	0.55		0.10	0.10	0.06			
	TOTAL		1	1			0.55		0.00	0.06	0.50	90,137	10%
tomatoes	machine harvest	open harvest lane	1	0.3	0.15	0.1		0.0	0.0	0.0			
		harvest	1	0.3	0.15	0.1		0.0	0.0	0.0			
		in field hauling	1	0.3	0.15	0.1		0.4	0.1	0.0			
		SUBTOTAL	3	1		0.150			0.13	0.02			
	TOTAL						0.150			0.020	0.13	228,250	13%
vegetables			1	1.00	0.15	0.15		0.10	0.10	0.02			
	TOTAL		1	1			0.15		0.00	0.02	0.14	81,409	10%
	WEIGHTED AVERAGE						0.23				0		11%

Table 21: Control Effiencies for CMP Shuttle System

Crop Profile	Harvest Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
				a	b	c = a x b	d	e	f = a x e	g = b x f			h= g/d x 100
Alfalfa	Unspecified	haylage 2x	0	0.00	0.01	0.00		0.00	0.00	0.00			
		hay 7x	7	21.00	0.01	0.24		0.17	3.47	0.04			
		SUBTOTAL	7	21.00		0.24			3.47	0.04			
	TOTAL						0.24			0.04			16.50%
~~Citrus~~/Tree fruit	hand pick	pick	1	0.33	0.14	0.05		0.00	0.00	0.00			
		pack	1	0.33	0.14	0.05		0.00	0.00	0.00			
		haul	1	0.33	0.14	0.05		0.50	0.17	0.02			
		SUBTOTAL	3	1.00	0.00	0.14			0.17	0.02			
	TOTAL						0.14			0.02			16.67%
Corn		cut	1	0.33	0.43	0.14		0.00	0.00	0.00			
		haul	1	0.33	0.43	0.14		0.50	0.17	0.07			
		pack	1	0.33	0.43	0.14		0.00	0.00	0.00			
		SUBTOTAL	3	1.00		0.43			0.17	0.07			
	TOTAL						0.43			0.07			16.67%
Cotton		harvest 1st pick	1	0.25	3.37	0.84		0.00	0.00	0.00			
		harvest 2nd pick	0	0.00	3.37	0.00		0.00	0.00	0.00			
		build module and tarp	1	0.25	3.37	0.84		0.80	0.20	0.67			
		haul and gin cotton	1	0.25	3.37	0.84		0.80	0.20	0.67			
		compress cotton	1	0.25	3.37	0.84		0.00	0.00	0.00			
		SUBTOTAL	4	1.00		3.37			0.40	1.35			
	TOTAL						3.37			1.35			40%
Almonds		shake trees	1	0.80	9.13	7.30		0.00	0.00	0.00			
		sweep nuts	1	0.80	9.13	7.30		0.00	0.00	0.00			
		hand rake	1	0.80	9.13	7.30		0.00	0.00	0.00			
		pick up and haul	1	0.80	9.13	7.30		0.50	0.40	3.65			
		hull nuts	1	0.80	9.13	7.30		0.00	0.00	0.00			
		SUBTOTAL	5	4.00		36.50			0.40	3.65			

	TOTAL						36.50		0.40	3.65			10%
sugar beet	top	top and dig	2	1.33	0.85	1.13		0.00	0.00	0.00			
	dig	haul	1	0.67	0.85	0.56		0.50	0.33	0.28			
		SUBTOTAL	3	2.00		1.69			0.33	0.28			
	TOTAL						1.69			0.28			16.67%
onions	top	top	1	1.00	0.56	0.56		0.00	0.00	0.00			
	undercut	dig	1	1.00	0.56	0.56		0.00	0.00	0.00			
	windrow	haul/sell	1	1.00	0.56	0.56		0.50	0.50	0.28			
		SUBTOTAL	3	3.00		1.68			0.50	0.28			
	TOTAL						1.68			0.28			17%
garlic	top	top	1	1.00	0.56	0.56		0.00	0.00	0.00			
	undercut	dig	1	1.00	0.56	0.56		0.00	0.00	0.00			
	windrow	haul/sell	1	1.00	0.56	0.56		0.50	0.50	0.28			
		SUBTOTAL	3	3.00		1.68			0.50	0.28			
	TOTAL						1.68			0.28			17%
							3.36			0.56			16.67%
grapes-raisin	machine harvest		1	0.01	0.65	0.01		0.00	0.00	0.00			
		SUBTOTAL	1	0.01									
	trailer activity	turn and roll	1	0.08	0.65	0.05		0.00	0.00	0.00			
		box and shake	1	0.08	0.65	0.05		0.00	0.00	0.00			
		haul to packer	1	0.08	0.65	0.05		0.50	0.04	0.03			
		SUBTOTAL	3	0.25		0.17							
	TOTAL			0.26			0.17		0.04	0.03	0.14	192,980	16%
grapes-table	machine harvest		1	0.01	0.65	0.01		0.00	0.00	0.00			
		SUBTOTAL	1	0.01									
	trailer activity		1	0.25	0.65	0.16		0.17	0.04	0.03			
		SUBTOTAL	1	0.25		0.17							
	TOTAL			0.26			0.17		0.04	0.03	0.14	75,895	16%
grapes-wine	machine harvest		1	0.01	0.65	0.01		0.00	0.00	0.00			
		SUBTOTAL	1	0.01									
	trailer activity		1	0.25	0.65	0.16		0.17	0.04	0.03			
		SUBTOTAL	1	0.25		0.17							
	TOTAL			0.26			0.17		0.04	0.03	0.14	303,035	16%
	WEIGHTED AVERAGE						0.17				0.14		15.92%
Dry Beans	cut beans		1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL	1	1.00									
	windrow		1	1.00	0.58	0.58		0.00	0.00	0.00			
		SUBTOTAL	1	1.00									
	harvest		1	1.00	0.58	0.58		0.50	0.50	0.29			
		SUBTOTAL	1	1.00		1.75							
	TOTAL			3.00			1.75		0.50	0.29	1.46	95,887	16.7%

