Estimation of Lifetime Exposure for Occupational Bystanders When Regularly Working at the Edge of 1,3-Dichloropropene Treated Fields

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Summary

The Office of Environmental Health Hazard Assessment (OEHHA) estimated the working lifetime exposure for occupational bystanders who regularly work at the edge of 1,3-dichloropropene (1,3-D) treated fields. The analysis was based on air dispersion modeling results and 2013-2023 1,3-D use data provided by the Department of Pesticide Regulation (DPR). This technical report summarizes the analytical methodology and results used in OEHHA's health-based recommendations to mitigate cancer risk of occupational bystanders who are exposed to 1,3-D when working in close proximity to treated fields. While separate estimations were conducted for coastal and inland regions, both accounted for seasonal variability and the proportional contributions from each of the eight Field Fumigation Method (FFM) groups.

This analysis shows that the estimated exposure of occupational bystanders who work at the edge of treated fields could exceed the acceptable exposure level of 0.21 ppb. Mitigation measures should reduce the exposure to a level below 0.21 ppb. One example of an effective mitigation measure is inclusion of a 100 ft buffer zone for the first 48 hours following applications with any FFM in groups 1201, 1206, and 1209 or for any 1,3-D treatment on tree and grape fields.

Introduction

1,3-Dichloropropene (1,3-D) is a soil fumigant widely used in the cultivation of fruit and nut trees, strawberries, grapes, carrots, and many other crops grown in California. Applied via soil injection or drip irrigation before planting, 1,3-D can volatilize and disperse into the air. Inhalation is the most common route of exposure to 1,3-D. The US Environmental Protection Agency (US EPA) has classified 1,3-D as a Group B2 probable human carcinogen. In California, 1,3-D was listed as known to the state to cause cancer under Proposition 65 on January 1, 1989.

Occupational bystanders who regularly work in an area treated with 1,3-D may be chronically exposed to this fumigant. However, the exposure frequencies and concentrations for this scenario are not well defined. In 2023, DPR developed mitigation measures for residential bystanders using air dispersion modeling to evaluate acute exposure to 1,3-D (Luo, 2022; DPR, 2023). For the ongoing work, OEHHA adopted the same modeling approach and obtained input parameters from DPR to estimate long-term exposure of occupational bystanders who regularly work at the edge of treated fields. DPR provided OEHHA with 1,3-D use data from 2013–2023 and model-estimated concentrations for a single 1,3-D application. OEHHA determined the exposure period and frequency based on 1,3-D use patterns from 2013-2023 and combined them with the estimated concentrations to evaluate the occupational bystander's working lifetime exposure.

The estimation was based on OEHHA's best knowledge and professional judgement of the 1,3-D use scenarios. An additional scenario which included a proposed mitigation measure was also evaluated. This analysis did not evaluate exposure of occupational bystanders to 1,3-D in ambient air when working in the general vicinity of agricultural fields. Although fieldworkers tend to live in an agricultural area close to where they work, their exposure outside of working hours were also not evaluated in this analysis.

Methods

Working lifetime exposure of occupational bystanders

OEHHA determined that an occupational bystander who is exposed to 0.21 ppb 1,3-D for 8 hours per day, 5 days per week, 50 weeks per year, and 40 years (i.e., a working lifetime) has a cancer risk of 1 in 100,000 (OEHHA, 2024). Other occupational exposure scenarios (i.e., different combinations of concentrations and exposure frequencies) can also result in a working lifetime exposure of 0.21 ppb.

Therefore, this analysis estimated a working lifetime exposure concentration, $\bar{C}_{working\ lifetime}$ as:

$$\bar{C}_{working\ lifetime} = \bar{C}_s \times \frac{8\frac{hrs}{day} \times \bar{D}_s \times 40\ years}{8\frac{hrs}{day} \times 5\frac{days}{wk} \times 50\frac{wks}{year} \times 40\ years} \quad (1)$$

For a determined exposure scenario *s,* $\bar{C}_s$ is the average exposure concentration during the 8-hour exposure day and $\bar{D}_s$ is the number of exposure days per year.

