MEMORANDUM

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DATE: April 6, 2007

SUBJECT: PESTICIDE VOLATILE ORGANIC COMPOUND EMISSION ADJUSTMENTS FOR FIELD CONDITIONS AND ESTIMATED VOLATILE ORGANIC COMPOUND REDUCTIONS–INITIAL ESTIMATES

I. Summary

The purposes of this memorandum is to develop refined emission adjustment factors to account for the effect of application method on volatile organic compound (VOC) emissions from pesticides, with particular emphasis on fumigants, and to estimate the VOC reductions associated with changes to fumigant application methods. Each year, the Department of Pesticide Regulation (DPR) updates an inventory of pesticide VOC emissions for May–October for specified areas and compares the emissions on a relative basis to 1990 or 1991 as the base year. DPR currently assumes 100% of applied fumigants volatilize to the air. Field monitoring data shows that fumigant emissions are less than 100% and vary with application method.

There are several dozen field studies that measured fumigant emissions. Emissions vary from 9 to 100% of the amount applied, depending on the fumigant and application method. However, data is not available for all application methods in current use or in use during the 1990/91 base year. When no data is available, emissions have been estimated with surrogate data. In addition to emission estimates associated with each application method, DPR has estimated the frequency with which the various application methods were used during 1990/91 base year, as well as currently. Registrant data and pesticide use reports (PURs) were used for these estimates.

DPR used the emissions for each application method, and the frequency with which the various application methods are used to adjust its VOC emission inventory, as well as to estimate the possible emission reductions that would result from further changes to application methods. This analysis shows that application method changes between 1990/91 and 2004 are insufficient to achieve the required VOC reductions in the targeted areas. While application method changes since 1990/91 have lowered emission rates, increased fumigant use more than offsets the application method reductions. Moreover, even if all fumigant applications used “low-emission” methods, the VOC reductions would be insufficient to achieve the required levels in at least one

area. Limits on fumigant VOC emissions may be needed during May–October to ensure the required VOC reductions are achieved.

II. Background

Pesticide VOCs can contribute to the formation of ground-level ozone, which when present in high concentrations is harmful to human health and vegetation. The federal Clean Air Act requires each state to submit a state implementation plan (SIP) for achieving and maintaining federal ambient air quality standards, including the ozone standard. In 1994, California's Air Resources Board and DPR developed a SIP element to track and reduce pesticidal sources of VOCs in five regions that do not meet the 1-hour ozone standard (ozone nonattainment areas): Sacramento Metro, San Joaquin Valley, Southeast Desert, Ventura, and South Coast. On February 21, 2006, the U.S. District Court (Eastern District of California) ordered DPR to implement regulations by January 1, 2008, to achieve the VOC emission reduction goals.

In accordance with the 1994 SIP, DPR developed a method to track pesticide VOC emissions (VOC emission inventory). Each year, DPR estimates pesticide VOC emissions for May–October in each nonattainment area and compares the emissions on a relative basis to 1990 or 1991 as the base year. DPR initiated major revisions to the pesticide VOC emission procedures in 2002 (Spurlock, 2002a). Numerous updates and improvements to the VOC inventory calculation procedures have been made since that time (Spurlock, 2002b, 2004, 2005, 2006; Roush, 2006). The revisions have improved the accuracy of DPR's VOC inventory relative to earlier versions (e.g., Spurlock, 2002c).

The potential emission for a pesticide application is currently calculated as:

VOC emission (pounds) = pounds pesticide product applied x emission potential (EP)

where the EP is the EP of the pesticide product. The EP is a measure of the VOC content of a product. However, additional factors beyond product composition affect emissions under actual use conditions. In recognition of this, the 1994 pesticide element of California's SIP contains a provision for incorporating new knowledge into pesticide VOC emissions estimation procedures.

"The 1990 baseline year and subsequent year estimates may be further adjusted by additional VOC Emission Factors if additional information becomes available regarding the reactivity of compounds, the impact of temperature, moisture, deposition substrate, method of application, and other factors. Any additional VOC Emission Factor(s) will be pesticide product specific." (DPR, 1994).[1]

[1] On February 21, 2006, the United States District Court (Eastern District of California) ordered DPR to use the 1991 inventory as a surrogate for the 1990 baseline year.

Fumigants are among the highest VOC contributors due to both their high levels of use and their high-EPs. For the fumigants 1,3-dichloropropene (1,3-D), chloropicrin, and methyl bromide EPs of 100% are assumed. Thus, current VOC estimation procedures assume that all of these applied fumigants are eventually released to the troposphere. In the case of metam-sodium and N-methyl dithiocarbamate (metam-potassium) products, EPs assume 100% conversion to methyl isothiocyanate (MITC) followed by eventual release of 100% of MITC to the air. Similarly, for products containing sodium tetrathiocarbonate, EPs assume 100% conversion to carbon disulfide followed by release of 100% of carbon disulfide to the air. DPR has conducted numerous fumigant field monitoring studies over the last 15 years (e.g. <http://www.cdpr.ca.gov/docs/dprdocs/methbrom/pubs.htm>). Other researchers have also published fumigant field study results in peer-reviewed literature. Those studies demonstrate that the assumption of 100% fumigant emission to the air is inaccurate in most cases. This memorandum describes development of emission adjustment factors accounting for the effect of application method on VOC emissions from pesticides, with particular emphasis on fumigants. Using application method adjustment factors, the potential emission for a pesticide application is calculated as:

VOC emission (pounds) =
pounds product applied x EP x application method adjustment factor

The fumigant application method adjustment factors developed here are expressed as a proportion of the amount of applied fumigant that is emitted to the air. The adjustment factors are application method- and fumigant-specific, based on measured data, and yield more refined estimates of fumigant VOC emissions than current assumptions. Section II describes the available emission data and development of the application method adjustment factors.

In California, all agricultural and commercial pesticide applications must be reported. County agricultural commissioners and DPR compile these PURs into a database. DPR uses pounds of product applied recorded in this database to calculate the VOC emissions for each pesticide application included in the pesticide VOC emission inventory, as shown in the equations above. Specific application methods are not recorded on PURs. Therefore, a second adjustment is needed to account for the use of each fumigant application method. Section III describes the pounds of product applied associated with each fumigant application method (method use fraction).

Without the application method adjustment factors, fumigants account for more than 50, 80, and 90% of the pesticide VOC emissions in the San Joaquin Valley, Southeast Desert, and Ventura nonattainment areas, respectively. Moreover, these are the 3 nonattainment areas where DPR does not currently achieve the 20% pesticide VOC reduction of the 1991 base year required by the Court order. DPR is considering two regulation strategies to achieve pesticide VOC reductions from fumigants, particularly in the nonattainment areas. One strategy is to require use of "low-emission" fumigant application methods and/or prohibit certain "high-emission" fumigant application methods. A second strategy is to establish limits on VOC emissions from fumigants within the nonattainment areas. Regulations that incorporate one or both of these strategies will be effective in 2008. Section IV assesses these regulatory strategies by: (1) estimating the pesticide VOC emissions for the 1990/91 base year for each nonattainment area, with the application method and method use fraction adjustment factors; (2) estimating the VOC reductions that would have occurred if low-emission fumigant application methods had been used in 2004 for each nonattainment area; and (3) estimating the limit on fumigant emissions in each nonattainment area that would achieve the VOC emission reductions required.

This document describes the initial VOC adjustments based on the data currently available to DPR. Additional data should become available later this year and we may be unaware of some data that should be incorporated. Section V describes DPR's future activities and process to revise the estimates.

III. Estimates of Volatile Organic Compound Emissions Under Field Conditions (Application Method Adjustment Factors)

In this context, an application method adjustment factor is the emissions of fumigant to the air under field conditions, expressed as a proportion (percentage) of applied fumigant, and is fumigant- as well as application method-specific. Fumigant emissions have been measured with several methods, both in the laboratory and in the field. Fumigant emission under field conditions is a complex process that likely varies with method of application, soil characteristics (e.g., particle size, moisture, organic content), weather conditions, and other factors. Due to this complexity, laboratory measurements may not provide an accurate estimate of fumigant emissions under field conditions. Therefore, DPR relies almost exclusively on field measurements to estimate emissions. Additionally, DPR prescribes many of the application procedures and equipment used for the monitoring studies as regulatory requirements. For example, DPR prescribes requirements for maximum application rate, application depth, tarpaulin type, soil moisture, and other critical parameters based on application equipment, procedures, and conditions of the monitoring studies. These parameters are summarized here, and full descriptions are provided in the original study reports.

The reason DPR has not incorporated application method adjustment factors previously is the need to estimate emissions using a consistent process for the 1990/91 base year as well as currently. Due to exposure concerns, fumigant application methods changed substantially beginning in 1993, and very few field studies have measured fumigant emissions associated with application methods prior to this date. This section summarizes the available emission data and the assumptions used to estimate emissions for methods that have no data.