garbanzo			1	1.00	1.68	1.68		0.17	0.17	0.28			
		SUBTOTAL	1	1.00		1.68			0.17	0.28			
	TOTAL						1.68			0.28	1.40	322	16.5%
Safflower			1	1.00	5.80	5.80		0.17	0.17	0.96			
		SUBTOTAL	1	1.00		5.80			0.17	0.96			
	TOTAL						5.80			0.96		16,542	16.5%
Wheat			1	1.00	3.73	3.73		0.17	0.17	0.62			
		SUBTOTAL	1	1.00		3.73			0.17	0.62			
	TOTAL						3.73			0.62	3.11	559,711	16.5%
rice	combine		1	0.01	3.29	0.03		0.00	0.00	0.00			
		SUBTOTAL	1	0.01									
	chop straw		1	0.50	3.29	1.65		0.17	0.08	0.27			
		SUBTOTAL	1	0.50		1.68							
	TOTAL			0.51			1.68		0.08	0.27	1.41	18,806	16.2%
	WEIGHTED AVERAGE						3.45				2.76		19.87%
lettuce			1	1.00	0.08	0.08		0.17	0.17	0.01			
		SUBTOTAL	1	1.00		0.08			0.17	0.01			
	TOTAL						0.08			0.01	0.07	28,887	17%
melon			1	1.00	0.55	0.55		0.17	0.17	0.09			
	TOTAL		1	1.00			0.55		0.00	0.09	0.46	90,137	17%
tomatoes	machine harvest	open harvest lane	1	0.33	0.15	0.05		0.00	0.00	0.00			
		harvest	1	0.33	0.15	0.05		0.00	0.00	0.00			
		in field hauling	1	0.33	0.15	0.05		0.50	0.17	0.03			
		SUBTOTAL	3	1.00		0.15			0.17	0.03			
	TOTAL						0.15			0.03	0.13	228,250	17%
vegetables			1	1.00	0.15	0.15		0.17	0.17	0.02			
	TOTAL		1	1.00			0.15		0.00	0.02	0.13	81,409	17%
	WEIGHTED AVERAGE						0.23				0.19		16.56%

Table 22: Control Effiencies for Transgenic under Land Preparation

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB)								
						Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.56	1.20	0.67		0.00	0.00	0.00			
		make border	1	Discing	0.28	1.20	0.33		0.25	0.07	0.08			
		fertilizer .5	0.5	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		finish disc and harrow	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		SUBTOTAL	4.5		1.25	1.20	1.50			0.07	0.08			
	Land Maintenance	chisel field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		laser lever field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		plant	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		irrigate	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		weed winter	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		SUBTOTAL	5		0.20	12.50	2.50			0.00	0.00			
	TOTAL							4.00		0.07	0.08			2%
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			

		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		1.00	0.80			12%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.00	0.00	0.00			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		make ditch	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		close ditch	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		cultivate 4x	4	Weeding	0.67	0.80	0.53		1.00	0.67	0.53			
		SUBTOTAL	12		2.00	0.80	1.60			1.00	0.80			
	TOTAL							8.90		1.00	0.80			9%
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			