The estimates of $\bar{C}_{working\ lifetime}$ can then be compared with 0.21 ppb to determine if the estimated exposures need to be mitigated and if proposed mitigation measures can achieve this health-protective level.

Occupational exposure to pesticides is typically evaluated for pesticide handlers and applicators. It is difficult to evaluate soil fumigant exposure for occupational bystanders, who do not handle or apply pesticides, but are exposed to this highly volatile pesticide by inhalation while working at varying distances from a treated field. OEHHA considered that, among all occupational bystanders, fieldworkers (farmworkers) who work in production agriculture near or at the edge of treated fields may have the highest cancer risk due to repeated exposure to high 1,3-D concentrations over their lifetime. Considerations to estimate their long-term exposure include but are not limited to:

- Pesticide applications are a type of episodic pollution source. A field is fumigated with 1,3-D once every 1-20 years depending on the crop and recommended agricultural practices.
- Applications may be conducted on multiple fields within a relatively small area. Individual fieldworkers working nearby may be exposed to 1,3-D emitted from all these applications at the same time or at different times during their working lifetime.
- The work activities of fieldworkers, including the type (manual versus mechanical labor) and duration, may vary significantly depending on the crop and season.
- Different types of fieldworkers (employed by a farmer versus by a labor contractor) may have different exposure scenarios.

Two independent methodologies are currently available to estimate bystander exposure, one for exposure from a nearby field application and one for exposure from ambient air. However, because these estimates are based on completely different spatial and temporal assumptions and modeling configurations, the methodology for combining them to estimate aggregate exposure is not yet available and developing the methodology is an ongoing complex and time-consuming undertaking. Due to this limitation, OEHHA developed this edge-of-field analysis to estimate $\bar{C}_{lifetime}$ for the most exposed occupational bystanders as a relatively worst-case scenario and to evaluate mitigation measures that would protect these bystanders. OEHHA anticipates that the recommended mitigation measures would also protect other occupational bystanders who are less exposed.

OEHHA used air dispersion modeling results to estimate the average exposure concentration $\bar{C}_s$, then employed 1,3-D reported usage summaries and other data sources to determine yearly exposure days $\overline{D}_s$. Lifetime exposure estimates were calculated for fieldworkers in inland and coastal regions separately due to the differences in regional agricultural practices and meteorological conditions. The counties included in each region are described in the 1,3-D residential regulation (DPR, 2023). The detailed methods to determine these values are provided in the following sections.

Regional average concentration

Over their working lifetime, fieldworkers are exposed to 1,3-D applications with various FFMs and application rates. For each region, this analysis combined the exposure contributed by different FFMs based on their use frequencies and average application rates in the region during winter (November -February) and non-winter (March-October) seasons using the following equation:

$$\bar{C}_{w-region} = \sum_{FFM,season} C_{model-FFM-season-region} \times \frac{r_{FFM-season-region}}{332\ lbs./ac.} \times P_{FFM-season-region} \quad (2)$$

Where $C_{model\text{-}FFM\text{-}season\text{-}region}$ is the model-estimated concentration at the edge of a single application with the maximum application rate of 332 lbs/acre in each region during each season.

$r_{FFM\text{-}season\text{-}region}$ is the average application rate (lbs/acre) summarized for each FFM in each region during each season.

$P_{FFM\text{-}season\text{-}region}$ is the use proportion (%) of each FFM in each region during each season.

This equation assumes that the likelihood that a worker is exposed to 1,3-D from specific FFMs is directly related to the frequency of use of these FFMs within a region during a season. In addition, because concentrations are linearly proportional to application rates, concentrations were adjusted to the FFM-, season-, and region- specific average application rates. The months included in winter and non-winter seasons are consistent with the 1,3-D residential regulation (DPR, 2023; Luo, 2022). This analysis used the estimated $\bar{C}_{w-region}$ (Eq. (2)) as $\bar{C}_s$ in Eq. (1) for the exposure scenario of fieldworkers regularly working at the edge of a treated field.