A. Methyl Bromide

DPR proposes application method adjustment factors for three main groups of methyl bromide field application methods: methods that use tractor shanks to inject methyl bromide into pre-formed beds and are covered with a tarpaulin, methods that use tractor shanks to inject methyl bromide into flat fields (broadcast) and are covered with a tarpaulin, and methods that use tractor shanks to inject methyl bromide into flat fields (broadcast) without a tarpaulin. In addition, there are some non-field application methods. This approach is consistent with DPR's current regulations for methyl bromide.

1. Methyl Bromide Emission Studies

DPR's data set includes 30 field studies utilizing current application methods (Table 1). DPR's analysis of these data shows that the nine bed fumigations monitored had very high 24-hour emissions (average of 81% of amount applied, coefficient of variation [CV] 38%). The 13 broadcast applications with a tarpaulin show peak 24-hour emissions that average 24% of the amount applied (CV 52%). Broadcast applications without a tarpaulin show peak 24-hour emissions that average 37% of the amount applied (CV 47%). Methyl bromide is injected at different depths below the soil surface depending on the crop, with 6–12 inches classified as shallow injection, and 18–30 inches classified as deep injection. Analysis of the data (Barry 1999) shows that depth of application had no significant effect on the highest 24-hour emissions. While in concept there should be a depth effect, it is likely in practice that application-to-application variability is too large to detect that effect.

Five journal articles contained methyl bromide data most appropriate for developing application method adjustment factors: Majewski et al. (1995), Gan et al. (1996), Yates et al. (1996a), Yates et al. (1996b), and Gan et al. (1997). These articles report either direct flux (emission) measurements (e.g., aerodynamic method) in the field or measured soil column results. No flux chamber estimates of mass loss are included because there are significant technical issues associated with flux chamber estimates (Yates 2006). Table 2 summarizes these studies and shows emission estimates for Broadcast Tarp and Broadcast Nontarp methods. Shallow and deep injections are pooled within these two categories due to the lack of significant difference associated with injection depth observed in the DPR data set. The average emission for Broadcast Tarp application method in these studies is 40%. The average emission for Broadcast Nontarp application method in these studies is 66%.

2. Methyl Bromide Application Method Adjustment Factors

The average peak 24-hour emissions for the three groups are used as the basis for the DPR application method adjustment factors. Majewski et al. (1995) conclude that about 50% of the total emissions occur in the first 24 hours for applications. Therefore, the 24-hour emissions from the DPR data set can reasonably be doubled to provide an estimate of the application method adjustment factors. The application method adjustment factor for methyl bromide broadcast applications with a tarpaulin is 48% (both shallow and deep injection). The application method adjustment factor for methyl bromide broadcast applications without a tarpaulin is 74% (both shallow and deep injection). Due to the high 24-hour emissions for bed applications with a tarpaulin, 100% loss should be assumed. Of the two field studies described in the journal articles, Majewski et al. (1995) was a joint study with DPR, and its results are accounted for in DPR's emission estimates shown in Table 1. The emissions measured in the remaining field study (Yates et al. 1996b) were consistent with the 13 DPR and registrant studies of that same application method that are used for the current methyl bromide regulations (Table 1). This last study has not been included in the determination of the application method adjustment factors because it has a negligible effect when grouped with 13 other studies, and to maintain consistency between the application method adjustment factors and current methyl bromide regulations.

The data described support application method adjustment factors for current fumigation methods. Methods in use during 1990/91 were significantly different, particularly in the types of tarpaulins that were used. Low-density polyethylene tarpaulins were commonly used in 1990/91. No field data for applications with low-density tarpaulin is available. However, laboratory data shows that these are more permeable than the tarpaulins currently used. Due to the lack of data, the application method adjustment factor for methyl bromide methods used in the 1990/91 base year are assumed to have the same emissions as current methods without a tarpaulin (74%). This assumption accounts for the permeable low-density tarpaulins that were in use at the time.

In 1990/91 as well as currently, methyl bromide has uses as a space fumigant for both structures and harvested commodities. Methyl bromide emissions from these application methods are assumed to be 100% of the amount applied.

The methyl bromide registrants submitted proposed application method adjustment factors to DPR (Stangellhini 2006a; Appendix 1), based on the Gan et al. (1997) study. Some of the registrants' adjustment factors are similar to those proposed by DPR. However, several are inconsistent with DPR's analysis of the available data (Appendix 2).

Based on the emission data shown in Table 1 and the assumptions discussed above, the application method adjustment factors for methyl bromide are:

Shallow injection w/ high permeability tarp or no tarp-broadcast	74%
Shallow injection w/ low permeability tarp-broadcast	48%
Shallow injection w/ high permeability tarp or no tarp-bed	100%
Shallow injection w/ low permeability tarp-bed	100%
Deep injection w/ high permeability tarp or no tarp-broadcast	74%
Deep injection w/ low permeability tarp-broadcast	48%
Nonfield soil (structural/post-harvest)	100%

B. 1,3-Dichloropropene

DPR proposes application method adjustment factors for five 1,3-D field application methods: methods that use tractor shanks to inject 1,3-D at shallow depths, methods that use tractor shanks to inject 1,3-D at deep depths, methods that include post-fumigation water treatments for both shallow injection and deep injection, and chemigation with drip irrigation systems.

1. 1,3-Dichloropropene Emission Studies

Appendix 3 is a recent analysis of six 1,3-D field monitoring studies. Four studies employed a shank injection at varying depths and two studies employed drip application. In contrast to methyl bromide, 1,3-D studies appear to show differing emissions with depth of injection, but standard high-density tarpaulins have little or no effect on 1,3-D emissions (Yates et al. 2002). In order to fully utilize the four studies, they were combined by linear interpolation to estimate the flux at two standard depths: 18 inches and 12 inches.

Use of 1,3-D was suspended in early 1990 due to high ambient air concentrations monitored in Merced. In researching mitigation measures to reduce emissions, the registrant conducted a flux study using elevated soil moisture (Knuteson et al. 1992). This soil moisture mitigation measure is now a part of the shank application methodology.

Gao and Trout (2007) used flux chambers to estimate emissions for several chloropicrin and 1,3-D application methods, including high-density polyethylene tarpaulin, high-density polyethylene tarpaulin with pre-irrigation, single post-fumigation water treatment, multiple post-fumigation water treatments (intermittent watering-in), and virtually impermeable film. Those researchers reported problems maintaining a seal between the soil and the chamber. Other researchers have concluded that the chamber methodology does not accurately measure emissions under field conditions (Yates 2006). Consequently predictions of 1,3-D emission reductions due to post-fumigation water treatments are subject to considerable uncertainty because the Gao and Trout (2007) study is the only information available for 1,3-D on this mitigation measure. However, reductions observed in their study are qualitatively consistent with demonstrated reductions in MITC emissions for post-fumigation water treatments.

2. *1,3-Dichloropropene Application Method Adjustment Factors*

Appendix 3 summarizes and estimates the 1,3-D emissions for the application methods currently used, based on the available field studies and the emission adjustments (application factors) described in DPR's recommended conditions for 1,3-D restricted materials permits (DPR 2002). Field studies for 1,3-D have been conducted during the fall and spring seasons only. DPR's recommended permit conditions (2002) include an ad hoc adjustment factor for 1,3-D applications during the summer. We have chosen not to include the summer adjustment factor for 1,3-D application methods in these VOC emission estimates for three reasons. One, the summer adjustment factors are ad hoc, and not based on any scientific data or evaluation. Two, DPR does not use a seasonal adjustment for its regulatory emission values for any of the other fumigant. Three, the revised method for estimating VOC emissions described here is based on assigning a single field adjustment factor for each application method and fumigant combination; a seasonal emission adjustment would greatly increase the complexity of the VOC calculations.

DPR will assume that reductions in 1,3-D emissions for three post-fumigation water treatments is approximately one-third less than an untarped application. Other application methods that appear to reduce chloropicrin emissions, such as pre-irrigation and virtually impermeable film may be problematic due to labeling requirements and other factors (Gao and Trout, 2007). Therefore, these application methods are not recommended at this time.

In 1990/91 there were virtually no applications of 1,3-D during the ozone season so no application method adjustment factors are needed for methods in those years.

Based on the emission data shown in Table 3 and the assumptions discussed above, the application method adjustment factors for the 1,3-D are:

Shallow injection w/ high permeability tarp or no tarp-broadcast	61%
Shallow injection w/ 3 water treatments	41%
Deep injection w/ high permeability tarp or no tarp-broadcast	41%
Deep injection w/ 3 water treatments	27%
Drip w/ high permeability tarp or no tarp	29%

C. Chloropicrin

The majority of chloropicrin is applied as a mixture with either methyl bromide or 1,3-D; a few applications use chloropicrin as the sole fumigant. The same application methods that are used for methyl bromide or 1,3-D will be used for chloropicrin, but with different application method adjustment factors.