	TOTAL							6.50		1.00	0.80			12%
	GRAND TOTAL							~~13.00~~		2.00	1.60			12%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.50	0.50	0.40			
		SUBTOTAL	1		1.00	0.80	0.80			0.50	0.40			
	TOTAL							7.70		0.50	0.40	7.30	95,887	5%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.25	0.25	0.20			
		SUBTOTAL	1		1.00	0.80	0.80			0.25	0.20			
	TOTAL							7.70		0.25	0.20	7.50	322	3%
Safflower	list		1	Weeding	1.00	0.80	0.80		0.25	0.25	0.20			
		SUBTOTAL	1		1.00	0.80	0.80			0.25	0.20			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		0.25	0.20	4.30	16,542	4%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		0.25	0.13	0.15			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.13	0.15			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.13	0.15	3.55	559,711	4%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			

		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		0.25	0.25	0.20			
		SUBTOTAL	1		1.00	0.80	0.80			0.25	0.20			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		0.25	0.20	9.80	18,806	2%
	WEIGHTED AVERAGE							4.45				4.26		4%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		1.00	0.80	11.95	28,887	6%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		1.00	0.14	0.11			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.14	0.11			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			

		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		0.14	0.11	5.59	90,137	2%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		1.00	0.67	0.53			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.67	0.53			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		0.67	0.53	9.57	228,250	5%
vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.30	0.06	0.75			
		SUBTOTAL	1		0.20	12.50	2.50			0.06	0.75			
	Unspecified		1	Discing	5.00	1.20	6.00		0.00	0.00	0.00			
		SUBTOTAL	1		5.00	1.20	6.00			0.00	0.00			
								8.50		0.06	0.75	7.75	81,409	9%
	WEIGHTED AVERAGE							9.05				8.55		6%

Table 23: Control Effiencies for Transgenic under Other

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
Alfalfa	Unspecified	stubble disc 2x	2	Discing	0.56	1.20	0.67		0.00	0.00	0.00			
		make border	1	Discing	0.28	1.20	0.33		1.00	0.28	0.33			
		fertilizer .5	0.5	Discing	0.14	1.20	0.17		0.00	0.00	0.00			
		finish disc and harrow	1	Discing	0.28	1.20	0.33		0.00	0.00	0.00			
		SUBTOTAL	4.5		1.25	1.20	1.50			0.28	0.33			
	Land Maintenance	chisel field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		laser lever field	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		plant	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		irrigate	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		weed winter	1	Land Planing	0.04	12.50	0.50		0.00	0.00	0.00			
		SUBTOTAL	5		0.20	12.50	2.50			0.00	0.00			
	TOTAL							4.00		0.28	0.33			8%
Corn	List and Fertilize	apply manure	1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Mulch Beds	cultivate	1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Finish disc	finish disc 2x	2	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	pull borders	1	Land Planing	0.10	12.50	1.25		0.00	0.00	0.00			
		knock down borders	1	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	2		0.20	12.50	2.50			0.00	0.00			
	Stubble disc	chisel 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		disc stubble 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		pre irrigate	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		weed control post/pre emergent	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		plant	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		cultivate 2x	2	Discing	0.18	1.20	0.22		0.00	0.00	0.00			
		fertilize	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		pest control	1	Discing	0.09	1.20	0.11		0.00	0.00	0.00			
		irigate 4x	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			
		irrigate and fertilizer	0	Discing	0.00	1.20	0.00		0.00	0.00	0.00			

		SUBTOTAL	11		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.90		1.00	0.80			12%
Cotton	Land Preparation	rip field	1	Discing	1.33	1.20	1.60		0.00	0.00	0.00			
		primary discing	2	Discing	2.67	1.20	3.20		0.00	0.00	0.00			
		SUBTOTAL	3		4.00	1.20	4.80			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Seed bed preparation	list beds	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		make ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		spray and incorporate herbicide	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		irrigate	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		close ditch	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		cultivate preplant	1	Weeding	0.17	0.80	0.13		1.00	0.17	0.13			
		plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		uncap beds	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate 4x	4	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	12		2.00	0.80	1.60			1.00	0.80			
	TOTAL							8.90		1.00	0.80			9%
Dry Beans	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	95,887	10%
garbanzo	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Shaping		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	discing		1	Discing	2.00	1.20	2.40		0.00	0.00	0.00			
		SUBTOTAL	1		2.00	1.20	2.40			0.00	0.00			
	listing		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							7.70		1.00	0.80	6.90	322	10%
Safflower	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			

		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							4.50		1.00	0.80	3.70	16,542	18%
Wheat	Stubble disc	chisel 2x	2	Discing	0.50	1.20	0.60		1.00	0.50	0.60			
		finish disc 2x	2	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	4		1.00	1.20	1.20			0.50	0.60			
	Land Maintenance	pull borders	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		fertilize	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		plant	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		pull tail/close ditch	1	Land Planing	0.05	12.50	0.63		0.00	0.00	0.00			
		SUBTOTAL	4		0.20	12.50	2.50			0.00	0.00			
	TOTAL							3.70		0.50	0.60	3.10	559,711	16%
rice	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	post burn/harvest discing		1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	1.20	0.60			0.00	0.00			
	roll		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	3 wheel plane		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	harrow disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Stubble disc		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							10.00		1.00	0.80	9.20	18,806	8%
	WEIGHTED AVERAGE							4.45				3.81		14%