AERMOD modeling

The American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) is US EPA's preferred air dispersion modeling system for near-field regulatory applications (less than 50 kilometers). It is also recommended by the California Air Resources Board (CARB) for Air Toxics Hot Spots risk assessments (OEHHA, 2015). In recent years, DPR has used this modeling system to evaluate residential bystanders' exposure to 1,3-D (Luo, 2022). During the joint and mutual process to evaluate occupational bystanders' working lifetime exposure, OEHHA and DPR have agreed to use similar AERMOD modeling inputs and appropriate statistics to summarize average air concentrations, including the following basic steps:

(1) A square-shaped source was used to represent a single 1,3-D application with a specific FFM, acreage, and application rate.
(2) Receptors were set up around the area source at different distances starting from the edge of the application and at the height of 1.0 meter (m). This height was chosen to simulate the average height of fieldworkers as they alternate between standing upright or crouching when harvesting or weeding near 1,3-D applications. These are considered working activities with potentially high 1,3-D exposure.
(3) The same 500-hr emission data that were used to develop mitigation measures for 1,3-D residential bystanders' acute exposure (Luo, 2022) were used for this analysis.

(4) As recommended by US EPA, each run of modeling used 5 consecutive years of National Weather Service (NWS) meteorological data to ensure that worst-case meteorological conditions were adequately represented in the results (US EPA, 2017). In addition, weather data from two NWS stations (Fresno and Watsonville) were modeled to represent weather conditions in inland and coastal counties, respectively (DPR, 2023).

(5) The model generated hourly concentration estimates for 500 hours following every application on each day of the 5-year period as:

$$C_{ijkd}$$

Where $i = 1, \ldots, 500\ hour$;
$j = 1, \ldots, n_k\ receptor\ at\ distance\ k$;
$d = 1, \ldots, 1{,}805\ application$, one for each of a total of 1,826 days in a 5-year period minus the flux duration of 21 days.

(6) Hourly concentration estimates for 120 working hours were averaged to estimate the concentrations ($\bar{C}_{jkd}$) at each receptor following the application. Working hours were determined to be from 8:00 AM to 4:00 PM, Monday- Friday, and for the 3 weeks emission period. The equation is:

$$\bar{C}_{jkd} = \frac{\sum_i C_{ijkd}}{120}\ where\ i \in\ working\ hours \quad (3)$$

(7) Concentrations for all receptors at the same distance from the treated field were averaged to estimate the air concentration ($\bar{C}_{kd}$) at the specific distance (e.g., $k = 0\ ft$ for the edge of field estimation) during the 120 working hours. The equation is:

$$\bar{C}_{kd} = \frac{\sum_j \bar{C}_{jkd}}{n_k} \quad (4)$$

Calculating the average concentration at each receptor (i.e., step 6) included both high and low emission periods following an application. Calculating the average concentration from all receptors at a distance (i.e., step 7) included receptors located both downwind and upwind from the application and encompassed both high and low concentrations. These two steps were needed to evaluate fieldworkers' lifetime exposure.

In this analysis, OEHHA assumed that fieldworkers work at the edge of treated fields and are exposed to multiple 1,3-D applications each year during their working lifetime. Over their lifetime, work activities would be conducted at various locations near treated fields, and during times of varying emissions after applications. This averaging approach was used for the evaluation of lifetime exposure and differed from the evaluation of acute exposure performed for the 1,3-D residential regulation (DPR, 2023).

DPR performed two rounds of modeling for applications on an 80-acre field with an application rate of 332 lbs/acre using 5-year weather data. The first modeling run used weather data from 2013-2017, the same data that were used in DPR's analysis for the residential regulation. The second run used weather data from 2019-2023, which covered the most recently available years.

For each of the 8 FFM groups, results were summarized as the average concentrations at the edge of treated fields during the 120 working hours for each application in a 5-year period. The 120-hour average concentration was an average of 8-hour concentrations over the 15 working days of a 3-week emission period. In addition, results were summarized for each application under 2 mitigation scenarios:

(1) No mitigation: averaged all concentrations estimated at the edge of fields ($k = 0\ ft$).
(2) Buffer zone at 100 ft for 48 hours: extracted the first 16-hr concentrations from the estimates at $k = 100\ ft$ during working hours of the first 48 emission hours and extracted the remaining 104-hr concentrations from the estimates at the edge of fields ($k = 0\ ft$) starting from the third day, then estimated the average of these 120-hr concentrations.