1. Chloropicrin Emission Studies

Chloropicrin registrants measured chloropicrin emissions from several field applications (Beard et al. 1996). This study provides adequate data to characterize chloropicrin emissions for most of the current application practices. Emissions measured in this study showed relative differences similar to methyl bromide, with lower emissions associated with tarped broadcast applications and higher emissions associated with untarped broadcast and bed applications (Table 4). However, the study did not measure emissions for deep injection application methods, so the effect of injection depth is unknown. Data presented by the chloropicrin registrants yield similar conclusions, except the two studies Gillis and Smith (2002) and Lee et al. (1994) are either not of sufficient quality or do not include sufficient data to judge the quality to support their use in the DPR estimation of the adjustment factors. Chloropicrin registrants also measured emissions associated with chemigation of chloropicrin through a drip irrigation system (Rotonardo, 2004). This study provides adequate data for the emissions from the drip application method, and shows substantially lower emissions than injection methods (Table 4).

Gao and Trout (2007) used flux chambers to estimate emissions for several chloropicrin and 1,3-D application methods, including high-density polyethylene tarpaulin, high-density polyethylene tarpaulin with pre-irrigation, single post-application water treatment, multiple post-application water treatments (intermittent watering-in), and virtually impermeable film. Those researchers reported problems maintaining a seal between the soil and the chamber. Other researchers have concluded that the chamber methodology does not accurately measure emissions under field conditions (Yates 2006). Consequently, predictions of chloropicrin emissions associated with the intermittent watering-in application method are subject to considerable uncertainty because the Gao and Trout (2007) study is the only information available for chloropicrin on this mitigation measure. However, reductions observed in their results are qualitatively consistent with demonstrated reductions in MITC emissions for intermittent watering-in methods.

2. Chloropicrin Application Method Adjustment Factors

The Beard et al. (1996) and Rotonardo (2004) studies will be used to produce the DPR application method adjustment factors. The emissions from Beard et al. (1996) are shown in Table 4. Similar to the proposed methyl bromide factors (Barry, 2006), the proposed chloropicrin factors only distinguish between tarpaulin and no tarpaulin. No depth factor will be included. All broadcast tarpaulin method emission results will be combined to produce an average estimate.

The chloropicrin data set is small, as a result it is impossible to reliably distinguish between emissions for bed and broadcast applications. Thus, no separate field adjustment factor for bed methods will be estimated. Instead, based on the known high-emission characteristics of methyl bromide bed applications (Barry, 1999), the chloropicrin emission estimates for bed will be combined with the no tarpaulin method.

The drip application method is separated because although only one acceptable study exists for that method (Rotonardo, 2004) the emissions appear to be substantially lower than the shank injection methods.

As with methyl bromide, chloropicrin applications methods in 1990/91 used more permeable low-density polyethylene tarpaulins. Stangellhini (2006b, Appendix 1) proposes, and DPR agrees, that 1990/91 chloropicrin applications should be assigned the application method adjustment factor for applications without a tarpaulin.

DPR will assume that reductions in chloropicrin emissions for intermittent watering-in consisting of three post-fumigation water treatments is approximately one-third less than an untarped application. Other application methods that appear to reduce chloropicrin emissions, such as pre-irrigation and virtually impermeable films may be problematic due to labeling requirements and other factors (Gao and Trout, 2007). Therefore, these application methods are not recommended at this time.

Based on the emission data shown in Table 4 and the assumptions discussed above, the application method adjustment factors for chloropicrin are:

Shallow injection w/ high permeability tarp or no tarp-broadcast	64%
Shallow injection w/ low permeability tarp-broadcast	44%
Shallow injection w/ high permeability tarp or no tarp-bed	64%
Shallow injection w/ 3 water treatments	20%
Shallow injection w/ low permeability tarp-bed	64%
Deep injection w/ high permeability tarp or no tarp-broadcast	64%
Deep injection w/ low permeability tarp-broadcast	44%
Deep injection w/ 3 water treatments	20%
Drip w/ low permeability tarp	15%

C. Metam-sodium and Metam-potassium

Metam-sodium and metam-potassium fumigant action and VOC emissions are due to the hydrolysis product MITC, which is generated when sufficient water is applied to either metam-sodium or metam-potassium. The two active ingredients display essentially identical chemical behavior. In the remainder of this document metam be used to collectively refer to both metam-sodium and metam-potassium. EPs for products containing these chemicals are expressed on an MITC equivalent basis (Spurlock, 2002a, 2005). Here emission factors are also derived on an MITC emission basis.

DPR proposes application method adjustment factors for eight metam field application methods:

Using tractor shanks to inject metam at shallow depths
Chemigation through sprinkler irrigation systems
Post-fumigation water treatments for both shank injection and sprinkler applications
Spraying metam on the soil surface and incorporate using a rototiller
Spraying metam on the soil surface and cover with additional soil (soil capping)
Chemigation through flood irrigation systems
Chemigation with drip irrigation systems

1. Metam-Sodium Emission Studies

The Metam-sodium Task Force submitted results from field studies conducted under their 1997-2001 Field Program. The earliest studies monitored MITC air concentrations associated with standard sprinkler and standard shank injection applications (Merricks, 1999). Standard sprinkler and standard shank injection methods include water treatments immediately following completion of the application. Field study results were also submitted for shank injection and sprinkler applications employing new post-fumigation water treatments as mitigation measures aimed at suppressing MITC emissions (Merricks, 2001; Merricks, 2002). The post-fumigation water treatments consist of water applied immediately following the application but also additional water, usually at sunset of the first and second evenings following completion of an application. Emission profiles developed for all four of these application methods have been used previously by DPR to develop MITC buffer zones (Barry, 2006).

DPR has three metam-sodium drip method and one rototiller method emission profiles developed using results from three field studies (Levine et al, 2005; Li et al., 2006; Wofford 2005).

Table 5 shows the total MITC emissions over the 96-hour flux profiles for each of the application methods. The total MITC available for emission was calculated assuming a maximum, immediate conversion of metam-sodium to MITC of 95% (Wales, 2000) and adjusting for difference in molecular weight between metam-sodium and MITC.

2. Metam Application Method Adjustment Factors

The metam-sodium data set is small, as a result it is impossible to reliably distinguish between emission rates for sprinkler and shank injection methods. However, relative to the standard application methods, the emissions are substantially lower for post-fumigation water treatments of both sprinkler and shank injection. Thus, sprinkler and shank injection methods are combined but standard and post-fumigation water treatments are separated. The drip and rototiller application methods are separated because the emissions observed in Levine et al. (2005) and Wofford (2005) are substantially lower than observed for other application methods.

Other application methods were commonly used in 1990/91 as well as currently, but the emissions have not been measured either in the laboratory or in the field. Specifically, no emission data is available for methods that consist of spraying metam on the soil surface and covering with additional soil (soil capping) or for methods that consist of chemigating using flood irrigation systems. In order to account for the emissions from these application methods in 1990/91, DPR assumes that emissions from the soil capping method are the same as rototiller, and emissions from flood chemigation are the same as sprinkler.

All of the metam studies and emissions described above were daylight applications. Unlike other fumigants, metam applications commonly have higher emissions at night compared to the day, particularly if applications occur at night. Wofford et al. (1994) measured emissions of nearly 100% from a night sprinkler application. It is likely that other metam application methods also have higher emissions when done at night. Except for the standard sprinkler method, the emissions for metam night applications are unknown. The frequency of night applications is also unknown. Therefore, DPR does not currently account for the emission difference between day and night applications.

Based on the emission data shown in Table 5 and the assumptions discussed above, the application method adjustment factors for metam (as a percentage of MITC) are:

Shallow injection w/ high permeability tarp or no tarp-bed	77%
Shallow injection w/ 3 water treatments	21%
Rotovate/rototill	14%
Soil capping	14%
Sprinkler	77%
Sprinkler w/ 3 water treatments	21%
Flood	77%
Drip w/ high permeability tarp or no tarp	9%
Drip w/ low permeability tarp	9%

D. Dazomet

Similar to metam-sodium and metam-potassium, dazomet fumigant action and VOC emissions are due to the hydrolysis product MITC, which is generated when sufficient water is applied to dazomet. In addition to their chemical differences, dazomet is formulated as granules while metam-sodium and metam-potassium are formulated as liquids. The EP for dazomet is expressed on an MITC equivalent basis (Spurlock, 2002a, 2005). Here application method adjustment factors are also derived on an MITC emission basis.

DPR proposes application method adjustment factors for two dazomet application methods: methods for which dazomet is applied to the soil surface followed by post-fumigation water treatments, and methods for which dazomet is incorporated into the soil followed by post-fumigation water treatments.