Table 24: Control Effiencies for Transplanting

Crop Profile	Land Preparation Operations (ARB)	Type of Operations (UC Davis)	Number of Pass (UC Davis)	Emissions Category	Acre-Pass	Emission Factor (ARB) Operation (lbs/acre-pass)	sum of passes	Crop (lbs/acre/yr)	Reduction (%)	reduced Acre-pass	Emissions Reduction (lbs/acre/yr)	Emissions with Control Efficiency (lbs/acre/yr	Crop Acreage (ARB)	Control Efficiency (%)
onions	list		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	shape beds		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	Land Maintenance	land plane 2x	2	Land Planing	0.13	12.50	1.67		0.00	0.00	0.00			
		triplane 1x	1	Discing	0.07	12.50	0.83		0.00	0.00	0.00			
		SUBTOTAL	3		0.20	12.50	2.50			0.00	0.00			
	Chisel	discing	2	Discing	0.40	1.20	0.48		0.00	0.00	0.00			
		stubble disc	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		subsoil	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		border crop check	1	Discing	0.20	1.20	0.24		0.00	0.00	0.00			
		SUBTOTAL	5		1.00	1.20	1.20			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
garlic	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	disc and roll		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			
		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	shape beds		1	Weeding	1.00	0.80	0.80		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	0.80	0.80			0.00	0.00			
	TOTAL							6.50		1.00	0.80			12%
	GRAND TOTAL							~~13.00~~		2.00	1.60			12%
lettuce	disc and roll	disc	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		subsoil	1	Discing	0.50	1.20	0.60		0.00	0.00	0.00			
		SUBTOTAL	2		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance	land plane	1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	Chisel		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	list		1	Weeding	1.00	0.80	0.80		1.00	1.00	0.80			

		SUBTOTAL	1		1.00	0.80	0.80			1.00	0.80			
	plane		1	Land Planing	0.50	12.50	6.25		0.00	0.00	0.00			
		SUBTOTAL	1		0.50	12.50	6.25			0.00	0.00			
	shape beds and roll	laser level	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		bed shape/prep	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		minimum tillage	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		precision plant	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		pre-irrigate	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		cultivate and fertilizer	1	Weeding	0.17	0.80	0.13		0.00	0.00	0.00			
		SUBTOTAL	6		1.00	0.80	0.80			0.00	0.00			
	TOTAL							12.75		1.00	0.80	11.95	28,887	6%
melon	plow		1	Discing	1.00	1.20	1.20		0.00	0.00	0.00			
		SUBTOTAL	1		1.00	1.20	1.20			0.00	0.00			
	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.00	0.00	0.00			
		SUBTOTAL	1		0.20	12.50	2.50			0.00	0.00			
	shape beds	list and rerun bed	1	Weeding	0.14	0.80	0.11		1.00	0.14	0.11			
		shape beds and plant	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		cultivate/move beds 3x	3	Weeding	0.43	0.80	0.34		0.00	0.00	0.00			
		center bed	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		work bed tops	1	Weeding	0.14	0.80	0.11		0.00	0.00	0.00			
		SUBTOTAL	7		1.00	0.80	0.80			0.14	0.11			
	disc	disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		disc 2x	2	Discing	0.17	1.20	0.20		0.00	0.00	0.00			
		border/crosscheck	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		back-fill furrow	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		furrow out	1	Discing	0.08	1.20	0.10		0.00	0.00	0.00			
		irrigate 5x	5	Discing	0.42	1.20	0.50		0.00	0.00	0.00			
		SUBTOTAL	12		1.00	1.20	1.20			0.00	0.00			
	TOTAL							5.70		0.14	0.11	5.59	90,137	2%
tomatoes	bed preparation	list bed	1	Weeding	0.67	0.80	0.53		1.00	0.67	0.53			
		shape bed and fertilizer	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		plant direct seeded	1	Weeding	0.67	0.80	0.53		0.00	0.00	0.00			
		SUBTOTAL	3		2.00	0.80	1.60			0.67	0.53			
	land preparation	disc 4x	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		subsoil	2	Discing	2.50	1.20	3.00		0.00	0.00	0.00			
		SUBTOTAL	4		5.00	1.20	6.00			0.00	0.00			
	Land Maintenance	triplane	2	Discing	0.04	12.50	0.50		0.00	0.00	0.00			
		cultibate 2x	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		irrigate furrow	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		open ditch	1	Discing	0.02	12.50	0.25		0.00	0.00	0.00			
		close ditch and drag	5	Discing	0.10	12.50	1.25		0.00	0.00	0.00			
		SUBTOTAL	10		0.20	12.50	2.50			0.00	0.00			
	TOTAL							10.10		0.67	0.53	9.57	228,250	5%

vegetables	Land Maintenance		1	Land Planing	0.20	12.50	2.50		0.30	0.06	0.75			
		SUBTOTAL	1		0.20	12.50	2.50			0.06	0.75			
	Unspecified		1	Discing	5.00	1.20	6.00		0.00	0.00	0.00			
		SUBTOTAL	1		5.00	1.20	6.00			0.00	0.00			
								8.50		0.06	0.75	7.75	81,409	9%
	WEIGHTED AVERAGE							9.05				8.55		6%