DPR provided the median concentrations of the two seasons (winter and non-winter) in the two regions (inland and coastal) from each set of 5-year results (Appendix A). These results ($C_{model-FFM-season-region}$) represented average concentrations that fieldworkers would be exposed to during the emission period of one 80-acre application with one type of FFM at an application rate of 332 lbs/acre.

Average application rate and FFM use proportion

OEHHA used data from 2013-2023, provided by DPR, to summarize the average application rate ($r_{FFM-season-region}$) and the frequency at which each FFM was used as a proportion of total applications ($P_{FFM-season-region}$). The 1,3-D residential regulation took effect on January 1, 2024, and, per DPR's preliminary analysis, has already affected 1,3-D use patterns (DPR, 2023). However, data for 2024 are too limited to provide sufficient information for this analysis.

Therefore, OEHHA summarized average application rates and FFM use proportions with 2013-2023 pesticide use data with the following assumptions:

- All reported uses for tree and grape fields with FFMs 1201 and 1206 in 2013-2023 would use FFM 1224 under the 1,3-D residential regulation.
- All the treatments for fields other than tree and grape with FFMs 1201, 1206, and 1209 would still use the same method.

Under the residential regulation, treatment for tree and grape fields are only allowed to use a method in FFM 1224 group or in four totally impermeable film (TIF) tarp method groups (FFMs 1242, 1243, 1250, and 1264) (DPR, 2023). Due to the high cost of TIF tarps, treatments for tree and grape fields that previously used FFMs 1201 and 1206 would most likely shift to FFM 1224 (Goodhue et al., 2022a; Goodhue et al., 2022b). In addition, the modeled 1,3-D concentrations of FFM 1224 were similar to the average of modeled concentrations of the four TIF tarp FFM groups (Appendix A). Thus, OEHHA concluded it was appropriate to assign all tree and grape field treatments originally reported using FFMs 1201 and 1206 to FFM 1224 and combine their usage summary with the FFM 1224 modeled concentrations to estimate representative exposure from applications for tree and grape fields.

Between 2013-2023, about 98.7% of applications for tree and grape fields used FFM 1206, 0.2% used FFM 1201, and 1.1% used FFM 1242. Therefore, FFM records of a total of 98.9% applications for tree and grape fields were assigned to FFM 1224. After this conversion, the data for each FFM group was summarized for average application rates and application count proportions by season and region (Table 1 and Table 2). The results were then used in the exposure estimation shown in Eq. 2.

OEHHA used statewide averages for application rates and FFM use proportions to reduce the uncertainty of possible crop changes and consequent FFM changes in the future.

Table 1. Average application rate ($r_{FFM-season-region}$) of FFM groups

Field Fumigation Method (FFM)	FFM Group	Average Application Rate (lbs/acre)			
		Inland		Coastal	
		Nov-Feb	Mar-Oct	Nov-Feb	Mar-Oct
Nontarp/shallow/broadcast or bed	1201	120	100	100	100
Nontarp/18 inches deep/broadcast or bed	1206	130	120	120	150
Chemigation (drip system)/tarp	1209	90	90	100	120
Nontarp/24 inches deep/broadcast	1224	320	320	330	330
Totally Impermeable Film (TIF) tarp/shallow/broadcast	1242	130	190	140	110
TIF tarp/shallow/bed	1243	100	90	90	90

Table 2. FFM use proportion ($P_{FFM-season-region}$)

Field Fumigation Method (FFM)	FFM Group	Use Proportion (%)			
		Inland		Coastal	
		Nov-Feb	Mar-Oct	Nov-Feb	Mar-Oct
Nontarp/shallow/broadcast or bed	1201	0.21	4.14	2.17	8.85
Nontarp/18 inches deep/broadcast or bed	1206	8.73	19.15	1.49	8.71