1. Dazomet Emission Studies

The data set for dazomet consists of three studies, two surface applied and one incorporated (Table 5). The registrants for a dazomet product submitted study results that included air concentrations and emission calculations for a surface and an incorporated application (Certis, 2004). There is significant uncertainty in the emission estimates for both the surface and the incorporated application methods due to the very calm wind conditions during the studies. Out of 18 sampling periods for each study only three sampling periods from the incorporated application and none of the sampling periods from the surface application resulted in statistically significant regressions used to estimate the emission rate. A third study conducted by DPR (Fan, in progress) monitored a surface application to small plots of dazomet. The regression analysis used to estimate emissions was statistically significant, but resulted in an emission calculation that was a factor of ten higher than the registrant studies. Because of the discrepancies in the emission estimates between the three studies, DPR and the registrant jointly initiated a fourth study. The analysis of the data from that study is in progress. Additionally, all of the available studies may underestimate VOC emissions from dazomet because of other VOCs formed by its degradation. The available studies only measured MITC, but other degradation products may also have significant VOC emissions (Subramanian, et al. 1996).

2. Dazomet Application Method Adjustment Factors

The available data set for dazomet is small and the emission factors vary by a factor of ten, so an average of the fraction of MITC emitted from all of the studies is used as the interim application method adjustment factor for all applications of dazomet products. DPR may revise this adjustment factor once the third and fourth studies are completed. DPR may also revise this adjustment factor after further evaluation of the other dazomet degradation products. The interim application method adjustment factor for all dazomet application methods is 17%.

E. Sodium Tetrathiocarbonate

Sodium tetrathiocarbonate fumigant action and VOC emissions are due to the hydrolysis product carbon disulfide, which is generated when sufficient water is applied to sodium tetrathiocarbonate. The EP for sodium tetrathiocarbonate is expressed on a carbon disulfide equivalent basis (Spurlock, 2002a, 2005). Here application method adjustment factors are also derived here on a carbon disulfide emission basis.

DPR proposes application method adjustment factors for three sodium tetrathiocarbonate application methods: chemigation using drip irrigation systems, chemigation using mini-sprinkler systems, and flood/furrow chemigation.

1. Sodium Tetrathiocarbonate Emission Studies

Evaluations by DPR staff concluded that mini-sprinklers potentially result in higher off-site carbon disulfide air concentrations relative to the other application methods (Haskell, 1995). Thus, this method may also represent worst-case emissions of carbon disulfide. DPR has one direct flux (emission) study characterizing emissions of carbon disulfide following application of sodium tetrathiocarbonate by mini-sprinklers (Pilling, 1996). This study was the basis for buffer zones on the current labels. Emissions were characterized by the integrated horizontal flux method (Wilson and Shum, 1992) for 34.2 hours consisting of: (1) the application, (2) follow-up irrigation (watering-in), and (3) an additional 24 hours after completion of watering-in. The emission estimates indicate that 9.6% of the carbon disulfide generated by the sodium tetrathiocarbonate product was emitted during the 34.2 hours sampled. The emission profile shows the peak emissions occurred during the application process and then dropped rapidly to low emissions that were relatively uniform in value between 0.41 micrograms per square meter-second (ug/m^{2}sec) and 1.02 ug/m^{2}sec. However, on the morning of the second day emissions began to rise. At 0900 hours on the second day the emission estimate was 1.23 ug/m^{2}sec and the last 4-hour interval (mid-point time 1700 hours) showed an emission estimate of 2.6 ug/m^{2}sec. The emission profile for the second night is unknown. Based upon emission profiles for standard shank and standard sprinkler application methods of metam-sodium, it is possible that without watering-in on the second night the emission of carbon disulfide would have continued to rise. Thus, the 9.6% estimate of total carbon disulfide emissions may underestimate the true total emissions.

2. Sodium Tetrathiocarbonate Application Method Adjustment Factors

We assume that the emissions from drip and flood/furrow chemigation are the same as mini-sprinkler. Based on the 9.6% emission rate measured in the study described above, the application method adjustment factors for sodium tetrathiocarbonate are:

Drip	10%
Sprinkler	10%
Flood	10%

F. Other pesticides

Fumigants are the dominant contributors to pesticide VOCs, generally responsible for at least 50–60% of emission in most California nonattainment areas. The next largest class of high-contributing pesticides is liquid formulations such as emulsifiable concentrates. In some cases, emissions calculated directly from the thermogravimetric analyses measurements without accounting for application method may over-estimate actual field emissions for some of these products. This may be especially true for products that are incorporated into the soil. In other cases, such as high solvent formulations that are foliar applied, it is unlikely that field processes reduce emissions significantly. In any event, there is little, if any data available that would allow estimation of application method-based emission factors for nonfumigant pesticides. Consequently, emission factors for nonfumigants are assumed to be 100% in all years. DPR may reconsider these nonfumigant field adjustment factors as further data becomes available.

IV. Estimated Frequency of Use for Each Fumigant Application Method During May–October (Method Use Fractions)

In California, all agricultural and commercial pesticide applications must be reported. County agricultural commissioners and DPR compile these PURs into a database. The PUR database includes the identity of the product applied, the amount applied, location, date, crop/site treated, and other information. DPR uses the pounds of product applied recorded in the PUR database to calculate the VOC emissions for each pesticide application included in the pesticide VOC emission inventory. The PUR database contains general information about the application method (i.e. air, ground, or other), but it does not indicate the specific application method. Therefore, another adjustment is needed to account for the use of each fumigant application method.

In general, different crops use different fumigant application methods. Roush (2006) found that the different nonattainment areas have different crops responsible for the majority of pesticide

VOC emissions. Therefore, each nonattainment area should have a different set of adjustment factors to characterize the use of fumigant application methods. While the application method depends on the crop to be planted, other factors such as soil type, cost, and equipment availability also influence the choice of application method. For example, strawberries always use a shallow application method. However, the tarp broadcast and tarp bed application methods are both commonly used for strawberries, and these application methods have different emissions. Therefore, the type of crop is an unreliable surrogate to identify the fumigant application method in some cases.

DPR proposes to use a variety of methods to estimate the use of each of the fumigant application methods (method use fraction). The method for 1,3-D is the most accurate. As required under DPR's 1,3-D management plan, the registrants maintain records of the specific application method for all 1,3-D applications. Johnson (2006) describes the May–October method use fractions, based on the registrants' data.

Lawson (2006) provides a survey of metam-sodium practices by several dozen growers and applicators in certain areas of the state. This survey includes a compilation of the application methods. The survey includes specific information for three nonattainment areas, as well as the top ten counties. DPR uses the percentage breakdown described in Lawson (2006) on the use of the various metam-sodium applications for the San Joaquin Valley, Southeast Desert, and Ventura nonattainment areas. DPR uses the breakdown for the top ten counties described in Lawson (2006) as a surrogate for the Sacramento Metro nonattainment area, and Ventura as a surrogate for the South Coast nonattainment area.

Similar to the approach described by Stangellhini (2006a, 2006b; Appendix 1), DPR uses information from the PURs to estimate the May–October method use fractions for methyl bromide and chloropicrin based on the following assumptions:

- For 1990/91 methyl bromide and chloropicrin applications, all row, vegetable, and nursery crops (except strawberries) were fumigated using a shallow injection broadcast method with a high permeability tarpaulin or no tarpaulin.
- For 1990/91 methyl bromide and chloropicrin applications, one-half of the strawberry applications were conducted with a shallow injection broadcast method and a high permeability tarpaulin, and one-half of the strawberry applications were conducted with a shallow injection bed method and a high permeability tarpaulin.
- For 1990/91 methyl bromide and chloropicrin applications, all tree and vine crops were fumigated using a deep injection method with a high permeability tarpaulin or no tarpaulin.
- For 2004 methyl bromide applications, all row, vegetable, and nursery crops (except strawberries) were fumigated using a shallow injection broadcast method with a low permeability tarpaulin.

- For 2004 methyl bromide applications, one-half of the strawberry applications were conducted with a shallow injection broadcast method and a low permeability tarpaulin, and one-half of the strawberry applications were conducted with a shallow injection bed method and a low permeability tarpaulin.
- For 2004 methyl bromide applications, all tree and vine crops were fumigated using a deep injection method with a low permeability tarpaulin.
- For 2004 chloropicrin applications, all row, vegetable, and nursery crops (except strawberries and Inline® applications) were fumigated using a shallow injection broadcast method with a low permeability tarpaulin. Inline® applications were conducted with a drip chemigation method.
- For 2004 chloropicrin applications, strawberry Inline product applications were conducted with a drip chemigation method. For the remaining strawberry applications, one-half were conducted with a shallow injection broadcast method and a low permeability tarpaulin, and one-half were conducted with a shallow injection bed method and a low permeability tarpaulin.
- For 2004 chloropicrin applications, all tree and vine crops were fumigated using a deep injection method with a low permeability tarpaulin.