Appendix D

San Joaquin Valley Air Pollution Control District. *Evaluation of PM10 Emission Factors For AFO CMPs.* September 2005.

EVALUATION OF PM10 EMISSION FACTORS FOR AFO CMPS

September 1, 2005

Prepared by: Sheraz Gill, Senior Air Quality Engineer

Dairy:

Overall Dairy EF:	2.46 lbs/hd-yr[1]
Unpaved Roads EF:	0.369 lbs/hd-yr[2]
Unpaved Equipment Areas EF:	0.123 lbs/hd-yr[3]
Feed EF:	0.123 lbs/hd-yr[4]
EF from Cows (Freestall):	1.845 lbs/hd-yr[5]
EF from Cows (Open Corral):	4.6 lbs/hd-yr[6]

The CMP under each category are as follows:

CMP for Feed - Bulk Material Control, Feeding near Dusk, wet feed during mixing

CMP for Cows - Sprinkling of open corral, Fibrous layer in dusty area, Freestall housing, Frequent scraping and/or manure removal, Pull-type manure harvesting, Scraping/harrowing, Shaded areas in open corral, Feeding near dusk, Downwind shelterbelts/boundary trees

[1] ARB – This emission factor includes emissions from the cows, feed, and emissions from the unpaved roads

[2] It will be assumed that 15% of the total dairy PM10 emissions are generated from the unpaved areas. Therefore, the emission factor from the unpaved areas = 2.46 lbs/hd-yr x 0.15 = 0.369 lbs/hd-yr

[3] It will be assumed that 5% of the total dairy PM10 emissions are generated from unpaved equipment areas. Therefore, the emission factor from the unpaved equipment areas = 2.46 lbs/hd-yr x 0.05 = 0.123 lbs/hd-yr

[4] It will be assumed that 5% of the total dairy PM10 emissions are generated from the feed areas. Therefore, the emission factor from the feed areas = 2.46 lbs/hd-yr x 0.05 = 0.123 lbs/hd-yr

[5] The emissions from the unpaved roads, unpaved equipment areas, and feed will be subtracted from the overall dairy PM10 EF in order to calculate the emissions from the dairy cows. Therefore, the EF from the dairy cows = 2.46 - 0.369 - 0.123 - 0.123 = 1.845 lbs/hd-yr

[6] The emission factor for open corral housing will be back calculated by using the emission factor from freestall housing and dividing it out by the control efficiency of the freestall housing. As calculated above, the emissions from the freestall housing is = 1.845 lbs/hd-yr. The PM10 control efficiency for freestall housing is approximately 60%. Therefore, the EF for open corral housing is = 4.6 lbs/hd-yr.

CMP Practices Formula for Cows

1. Sprinkling of open corral = # of cows x 1.845 lbs/hd-yr x Control Efficiency (CE)

2. Fibrous layer in dusty area = # of cows x 1.845 lbs/hd-yr x CE

3. Freestall housing = # of cows x 1.845 lbs/hd-yr x 0

4. Frequent scraping and/or manure removal = # of cows x 1.845 lbs/hd-yr x CE

5. Pull-type manure harvesting = # of cows x 1.845 lbs/hd-yr x CE

6. Scraping/harrowing = # of cows x 1.845 lbs/hd-yr x CE

7. Shaded areas in open corral = # of cows x 1.845 lbs/hd-yr x CE

8. Feeding near dusk = # of cows x 1.845 lbs/hd-yr x CE

9. Downwind shelterbelts/boundary trees = # of cows x 1.845 lbs/hd-yr x CE

CMP Practices Formula for Feed

10. Bulk material control = # of cows x 0.123 lbs/hd-yr x CE

11. Wet feed during mixing = # of cows x 0.123 lbs/hd-yr x CE

12. Place wet material in feedwagon first before mixing = # of cows x 0.123 lbs/hd-yr x CE

Feedlot:

Overall Feedlot EF:	10.59 lbs/hd-yr[7]
Unpaved Roads EF:	1.59 lbs/hd-yr[8]
Unpaved Equipment Areas EF:	0.53 lbs/hd-yr[9]