Chemigation (drip system)/tarp	1209	1.10	0.97	0.35	5.76
Nontarp/24 inches deep/broadcast	1224	28.83	31.63	0.21	1.99
Totally Impermeable Film (TIF) tarp/shallow/broadcast	1242	2.59	2.08	0.74	40.28
TIF tarp/shallow/bed	1243	0.18	0.39	1.98	27.47
Total		**100**		**100**	

It is likely that soil treatment for crops other than tree and grape would also change their FFM and switch to lower emission FFMs to meet the setback requirement of the 1,3-D residential regulation (DPR, 2023). However, it is still unclear how the overall use pattern will change, especially how the new FFM groups (FFM 1224, 1250, and 1264) will be used. This analysis made no assumptions for these scenarios. As a result, OEHHA used high application rates for FFM 1224 that were summarized from tree and grape soil treatments based only on historical data. In addition, application rates and count proportions were not estimated for FFM 1250 and 1264. However, if some of the applications that previously used higher emission methods (FFM 1201, 1206, and 1209) change to one of the lower emission methods (FFM 1224, 1242, 1243, 1250, and 1264), the exposure would likely be lower than what was estimated in this analysis. Overall, OEHHA's assumptions and approaches to summarize data were based on best professional judgement and knowledge of 1,3-D use scenarios under the new 1,3-D residential regulation.

Average application block size

The modeling in this analysis simulated applications with a size of 80 acres, which is the maximum allowable acreage under the current regulation (DPR, 2023). OEHHA analyzed the 11-year 1,3-D use data to determine if the simulations need to be adjusted to a different application block size. OEHHA assumed that application block sizes are related to the locations of fieldworkers' employment.

In California's pesticide use data, the locations of 1,3-D applications are reported as section, township, range, base, and meridian in the Public Land Survey System (PLSS). A section, a 1 mile × 1 mile (640 acres) area, is the smallest geographic unit used to report the location of pesticide applications and is larger than a typical farm in California (CDFA, 2022; USDA, 2022). A township contains 36 sections (approximately 6 miles × 6 miles) and is used as an area unit to limit 1,3-D use in California regulations. For this analysis, OEHHA assumed:

- The most exposed fieldworkers work for a single farm within a section-size area during a year.
- Fieldworkers may move around within a township-size area due to changes in employment and/or croplands over a working lifetime.

Therefore, OEHHA first summarized the average application block size in each section for each year, then calculated the 11-year averages of all the sections that had 1,3-D uses within each township. This resulted in one average acreage for each township. A total of 462 inland townships and 132 coastal townships reported 1,3-D uses during 2013-2023. To protect fieldworkers who are exposed to large size applications, OEHHA used the 99th percentile of average application block sizes for inland estimates. To account for a similar number of data points, OEHHA used the 96.5th percentile for the coastal variables, which was determined using the following equation:

$$\left(1 - \frac{99}{100}\right) \times 462 = \left(1 - \frac{96.5}{100}\right) \times 132 \qquad (5)$$

)

The 99th percentile of average application block sizes in the inland region was 140 acres and the 96.5th percentile in the coastal region was 85 acres. More specifically, 26 inland townships and 5 coastal townships had an average application acreage greater than 80 in 2013-2023. Since the 1,3-D residential regulation has restricted the maximum application size to 80 acres, average application sizes in these townships are expected to decrease to a level at or below 80 acres in coming years. Therefore, OEHHA determined that using air concentration estimates for 80-acre applications was appropriate and health protective.

Yearly exposure days

To estimate fieldworkers' lifetime exposure to 1,3-D, OEHHA made the following assumptions:

- Fieldworkers have a 40-year working lifetime.
- Fieldworkers are potentially exposed to 1,3-D during working hours 8:00 AM to 4:00 PM (8 hours per day) on working days Monday-Friday (5 days per week).

These are common default assumptions used in occupational exposure assessments of fieldworkers. Work hours and meteorological conditions vary significantly between growing, harvest and dormant seasons, and fieldworkers may be required to work outside of the 8:00 AM to 4:00 PM period. However, OEHHA found no data to support altering these default assumptions (NAWHS, 2022).