NOTE: 2004 is the most recent year for which DPR has calculated a VOC emission inventory.

The method use fractions for dazomet have no effect on the total emission estimates because the application method adjustment factor is 17% for both application methods. Similarly, the method use fractions for sodium tetrathiocarbonate have no effect on the total emission estimates because the application method adjustment factor for all 3 application methods is 10%.

The information from the 1,3-D registrants, Lawson (2006), and PURs is adequate for estimating the method use fractions during the 1990/91 base year and currently. Tables 6–10 show the method use fractions during the 1990/91 base year in each nonattainment area. Tables 11–15 show the method use fractions for 2004 in each nonattainment area. Tables 16–20 show the predicted method use fractions if all applications switched to a “low-emission” method for each nonattainment area. This last set of method use fractions was predicted by assuming that all “high-emission” methods switch to the most similar “low-emission” method. For example, Table 11 shows that 45% of the metam applications were conducted using the standard sprinkler (high-emission) method in the Sacramento Metro area during 2004. As shown in Table 16, DPR predicts that applicators using the standard sprinkler method change to the sprinkler with three water treatments (low-emission) method to reduce emissions.

V. Estimated Effect of Fumigant Application Method Adjustments on the Volatile Organic Compound Inventory

Previously, DPR did not include application method adjustment factors and method use fractions as part of its pesticide VOC emission calculations. Historically, DPR assumed all application method adjustment factors were 100%, and that fumigant use is equivalent to fumigant VOC emission. Table 21 summarizes the current May–October emission inventory (assuming 100% fumigant VOC emissions) for 1990, 1991, and 2004 in each nonattainment area, and shows an overall increase in fumigant use and emissions for most nonattainment areas.

This memorandum derives various fumigant- and application method-specific adjustment factors to refine the accuracy of the VOC inventory. Table 22 summarizes the application method adjustment factors associated with each fumigant and application method combination, and shows that most current application methods have substantially lower emissions than methods used in 1990/91.

Tables 6–20 summarize the May–October method use fractions during 1990/91, 2004, and the predicted method use fractions if all applications switched to a “low-emission” method for the 2008 regulations. The predicted method use fractions under the proposed regulations were determined using best professional judgment and the application methods used during 2004.

Estimated pesticide VOC emissions for May–October that account for fumigant application methods are calculated by multiplying the unadjusted VOC emissions shown in Table 21, by the application method adjustment factors shown in Table 22 and the corresponding method use fractions in Tables 6–20. Table 23 shows the results of these calculations and provides estimates of the adjusted VOC emissions during the 1990/91 base year and 2004. Table 23 indicates that application method changes between 1990/91 and 2004 are insufficient to achieve the required VOC reductions in the San Joaquin Valley, Southeast Desert, and Ventura nonattainment areas. While application method changes since 1990/91 have lowered emission rates, increased fumigant use more than offsets the application method reductions.

Table 23 also includes an estimate of the lowest pesticide VOC emissions currently feasible through changes in fumigant application methods. This was estimated by assuming that all field fumigations in 2004 used “low-emission” methods. Table 23 shows that even if all fumigant applications used “low-emission” methods, the VOC reductions will be insufficient to meet the SIP obligations for Ventura and possibly insufficient for San Joaquin Valley and Southeast Desert. If future fumigant use decreases relative to 2004, the San Joaquin Valley and Southeast Desert nonattainment areas will likely achieve the required VOC reductions by switching to “low-emission” methods. Conversely, if future fumigant use increases, these two areas are unlikely to achieve the required VOC reductions by relying solely on changing to "low-emission" methods. The Ventura nonattainment area will likely require a substantial decrease in use during May–October in order to achieve the required VOC reduction, even if all applications changed to "low-emission" methods.

Limits on fumigant emissions during May–October within each nonattainment area could achieve the required VOC reductions. Table 24 shows the maximum fumigant emissions that would achieve the required reductions, assuming VOC emissions from nonfumigant pesticides remain the same as 2004. If there are also no changes to the 2004 fumigation practices (i.e. no low-emission methods are adopted), acres fumigated and/or application rates during the May–October period would need to decrease approximately 40–50% in the San Joaquin Valley, Southeast Desert, and Ventura nonattainment areas in order to achieve the required VOC reductions (Table 24). The Sacramento Metro and South Coast nonattainment areas easily achieve the required reductions with current practices. It is likely that some combination of application method changes and emission limits is necessary to achieve the required VOC reductions for several nonattainment areas.

VI. Future Activities and Revised Estimates

These initial estimates of application method adjustment factors, method use fractions, and resulting VOC emission reductions support DPR's proposed regulations for field fumigations. As required by law, DPR will submit this document and the proposed regulations for peer review and public comment. It is likely, if not certain, that DPR will revise its application method adjustment factors, method use fraction estimates, and the proposed regulations based on the peer review and public comment. DPR anticipates that the comments will include information not previously available to DPR. Moreover, additional field emission studies should be completed later this year.

Research is also in progress on methods to more accurately estimate VOC emissions from nonfumigant pesticides, such as emulsifiable concentrates. If this work is completed in time, it may provide the basis for DPR to develop adjustment factors for other pesticides.

DPR will make revisions after the peer review and public comment period, and incorporate any new data. These revisions will include updates of the application method adjustment factors, method use fractions, and estimated VOC emissions. The revisions will also include an estimate of the pesticide VOC emissions for 2005, based on the 2005 PUR data.

Accuracy of the application method adjustment factors varies. In many cases, the application method adjustment factors are based on preliminary studies or studies for similar application methods, such as the chloropicrin post-fumigation water treatments. Some uncertainties will remain after the review and revisions because the studies in progress will not provide data for all of the uncertain application method adjustment factors. We recommend that DPR conduct monitoring of commercial fumigant applications in 2008 and/or 2009 to determine the effectiveness of the regulations and to update the VOC reduction estimates.

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Table 1. Summary of methyl bromide emission estimates from DPR and registrant field studies. The methyl bromide application method adjustment factors are twice the average emission values shown, based on the assumption that the peak 24-hour emissions are one-half the total emissions.

Study ID[1]	**Bed/Broadcast**	**Tarpaulin Type**	**Chisel Type**	**Injection Depth (inches)**	**Date Applied**	**Peak Emissions in 24 hrs (%)**	**Average Emissions (%)**	**CV (%)**
SE1.1	Bed	None	Rearward curved	12	8/19/92	34	37	47
SE1.2	Bed	None	Rearward curved	12	9/24/92	56		
SE1.3/EH127-2	Bed	None	Rearward curved	12	10/27/92	40		
SE2.2	Broadcast	None	Forward curved	20	10/21/92	62		
EH164-7	Broadcast	None	Forward curved	20	1/22/98	32		
S104.2-1	Broadcast	None	Forward curved	24	3/8/93	44		
S100B1.1	Broadcast	None	Forward curved	24	3/13/93	22		
S110.1	Broadcast	None	Forward curved	24	10/31/95	8.4		
TC199	Broadcast	High barrier	Nobel Plow	12	6/30/92	26	24	52
EH127-1	Broadcast	High barrier	Nobel Plow	12	10/26/92	16		
EH150-6	Broadcast	High barrier	Nobel Plow	12	2/13/97	9.8		
EH163-2	Broadcast	High barrier	Nobel Plow	12	8/21/97	40		
EH164-5	Broadcast	High barrier	Nobel Plow	12	11/1/97	36		
EH164-10A	Broadcast	High barrier	Nobel Plow	12	6/5/98	36		
EH164-10C	Broadcast	High barrier	Nobel Plow	12	6/5/98	30		
EH164-10E	Broadcast	High barrier	Nobel Plow	12	6/7/98	17		
EH164-10G	Broadcast	High barrier	Nobel Plow	12	6/7/98	17		
TC324.1	Broadcast	High barrier	Nobel Plow	12	7/25/98	6.8		
EH163-4	Broadcast	High barrier	Nobel Plow	12	9/2/98	26		
BR787.1A	Broadcast	High barrier	Nobel Plow	12	6/24/99	20		
BR787.2A	Broadcast	High barrier	Nobel Plow	12	6/30/99	48		
S110F1	Bed	High barrier	Rearward curved	6	7/13/93	6.2	81	38
EH164-2	Bed	High barrier	Rearward curved	6	9/8/97	68		
EH164-11	Bed	High barrier	Rearward curved	6	10/6/98	100		
BR787.1B	Bed	High barrier	Rearward curved	6	6/24/99	100		
BR787.1C	Bed	High barrier	Forward curved	6	6/24/99	100		
BR787.2B	Bed	High barrier	Forward curved	6	6/30/99	76		
BR787.2C	Bed	High barrier	Rearward curved	6	6/30/99	76		
EH150-2	Bed	High barrier	Rearward curved	6	12/12/96	100		
EH164-6	Bed	High barrier	Rearward curved	6	12/17/97	100		

[1] Study IDs beginning with EH are DPR studies, all others are registrant studies.