[7] ARB – This emission factor includes emissions from the cows, feed, and emissions from the unpaved roads

[8] It will be assumed that 15% of the total feedlot PM10 emissions are generated from the unpaved areas. Therefore, the emission factor from the unpaved areas = 10.59 lbs/hd-yr x 0.15 = 1.59 lbs/hd-yr

[9] It will be assumed that 5% of the total feedlot PM10 emissions are generated from unpaved equipment areas. Therefore, the emission factor from the unpaved equipment areas = 10.59 lbs/hd-yr x 0.05 = 0.53 lbs/hd-yr

Feed EF: 0.53 lbs/hd-yr[10]
EF from Cattle: 7.94 lbs/hd-yr[11]

The CMP under each category are as follows:

CMP for Feed - Bulk Material Control, Feeding near Dusk, wet feed during mixing

CMP for Cows - Sprinkling of open corral, Fibrous layer in dusty area, Frequent scraping and/or manure removal, Pull-type manure harvesting, Shaded areas, Feeding near dusk, Downwind shelterbelts/boundary trees

CMP Practices Formula for Cows

13. Shade for Animal = # of cows x 7.94 lbs/hd-yr x CE

14. Sprinkle = # of cows x 7.94 lbs/hd-yr x CE

15. Fibrous layer in working areas = # of cows x 7.94 lbs/hd-yr x CE

16. Frequent scraping and/or manure removal = # of cows x 7.94 lbs/hd-yr x CE

17. Pull-type manure harvesting = # of cows x 7.94 lbs/hd-yr x CE

18. Feeding near Dusk = # of cows x 7.94 lbs/hd-yr x CE
19. Downwind shelterbelts/boundary trees = # of cows x 7.94 lbs/hd-yr x CE

CMP Practices Formula for Feed

20. Bulk material control = # of cows x 0.53 lbs/hd-yr x CE

21. Wet feed during mixing = # of cows x 0.53 lbs/hd-yr x CE

22. Place wet material in feedwagon first before mixing = # of cows x 0.53 lbs/hd-yr x CE

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[10] It will be assumed that 5% of the total feedlot PM10 emissions are generated from the feed areas. Therefore, the emission factor from the feed areas = 10.59 lbs/hd-yr x 0.05 = 0.53 lbs/hd-yr

[11] The emissions from the unpaved roads, unpaved equipment areas, and feed will be subtracted from the overall feedlot cattle PM10 EF in order to calculate the emissions from the cows. Therefore, the EF from the feedlot cattle = 10.59 – 1.59 - 0.53 - 0.53 = 7.94 lbs/hd-yr

Poultry (Broilers and Layers:

Overall Poultry EF: 0.0213 lbs/hd-yr[12]

Open Area EF:	13.56 lbs-acre/yr[13]
Unpaved Roads EF:	2.0 VMT
Unpaved Equipment Areas EF:	2.0 VMT
Feeding EF:	0 lbs/hd-yr[14]

The CMPs under each category are as follows:

CMPs for manure handling - Time of manure spreading, cleanout frequency, outdoor storage

CMPs for open areas - Vegetation, dust suppressants, reduced tillage, wind blocks

CMP Practices Formula for Poultry

1. Time of manure spreading = # of birds x 0.0213 lbs/hd-yr x CE =
2. Cleanout Frequency = # of birds x 0.0213 lbs/hd-yr x CE =
3. Outdoor Storage = # of birds x 0.0213 lbs/hd-yr x CE =

CMP Practices Formula for Open Areas

1. Vegetation = 13.56 lbs-acre/yr x # of acres of open areas x CE =
2. Dust suppressant = 13.56 lbs-acre/yr x # of acres of open areas x CE =
3. Reduced Tillage = 13.56 lbs-acre/yr x # of acres of open areas x CE =
4. Wind Blocks = 13.56 lbs-acre/yr x # of acres of open areas x CE =

CMP Practices Formula for unpaved roads and equipment areas

Emissions reductions = 2.0 VMT x # of **TOTAL** acres of land x 0.4 VMT per acre per year[15] x CE

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[12] Particulate Matter and Ammonia Emission Factors for tunnel-Ventilated broiler houses in the Southern US", R.E. Lacey, J.S. Redwine, C.B Parnell, Jr., ASAE. Vol. 46(4): 1203-1214. 2003.
[13] Based on windblown dust EF for agriculture cropland
[14] The emissions from the feeding system are not known. However, when feed is conveyed into the feed bins or silos, a boot or sock is used in all facilities to mitigate the emissions into the air. Therefore, any further reduction in emissions will be negligible.
[15] The 0.4 VMT per acre per year is based on the alfalfa crop profile, since poultry operations don't have much traffic throughout the entire year. The main trips at a poultry facility consist of chicken and feed transport several times a year. Therefore, the use of the 0.4 VMT per acre is consistent with the alfalfa crop profile.