In addition, this analysis assumed fieldworkers were exposed at the edge of treated fields, where the highest concentrations were estimated, for the entire 8-hour workday. Instead of staying at the edge of treated fields for the whole day, fieldworkers would more likely move around within a field. They would be exposed to lower concentrations as they moved farther away from the treated fields. Therefore, even if actual exposures included some longer working days, they would also include exposure to some lower concentrations during a 40-year period. The results would not be anticipated to exceed the estimation in this analysis.

The average concentration estimated for a 6-day (Monday-Saturday) workweek were also examined and were not significantly different from the 5-day average concentration.

OEHHA made these additional assumptions to estimate the yearly exposure days $\overline{D}_S$:

- Fieldworkers work at the edge of a treated field for 3 days per week over the entire 3-week post-application emission period used by the model.
- This scenario occurs around 3.2 times (i.e., 3.2 applications) in the coastal region and around 1.6 times (i.e., 1.6 applications) in the inland region every year.

Crop advisors, cost studies, and other resources informed OEHHA that some crops such as strawberries and vegetables required hand weeding and hand harvesting (UC Davis, 2017a; UC Davis, 2017b; UC Davis, 2021). For this type of work, fieldworkers may stay in a narrow area for many hours every day. From conversations OEHHA had with University of California Cooperative Extension (UCCE) advisors, fieldworkers may return to the same fields to repeat the job every 2-3 days. Therefore, fieldworkers may be repeatedly exposed at the edge of the same application site for many hours each day and over several weeks. OEHHA assumed a 9-day exposure period (3 days per week for 3 weeks) following a single application (Table 3). Strawberry and vegetables are the dominant crops in the coastal region and may not be representative of crops for inland agriculture (USDA, 2023). When working with other crops where less hand labor is required, fieldworkers may have less exposure. However, using this assumption in the estimation can protect fieldworkers with the highest risk, especially for inland fieldworkers who may be exposed to higher ambient concentrations that OEHHA cannot assess in this study.

OEHHA determined yearly application counts based on the same assumptions as the average application block sizes, by first summarizing the yearly application count for each PLSS section in each year of the 2013-2023 period, and then calculating their averages over 11 years for all sections that had 1,3-D uses within each township. This procedure resulted in a total of 462 inland datapoints and 132 coastal datapoints. High percentiles were used to protect fieldworkers who were exposed to high frequencies of applications. The 99th percentile of inland yearly average application counts was 1.6 and the 96.5th percentile of coastal was 3.2 (Table 3).

OEHHA examined 6 inland townships and 5 coastal townships that had 11-year average application counts higher than 1.6 and 3.2. Their average application sizes were lower than 30 acres. For 31 townships with average application sizes larger than 80 acres, 29 townships had average application counts less than 0.2 and 2 townships had 0.7 – 0.8 applications per year with average sizes of about 100 acres. OEHHA considered that large size treatments in these townships might be broken into smaller ones to meet the 1,3-D residential regulation restrictions (DPR, 2023). OEHHA examined these possibilities using estimated concentrations from different block sizes and accordingly adjusted application counts. The results showed that the concentrations would not exceed the estimates in this analysis.

The yearly average exposure days $\overline{D}_s$ for fieldworkers working regularly at the edge of treated fields were estimated with the following equation and summarized in Table 3:

$$\overline{D}_s = 9\,\frac{days}{app} \times N\,\frac{apps}{year} \quad (6)$$

Table 3 Yearly average application counts $\boldsymbol{N}$ and average exposure days $\overline{\boldsymbol{D}}_{\boldsymbol{s}}$

	Inland	Coastal
Exposure days per application	9	9
Yearly application counts N	1.6	3.2
Yearly average exposure days $\overline{D}_s$	14.4	28.8

Mitigation scenario

OEHHA considered two mitigation scenarios for the regional exposure estimation:

(1) No mitigation.
(2) A buffer zone example scenario that assumed a 48-hour 100-ft buffer zone for high exposure applications including all applications using FFMs 1201, 1206 and 1209 and all tree and grape field treatments.