Table 2. Summary of methyl bromide emission estimates from the literature.

Broadcast Tarp						
Reference	**Study Type**	**Soil Type**	**Depth (cm)**	**Emissions (%)**	**Average (%)**	**CV (%)**
JEQ Vol 24:742	Field	Silty Clay Loam	25	32	40	35
JEQ Vol 25:185	Field	Sandy Loam	25	63		
JEQ Vol 26:310	Column	Sandy Loam	30	43		
JEQ Vol 26:310	Column	Sandy Loam	30	37		
JEQ Vol 26:310	Column	Sandy Loam	60	26		
Broadcast Nontarp						
Reference	**Study Type**		**Depth (cm)**	**Emissions (%)**	**Average (%)**	**CV (%)**
JEQ Vol 24:742	Field	Silty Clay Loam	25	89	66	34
JEQ Vol 26:310	Column	Sandy Loam	20	82		
JEQ Vol 26:310	Column	Sandy Loam	30	71		
JEQ Vol 26:310	Column	Sandy Loam	60	38		
ES&T Vol 30:1629	Column	Sandy Loam	30	77		
ES&T Vol 30:1629	Column	Loamy Sand	30	77		
ES&T Vol 30:1629	Column	Clay	30	37		

Table 3. Summary of 1,3-D emission estimates.

Reference	Application Method	Location	Measured Emissions (%)	Emissions (%) interpolated to 18 inches	Average Emissions (%) (interpolated to 18 inches)	CV (%)	Average Emissions (%) (interpolated to 12 inches)	CV (%)
Gillis and Dowling (1998)	Shank Broadcast - 14" depth	Salinas, CA	65	55	41[1]	32	61[2]	32
Gillis and Dowling (1998)	Shank Bed - 12" depth	Salinas, CA	65	48				
Knuteson et al. (1995)	Shank Broadcast - 20-22" depth	Firebaugh, CA	26	37				
Knuteson et al. (1992)	Shank Broadcast - 18" depth	Salinas, CA	25	25				
Knuteson et al. (1999)	Drip	Salinas, CA	29	NA	---	---	---	---
Wesenbeeck & Phillipps (2000)	Drip	Douglas, GA	29	NA	---	---	---	---

[1] Deep application 18 inches
[2] Shallow application 12 inches

Table 4. Summary of chloropicrin emission estimates.

Reference	Application Method	Location	Emissions (%)	Average (%)	CV (%)
Beard (1996)	Broadcast/No Tarp	Arizona	62.5	64.2	6.0
Beard (1996)	Broadcast/No Tarp	Arizona	61.4		
Beard (1996)	Bed/Tarp	Arizona	68.6		
Beard (1996)	Broadcast/Tarp	Arizona	62.3	44.2	35.6
Beard (1996)	Broadcast/Tarp	Washington	33.8		
Beard (1996)	Broadcast/Tarp	Florida	36.5		
Rotonardo (2004)	Drip		15	15	

Table 5. Summary of MITC emission estimates. All calculations are on a 1-acre basis. See text for description of the application methods.

Metam-Sodium Studies					
Reference	**Application Method**	**MITC Emissions (lbs)**	**Total MITC (lbs)**	**Emissions (%)**	**Average Emissions (%)**
Merricks (1999)	Standard Sprinkler	139	172	81	78
Merricks (1999)	Standard Shank	63	86	73	
Merricks (2001)	Sprinkler w/ 3 Water Treatments	39	172	23	21
Merricks (2001)	Shank w/ 3 Water Treatments	16	86	19	
Levine, et al. (2005)	Nontarp drip	0.92	21	4.4	9.1
Levine, et al. (2005)	Nontarp/intermittent drip	0.64	26.2	2.4	
Li, et al. (2006)	Tarp drip	3.58	16	20.5	
Wofford (2005)	Rototill			14	14
Dazomet Studies					
Reference	**Application Method**	**MITC Emissions (lbs)**	**Total MITC (lbs)**	**Emissions (%)**	**Average Emissions (%)**
Certis (2004)	Surface	6.26	137	4.57	17
Fan, in progress	Surface	45	105	42.9	
Certis (2004)	Surface incorporated	6.04	269	2.3	

Table 6. 1990/91 frequency of fumigation methods used (method use fractions) in the Sacramento Metro nonattainment area.

	% of Amount Applied					
Fumigation Method[1]	**1,3-D[1]**	**Chloropicrin**	**Methyl Bromide**	**Metam[3]**	**Dazomet[3]**	**Na Tetrathio-carbonate[4]**
Shallow injection w/ high permeability tarp or no tarp-broadcast		84	73			
Shallow injection w/ low permeability tarp-broadcast						
Shallow injection w/ high permeability tarp or no tarp-bed				18		
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast		16	14			
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping				2	100	
Sprinkler				55		33
Sprinkler w/ 3 water treatments						
Flood				10		33
Drip w/ high permeability tarp or no tarp				10		34
Drip w/ low permeability tarp				5		
Nonfield soil (structural/post-harvest)			13			

[1] Fumigation methods are described in detail in the text.
[2] Negligible amounts of 1,3-D were applied during 1990/91.
[3] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[4] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 7. 1990/91 frequency of fumigation methods used (method use fractions) in the San Joaquin Valley nonattainment area.

Fumigation Method[1]	**% of Amount Applied**					
	1,3-D[1]	**Chloropicrin**	**Methyl Bromide**	**Metam**[3]	**Dazomet**[3]	**Na Tetrathio-carbonate**[4]
Shallow injection w/ high permeability tarp or no tarp-broadcast		58	58			
Shallow injection w/ low permeability tarp-broadcast						
Shallow injection w/ high permeability tarp or no tarp-bed				33		
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast		42	42			
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping				3	100	
Sprinkler				60		33
Sprinkler w/ 3 water treatments						
Flood						33
Drip w/ high permeability tarp or no tarp				2		34
Drip w/ low permeability tarp				2		
Nonfield soil (structural/post-harvest)						

[1] Fumigation methods are described in detail in the text.
[2] Negligible amounts of 1,3-D were applied during 1990/91.
[3] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[4] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 8. 1990/91 frequency of fumigation methods used (method use fractions) in the Southeast Desert nonattainment area.

Fumigation Method[1]	**% of Amount Applied**					
	1,3-D[1]	**Chloropicrin**	**Methyl Bromide**	**Metam**[3]	**Dazomet**[3]	**Na Tetrathio-carbonate**[4]
Shallow injection w/ high permeability tarp or no tarp-broadcast		100	69			
Shallow injection w/ low permeability tarp-broadcast						
Shallow injection w/ high permeability tarp or no tarp-bed				10		
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler				30		33
Sprinkler w/ 3 water treatments						
Flood				50		33
Drip w/ high permeability tarp or no tarp				5		34
Drip w/ low permeability tarp				5		
Nonfield soil (structural/post-harvest)			31			

[1] Fumigation methods are described in detail in the text.
[2] Negligible amounts of 1,3-D were applied during 1990/91.
[3] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[4] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 9. 1990/91 frequency of fumigation methods used (method use fractions) in the Ventura nonattainment area.

Fumigation Method[1]	% of Amount Applied 1,3-D[1]	Chloropicrin	Methyl Bromide	Metam[3]	Dazomet[3]	Na Tetrathio-carbonate[4]
Shallow injection w/ high permeability tarp or no tarp-broadcast		50	49			
Shallow injection w/ low permeability tarp-broadcast						
Shallow injection w/ high permeability tarp or no tarp-bed		50	49	20		
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler				50		33
Sprinkler w/ 3 water treatments						
Flood						33
Drip w/ high permeability tarp or no tarp				15		34
Drip w/ low permeability tarp				15		
Nonfield soil (structural/post-harvest)			3			

[1] Fumigation methods are described in detail in the text.
[2] Negligible amounts of 1,3-D were applied during 1990/91.
[3] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[4] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 10. 1990/91 frequency of fumigation methods used (method use fractions) in the South Coast nonattainment area.

Fumigation Method[1]	**% of Amount Applied**					
	1,3-D[1]	**Chloropicrin**	**Methyl Bromide**	**Metam**[3]	**Dazomet**[3]	**Na Tetrathio-carbonate**[4]
Shallow injection w/ high permeability tarp or no tarp-broadcast		50	3			
Shallow injection w/ low permeability tarp-broadcast						
Shallow injection w/ high permeability tarp or no tarp-bed		50	3	20		
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler				50		33
Sprinkler w/ 3 water treatments						
Flood						33
Drip w/ high permeability tarp or no tarp				15		34
Drip w/ low permeability tarp				15		
Nonfield soil (structural/post-harvest)			95			

[1] Fumigation methods are described in detail in the text.
[2] Negligible amounts of 1,3-D were applied during 1990/91.
[3] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[4] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 11. 2004 frequency of fumigation methods used (method use fractions) in the Sacramento Metro nonattainment area.