Appendix E
CMP Program Summary Tables

Table 1: PM10 Emissions Reduction per CMP

	PM10 Emissions Reduction (tons/yr)			
CMP	Harvest	Land Preparation	Other	Grand Total
Alternate Till		11.74	213.91	225.65
Application Efficiencies			79.87	79.87
Baling/Large Balers	33.56		122.12	155.68
Bed/Row Size or Spacing		102.20		102.20
Bulk Materials Control		-		0.00
Chemigation/Fertigation		216.14		216.14
Combined Operations	47.01	796.56		843.57
Conservation Irrigation	104.02	148.10	146.74	398.86
Conservation Tillage	3.29	241.48		244.77
Continuous Tray/D.O.V.	8.79			8.79
Cover Crop		63.00	713.08	776.08
Equipment Changes/Technological Improvements	547.29	318.05		865.34
Fallowing Land	171.04	133.53		304.56
Floor Management	671.02	78.72		749.74
Green Chop	54.32			54.32
Grinding/Chipping/Shredding			1445.04	1445.04
Hand Harvesting	11.94			11.94
Integrated Pest Management		168.11	244.03	412.14
Irrigation Power Units		-		0.00
Mechanical Pruning		-		0.00
Mulching		17.10	301.53	318.63
Night Farming		59.26	1.73	60.99
Night Harvesting	8.04			8.04
No Burning			569.95	569.95
No Burning (Alfalfa)			1.59	1.59
No Burning (Paper Trays)	0.59			0.59
Non-Tillage/Chemical Tillage		92.18		92.18
Organic Practices			3.27	3.27
Permanent Crop		-		0.00
Precision Farming (GPS)		419.94		419.94
Pre-harvest Soil Preparation	1.75			1.75
Reduced Pruning			31.19	31.19
Shed Packing	1.38			1.38
Shuttle System	623.64			623.64
Soil Amendments			75.56	75.56
Soil Incorporation			0.15	0.15
Sulfur, Reduction or Elimination of Dusting		-		0.00
Surface Roughening		0.27	180.23	180.50
Time of Planting		0.00		0.00
Transgenic Crops		44.53	19.19	63.72
Transplanting		16.23		16.23
Wind Barrier			11.59	11.59
Grand Total	2287.66	2927.14	4160.77	9375.57

Table 2: PM10 Emissions Reduction per Crop Type

Crop Type	Emissions Reduction (tons/yr)
ALFALFA	628.13
CITRUS	56.11
CORN	639.91
COTTON	1563.38
GRAINS	1199.60
GRAPES	833.32
NUT CROPS	3640.88
ONIONS/GARLIC	86.89
OTHER	0.33
SUGAR BEETS	121.14
TREE FRUIT	67.72
VEGETABLES	538.16
Grand Total	9375.57

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Table 3: PM10 Emissions Reduction per CMP per AFO Type

	PM10 Emissions Reduction (tons/yr)			
CMP	Dairy	Feedlot	Poultry	Grand Total
Boot or Sock				
Bulk Materials Control	-	-		-
Cleanout Frequency			62.84	62.84
Downwind Shelterbelts/Boundary Trees	-	-		-
Dust Suppressants			4.09	4.09
Feeding Near Dusk		38.85		38.85
Feeding Youngstock Near Dusk	14.65			14.65
Fibrous Layer in Dusty Areas	9.66			9.66
Fibrous Layer in Working Areas		15.66		15.66
Freestall Housing	-			-
Frequent Scraping and/or Manure Removal	145.36	144.38		289.74
Outdoor Storage			0.49	0.49
Placing Wet Material in Feedwagon First	3.91	0.50		4.41
Pull Type Manure Harvesting Equipment	77.65	84.46		162.11
Reduced Tillage			6.92	6.92
Scraping/Harrowing(in Morning Hours)	71.44	4.76		76.21
Shade for Animals		84.51		84.51
Shaded Areas in Open Corrals	117.00			117.00
Sprinkling		115.21		115.21
Sprinkling of Open Corrals	4.20			4.20
Time of Manure Spreading			3.54	3.54
Vegetation			15.92	15.92
Wet Feed During Mixing	4.38	1.13		5.52
Windblocks			4.75	4.75
Grand Total	448.25	489.47	98.56	1036.28

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Table 4: PM10 Emissions Reduction per Crop CMP For Unpaved Roads and Unpaved Equipment/Traffic Areas

	PM10 Emissions Reduction (tons/yr)		
CMP	Unpaved Roads	Unpaved Equipment/Traffic Areas	Grand Total
Chips/Mulches	1.85	0.29	2.14
Dust Suppressants	12.15	1.82	13.97
Less Than 10 Vehicle Trips on Any Day	795.25	75.79	871.04
Less Than 10 Vehicle Trips on Any Day (trip	0.93	0.39	1.33
Mechanical Pruning	0.56		0.56
Organic Materials	0.84	0.29	1.13
Other	-	-	-
Paving	60.27	20.68	80.96
Polymers	11.73	2.42	14.15
Restricted Access	15.18	1.79	16.97
Road Mix	2.34	0.67	3.02
Road Oil	110.09	19.34	129.43
Sand	29.54	7.85	37.39
Speed Limit Posted	168.21	168.21	336.42
Track Out Control	-	-	-
Washed Gravel	14.92	19.05	33.98
Water	569.51	7.85	577.36
Wind Barrier	-	-	-
Grand Total	1793.39	248.37	2,041.75

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Table 5: PM10 Emissions Reduction per AFO CMP For Unpaved Roads and Unpaved Equipment/Traffic Areas

	PM10 Emissions Reduction (tons/yr)		
CMP	Unpaved Roads	Unpaved Equipment/Traffic Areas	Grand Total
Chips/Mulches	0.62	0.02	0.64
Dust Suppressants	4.24	1.98	6.22
Less Than 10 Vehicle Trips on Any Day	78.35	24.88	103.23
Less Than 10 Vehicle Trips on Any Day (trip threshold)		0.02	0.02
Organic Materials	0.05	0.04	0.09
Paving	80.13	23.27	103.40
Polymers	2.57	0.60	3.17
Restricted Access	1.77	0.39	2.16
Road Mix	0.88	0.15	1.03
Road Oil	26.12	3.66	29.79
Sand	4.54	1.63	6.16
Speed Bumps (Dairies only)	0.32		0.32
Speed Limit Posted	54.75	9.09	63.84
Track Out Control	0.00	0.00	0.00
Washed Gravel	27.87	10.54	38.40
Water	59.59	17.83	77.41
Wind Barrier	0.10	0.41	0.51
Grand Total	341.88	94.50	436.39

Table 6: PM10 Emission Factors and Adjustment Factors per CMP Category for Crops

Crop Type	Land Preparation (lbs/acre/yr)	Harvest (lbs/acre)	Other				Unpaved Road and Unpaved Vehicle/Equipment Area	
			Ag. Burn (lbs/ton)	Ag. Burn Adjustment Factor	Ag. Burn Fuel Loading (ton/acre)	Windblown (ton/acre/yr)	VMT per acre	Emission Factor (lbs/VMT)
ALFALFA	4	0.24	22.8	0.01151	0.8	13.56	0.4	2
CITRUS	0.07	0.14	5.9	0.02226	1	13.56	1.23	2
CORN	6.9	0.43	47.88	0.00689	4.2	13.56	0.4	2
COTTON	8.9	3.37	34.58	0.00023	2.2	13.56	0.4	2
DRY BEANS, etc.	4.45	3.45	22.36	0.13089	2.4	13.56	1.4	2
GRAPES	1.82	0.17	73.66	0.11352	10.8	13.56	1.05	2
NUT CROPS	3.13	36.5	18.63	0.45487	2.8	13.56	0.49	2
ONIONS/GARLIC	6.5	1.68	-	-	-	13.56	2.4	2
SUGAR BEETS	22.8	1.69	-	-	-	13.56	2.4	2
TREE FRUIT	0.07	0.14	11.99	0.16117	1.8	13.56	1.23	2
VEGETABLES, etc.	9.05	0.23	55.46	0.00317	1.6	13.56	2.4	2

Note: The Crop Type "Dry Beans, etc." includes cereal grains, safflower, wheat, and barley. The Crop Type "Vegetables, etc." includes tomatoes, melons, and other. The Ag burn emission factor is comprised of the PM10 emission factor multiplied by the Ag burn fuel-loading factor.

Table 7: PM10 Emission Factors and Adjustment Factors per CMP Category for AFO

AFO Type	CMP Category	PM10 Emission Factor (lbs/head/yr)	Adjustment Factor
Dairy	Corral/Manure Handling	1.845*	0.6
	Overall Management Feeding	1.845*	0.1
	Unpaved Roads	0.369	0.1
	Unpaved Vehicle/Equipment Areas	0.123	0.2
Feedlot	Pens/Manure Handling	7.94*	0.6
	Overall Management Feeding	7.94*	0.1
	Unpaved Roads	1.59	0.1
	Unpaved Vehicle/Equipment Areas	0.53	0.2
Poultry	Manure Handling and Storage	0.0213	-
	Feeding	-	-
	Open Areas	13.56	-
	Unpaved Roads	0.0213	-
	Unpaved Vehicle/Equipment Areas	0.0213	-

Note: *Depending on the CMP selected, the PM10 emission factor was adjusted. Please refer to Attachment D, Evaluation of PM10 Emission Factors for AFO CMPs.