Fumigation Method[1]	% of Amount Applied					
	1,3-D	Chloropicrin	Methyl Bromide	Metam[2]	Dazomet[2]	Na Tetrathio-carbonate[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast						
Shallow injection w/ low permeability tarp-broadcast		56	11			
Shallow injection w/ high permeability tarp or no tarp-bed				21		
Shallow injection w/ low permeability tarp-bed		33	6			
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast	100					
Deep injection w/ low permeability tarp-broadcast			11			
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping				15	100	
Sprinkler				45		33
Sprinkler w/ 3 water treatments						
Flood						33
Drip w/ high permeability tarp or no tarp				9		34
Drip w/ low permeability tarp		11		10		
Nonfield soil (structural/post-harvest)			71			

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 12. 2004 frequency of fumigation methods used (method use fractions) in the San Joaquin Valley nonattainment area.

Fumigation Method[1]	**% of Amount Applied**					
	1,3-D	**Chloropicrin**	**Methyl Bromide**	**Metam**[2]	**Dazomet**[2]	**Na Tetrathio-carbonate**[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast	2					
Shallow injection w/ low permeability tarp-broadcast		96	79			
Shallow injection w/ high permeability tarp or no tarp-bed				21		
Shallow injection w/ low permeability tarp-bed		2	1			
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast	98					
Deep injection w/ low permeability tarp-broadcast		1	16			
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping				20	100	
Sprinkler				35		33
Sprinkler w/ 3 water treatments						
Flood						33
Drip w/ high permeability tarp or no tarp				14		34
Drip w/ low permeability tarp				10		
Nonfield soil (structural/post-harvest)		1	4			

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 13. 2004 frequency of fumigation methods used (method use fractions) in the Southeast Desert nonattainment area.

Fumigation Method[1]	**% of Amount Applied**					
	1,3-D	**Chloropicrin**	**Methyl Bromide**	**Metam**[2]	**Dazomet**[2]	**Na Tetrathio-carbonate**[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast	4					
Shallow injection w/ low permeability tarp-broadcast		69	77			
Shallow injection w/ high permeability tarp or no tarp-bed				6		
Shallow injection w/ low permeability tarp-bed		19	19			
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast			1			
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler				75		33
Sprinkler w/ 3 water treatments						
Flood						33
Drip w/ high permeability tarp or no tarp	96			7		34
Drip w/ low permeability tarp		10		12		
Nonfield soil (structural/post-harvest)		2	3			

1 Fumigation methods are described in detail in the text.
2 DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
3 DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 14. 2004 frequency of fumigation methods used (method use fractions) in the Ventura nonattainment area.

Fumigation Method[1]	% of Amount Applied 1,3-D	Chloropicrin	Methyl Bromide	Metam[2]	Dazomet[2]	Na Tetrathio-carbonate[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast	2					
Shallow injection w/ low permeability tarp-broadcast		48	63			
Shallow injection w/ high permeability tarp or no tarp-bed						
Shallow injection w/ low permeability tarp-bed		28	37			
Shallow injection w/ 3 water treatments				25		
Deep injection w/ high permeability tarp or no tarp-broadcast	4					
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler						33
Sprinkler w/ 3 water treatments				20		
Flood						33
Drip w/ high permeability tarp or no tarp	94			5		34
Drip w/ low permeability tarp		24		50		
Nonfield soil (structural/post-harvest)						

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 15. 2004 frequency of fumigation methods used (method use fractions) in the South Coast nonattainment area.

Fumigation Method[1]	% of Amount Applied					
	1,3-D	Chloropicrin	Methyl Bromide	Metam[2]	Dazomet[2]	Na Tetrathio-carbonate[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast						
Shallow injection w/ low permeability tarp-broadcast		40	61			
Shallow injection w/ high permeability tarp or no tarp-bed				25		
Shallow injection w/ low permeability tarp-bed		36	31			
Shallow injection w/ 3 water treatments						
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler				20		33
Sprinkler w/ 3 water treatments						
Flood						33
Drip w/ high permeability tarp or no tarp	100			5		34
Drip w/ low permeability tarp		24		50		
Nonfield soil (structural/post-harvest)			8			

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 16. Predicted fumigation methods if only "low-emission" methods used (predicted method use fractions) in the Sacramento Metro nonattainment area.

Fumigation Method[1]	% of Amount Applied					
	1,3-D	Chloropicrin	Methyl Bromide	Metam[2]	Dazomet[2]	Na Tetrathio-carbonate[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast						
Shallow injection w/ low permeability tarp-broadcast		89	14			
Shallow injection w/ high permeability tarp or no tarp-bed						
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments				36		
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast		11	12			
Deep injection w/ 3 water treatments	100					
Rotovate/rototill/soil capping					100	
Sprinkler						33
Sprinkler w/ 3 water treatments				45		
Flood						33
Drip w/ high permeability tarp or no tarp				9		34
Drip w/ low permeability tarp				10		
Nonfield soil (structural/post-harvest)			74			

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 17. Predicted fumigation methods if only "low-emission" methods used (predicted method use fractions) in the San Joaquin Valley nonattainment area.

	% of Amount Applied					
Fumigation Method[1]	**1,3-D**	**Chloropicrin**	**Methyl Bromide**	**Metam[2]**	**Dazomet[2]**	**Na Tetrathio-carbonate[3]**
Shallow injection w/ high permeability tarp or no tarp-broadcast						
Shallow injection w/ low permeability tarp-broadcast		98	85			
Shallow injection w/ high permeability tarp or no tarp-bed						
Shallow injection w/ low permeability tarp-bed			13			
Shallow injection w/ 3 water treatments	2			41		
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments	98					
Rotovate/rototill/soil capping					100	
Sprinkler						33
Sprinkler w/ 3 water treatments				35		
Flood						33
Drip w/ high permeability tarp or no tarp				14		34
Drip w/ low permeability tarp		2		10		
Nonfield soil (structural/post-harvest)			2			

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 18. Predicted fumigation methods if only "low-emission" methods used (predicted method use fractions) in the Southeast Desert nonattainment area.

Fumigation Method[1]	% of Amount Applied					
	1,3-D	**Chloropicrin**	**Methyl Bromide**	**Metam[2]**	**Dazomet[2]**	**Na Tetrathio-carbonate**
Shallow injection w/ high permeability tarp or no tarp-broadcast						
Shallow injection w/ low permeability tarp-broadcast		89	100			
Shallow injection w/ high permeability tarp or no tarp-bed						
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments	4			6		
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler						33
Sprinkler w/ 3 water treatments				75		
Flood						33
Drip w/ high permeability tarp or no tarp	96	11		7		34
Drip w/ low permeability tarp				12		
Nonfield soil (structural/post-harvest)						

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 19. Predicted fumigation methods if only "low-emission" methods used (predicted method use fractions) in the Ventura nonattainment area.

	% of Amount Applied					
Fumigation Method[1]	**1,3-D**	**Chloropicrin**	**Methyl Bromide**	**Metam**[2]	**Dazomet**[2]	**Na Tetrathio-carbonate**[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast						
Shallow injection w/ low permeability tarp-broadcast		76	100			
Shallow injection w/ high permeability tarp or no tarp-bed						
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments	2			25		
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments	4					
Rotovate/rototill/soil capping					100	
Sprinkler						33
Sprinkler w/ 3 water treatments				20		
Flood						33
Drip w/ high permeability tarp or no tarp	94	24		5		34
Drip w/ low permeability tarp				50		
Non-field soil (structural/post-harvest)						

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 20. Predicted fumigation methods if only "low-emission" methods used (predicted method use fractions) in the South Coast nonattainment area.

Fumigation Method[1]	% of Amount Applied					
	1,3-D	Chloropicrin	Methyl Bromide	Metam[2]	Dazomet[2]	Na Tetrathio-carbonate[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast						
Shallow injection w/ low permeability tarp-broadcast		76	94			
Shallow injection w/ high permeability tarp or no tarp-bed						
Shallow injection w/ low permeability tarp-bed						
Shallow injection w/ 3 water treatments				25		
Deep injection w/ high permeability tarp or no tarp-broadcast						
Deep injection w/ low permeability tarp-broadcast						
Deep injection w/ 3 water treatments						
Rotovate/rototill/soil capping					100	
Sprinkler						33
Sprinkler w/ 3 water treatments				20		
Flood						33
Drip w/ high permeability tarp or no tarp	100			5		34
Drip w/ low permeability tarp		24		50		
Nonfield soil (structural/post-harvest)			6			

[1] Fumigation methods are described in detail in the text.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 21. Estimates of pesticide VOC emissions without application method adjustment factors (unadjusted standard EPs) for 1990, 1991, and 2004. The 1991 goal is a 20% reduction of the 1991 emissions.

Nonattainment Area	**Year**	**Unadjusted VOC Emissions, May – October (tons/day)**							
		1,3-D	**Chloropicrin**	**Methyl Bromide**	**Metam**	**Dazomet**	**Na Tetrathio-carbonate[1]**	**Other Pesticides**	**Total Emissions**
Sacramento Metro	1990	0.000	0.036	0.400	0.022	0.000	0.000	2.402	2.860
	1991	0.000	0.035	0.319	0.013	0.000	0.000	2.749	3.116
	2004	0.087	0.007	0.061	0.009	0.000	0.000	1.199	1.363
	1991 goal								2.493
San Joaquin Valley	1990	0.005	0.208	5.158	2.017	0.000	0.006	15.081	22.475
	1991	0.000	0.301	7.493	1.461	0.000	0.000	12.853	22.108
	2004	4.550	0.320	2.364	6.280	0.025	0.113	11.658	25.310
	1991 goal								17.686
Southeast Desert	1990	0.000	0.011	0.902	0.010	0.000	0.000	0.309	1.232
	1991	0.002	0.014	0.414	0.019	0.000	0.000	0.381	0.830
	2004	0.025	0.094	0.296	0.832	0.011	0.005	0.238	1.501
	1991 goal								0.664
Ventura	1990	0.000	0.929	2.785	0.160	0.000	0.001	0.620	4.495
	1991	0.000	0.745	2.531	0.085	0.000	0.000	0.554	3.915
	2004	1.543	3.322	3.317	0.482	0.009	0.000	0.637	9.310
	1991 goal								3.132
South Coast	1990	0.000	0.174	9.248	0.004	0.000	0.000	1.397	10.823
	1991	0.005	0.166	3.489	0.040	0.000	0.000	1.466	5.166
	2004	0.198	0.449	0.669	0.042	0.024	0.000	1.199	2.581
	1991 goal								4.133

[1] Sodium (Na) tetrathiocarbonate.

Table 22. Summary of fumigant application method adjustment factors.

Fumigation Method[1]	% of Amount Applied					
	1,3-D	Chloropicrin	Methyl Bromide	Metam[2]	Dazomet[2]	Na Tetrathio-carbonate[3]
Shallow injection w/ high permeability tarp or no tarp-broadcast	61	64	74	not applicable	not applicable	not applicable
Shallow injection w/ low permeability tarp-broadcast	not applicable	44	48	not applicable	not applicable	not applicable
Shallow injection w/ high permeability tarp or no tarp-bed	not applicable	64	100	77	not applicable	not applicable
Shallow injection w/ low permeability tarp-bed	not applicable	64	100	not applicable	not applicable	not applicable
Shallow injection w/ 3 water treatments	41	20	not applicable	21	not applicable	not applicable
Deep injection w/ high permeability tarp or no tarp-broadcast	41	64	74	not applicable	not applicable	not applicable
Deep injection w/ low permeability tarp-broadcast	not applicable	44	48	not applicable	not applicable	not applicable
Deep injection w/ 3 water treatments	27	20	not applicable	not applicable	not applicable	not applicable
Rotovate/rototill/soil capping	not applicable	not applicable	not applicable	14	100	not applicable
Sprinkler	not applicable	not applicable	not applicable	77	not applicable	33
Sprinkler w/ 3 water treatments	not applicable	not applicable	not applicable	21	not applicable	not applicable
Flood	not applicable	not applicable	not applicable	77	not applicable	33
Drip w/ high permeability tarp or no tarp	29	not applicable	not applicable	9	not applicable	34
Drip w/ low permeability tarp	not applicable	15	not applicable	9	not applicable	not applicable
Nonfield soil (structural/post-harvest)	not applicable	not applicable	100	not applicable	not applicable	not applicable

[1] Fumigation methods are described in detail in DPR's proposed regulations.
[2] DPR assumes 100% conversion of metam and dazomet to MITC and percentages are relative to the amount of MITC applied.
[3] DPR assumes 100% conversion of sodium (Na) tetrathiocarbonate to carbon disulfide and percentages are relative to the amount of carbon disulfide applied.

Table 23. Estimates of pesticide VOC emissions with application method adjustment factors for 1990, 1991, 2004, and predicted 2004 emissions if only "low-emission" methods are used under the 2008 regulations. The goal is a 20% reduction of the 1991 emissions.

Nonattainment Area	Year	Field Adjusted VOC Emissions, May – October (tons/day)							
		1,3-D	Chloropicrin	Methyl Bromide	Metam	Dazomet	Na Tetrathio-carbonate[1]	Other Pesticides[2]	Total Emissions
Sacramento Metro	1990	0.000	0.023	0.309	0.012	0.000	0.000	2.402	2.746
	1991	0.000	0.022	0.247	0.007	0.000	0.000	2.749	3.025
	2004	0.036	0.003	0.054	0.005	0.000	0.000	1.199	1.297
	2004 low[3]	0.023	0.003	0.053	0.002	0.000	0.000	1.199	1.280
	Goal (1991)								2.420
San Joaquin Valley	1990	0.005	0.133	3.817	1.136	0.000	0.001	15.081	20.173
	1991	0.000	0.192	5.545	0.823	0.000	0.000	12.853	19.413
	2004	1.883	0.144	1.189	3.019	0.004	0.011	11.658	17.908
	2004 low[3]	1.241	0.139	1.319	1.050	0.004	0.011	11.658	15.422
	Goal (1991)								15.530
Southeast Desert	1990	0.000	0.007	0.740	0.007	0.000	0.000	0.309	1.063
	1991	0.002	0.009	0.340	0.013	0.000	0.000	0.381	0.745
	2004	0.008	0.044	0.176	0.533	0.002	0.000	0.238	1.001
	2004 low[3]	0.007	0.039	0.142	0.156	0.002	0.000	0.238	0.584
	Goal (1991)								0.596
Ventura	1990	0.000	0.594	2.434	0.090	0.000	0.000	0.620	3.738
	1991	0.000	0.477	2.212	0.048	0.000	0.000	0.554	3.291
	2004	0.465	1.421	2.224	0.069	0.002	0.000	0.637	4.818
	2004 low[3]	0.450	1.231	1.592	0.069	0.002	0.000	0.637	3.981
	Goal (1991)								2.633
South Coast	1990	0.000	0.111	9.188	0.002	0.000	0.000	1.397	10.698
	1991	0.005	0.106	3.466	0.022	0.000	0.000	1.466	5.065
	2004	0.058	0.164	0.455	0.017	0.004	0.000	1.199	1.897
	2004 low[3]	0.058	0.166	0.342	0.006	0.004	0.000	1.199	1.775
	Goal (1991)								4.052

[1] Sodium (Na) tetrathiocarbonate.
[2] VOC emissions for other pesticides (nonfumigants) use the EPs without any adjustment for field conditions.
[3] 2004 low shows the predicted 2004 emissions if all fumigant applications used a "low-emission" application method.

Table 24. Maximum fumigant emissions (fumigant emission limit) that would achieve the goal of a 20% reduction of the 1991 pesticide VOC emissions, assuming VOC emissions from nonfumigant (other) pesticides remain the same as 2004. The 2004 fumigant emissions and the percentage reduction of these emissions needed to achieve the emissions goal are also shown.

	Field Adjusted VOC Emissions, May–October (tons/day)				**Additional 2004 Fumigant Emissions Reduction Needed to Achieve Goal (%)[2]**
Nonattainment Area	**Emissions Goal**	**2004 Emissions From Other Pesticides**	**Max Fumigant Emissions That Achieve Goal[1]**	**2004 Fumigant Emissions**	
Sacramento Metro	2.420	1.199	1.221	0.098	-1146 (goal achieved)
San Joaquin Valley	15.530	11.658	3.872	6.250	38
Southeast Desert	0.596	0.238	0.358	0.763	53
Ventura	2.633	0.637	1.996	4.181	52
South Coast	4.052	1.199	2.853	0.698	-308 (goal achieved)

[1] Maximum Fumigant Emissions That Achieve Goal calculated by subtracting the 2004 Emissions From Other Pesticides from the Emissions Goal.

[2] % reduction based on the difference between the Max Fumigant Emissions That Achieve Goal and the 2004 Fumigant Emissions, and assuming emissions from other pesticides remain the same as 2004. Examples: The 2004 fumigant emissions in Sacramento Metro could increase by 1146% and still meet the emissions goal. The 2004 fumigant emissions in San Joaquin Valley must decrease by 38% in order to meet the emissions goal.