OEHHA combined the application information summarized in Tables 1 and 2 with corresponding modeled concentrations in each scenario:

(1) The no mitigation scenario used modeling concentrations for all FFMs at the edge of field without buffer zone.
(2) The buffer zone example scenario used modeled concentrations for FFMs 1201, 1206, 1209, and 1224 at the edge of field with a 48-hour buffer zone at 100 ft, and concentrations for FFMs 1242 and 1243 at the edge of field without buffer zone.

Results

OEHHA used modeled air concentrations from a single 1,3-D application and the exposure frequencies summarized from 11-year 1,3-D use data to estimate exposure of occupational bystanders who regularly work at the edge of treated fields for their entire working lifetime in inland and coastal regions (Table 4). For this analysis, two rounds of modeling were conducted: the first model run used 2013-2017 weather data and the second used the 2019-2023 weather data. OEHHA used both sets to estimate exposure and calculated their averages.

The results showed that, without mitigation measures, the working lifetime exposure of occupational bystanders exceeded the acceptable level of 0.21 ppb. Mitigation measures, such as a 100 ft buffer zone for 48 hours after high exposure applications, would reduce exposure to the acceptable level of 0.21 ppb or lower.

Table 4 Estimated working lifetime exposure concentration (ppb) of occupational bystanders working in close proximity to 1,3-D treated fields

Mitigation Scenario	**Air Dispersion Modeling Results**	**Exposure (ppb)**	
		Inland	**Coastal**
No mitigation	2013-2017 Weather	0.226	0.225
	2019-2023 Weather	0.216	0.232
	Average	**0.221**	**0.229**
48-hour 100 ft buffer zone for all applications using FFMs 1201, 1206, 1209 and for all tree and grape field treatments	2013-2017 Weather	0.212	0.190
	2019-2023 Weather	0.207	0.192
	Average	**0.210**	**0.191**

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Appendix A. Model Estimated Air Concentrations of 1,3-D at the Edge of a Single 80-acre Application

Table A1. Model estimated air concentration (ppb) of 1,3-D at the edge of a single 80-acre application with a rate of 332 lbs/acre using 2013 – 2017 weather data

a. No buffer zone

Field Fumigation Method (FFM)	**FFM Group**	**Average Air Conc (ppb)**			
		Inland Nov-Feb	**Inland Mar-Oct**	**Coastal Nov-Feb**	**Coastal Mar-Oct**
Nontarp/shallow/broadcast or bed	1201	15.3	10.8	14.8	10.3
Nontarp/18 inches deep/broadcast or bed	1206	9.8	6.8	9.6	6.6
Chemigation (drip system)/tarp	1209	25.0	18.6	23.5	17.3
Nontarp/24 inches deep/broadcast	1224	5.6	3.9	5.5	3.8
Totally Impermeable Film (TIF) tarp/shallow/broadcast	1242	4.9	3.5	4.7	3.3
TIF tarp/shallow/bed	1243	6.2	4.3	6.1	4.2
40% TIF tarp/18 inches deep/broadcast	1250	7.3	4.9	7.0	4.8
40% TIF tarp/24 inches deep/broadcast	1264	4.2	2.9	4.3	2.9

b. Buffer zone 100 ft for 48 hours

Field Fumigation Method (FFM)	**FFM Group**	**Average Air Conc (ppb)**			
		Inland Nov-Feb	**Inland Mar-Oct**	**Coastal Nov-Feb**	**Coastal Mar-Oct**
Nontarp/shallow/broadcast or bed	1201	11.1	7.7	10.7	7.6
Nontarp/18 inches deep/broadcast or bed	1206	8.9	6.1	8.8	6.0
Chemigation (drip system)/tarp	1209	12.8	9.1	12.2	9.1
Nontarp/24 inches deep/broadcast	1224	5.5	3.8	5.5	3.8
Totally Impermeable Film (TIF) tarp/shallow/broadcast	1242	4.5	3.2	4.4	3.1
TIF tarp/shallow/bed	1243	5.5	3.8	5.4	3.7
40% TIF tarp/18 inches deep/broadcast	1250	6.5	4.5	6.5	4.4
40% TIF tarp/24 inches deep/broadcast	1264	4.2	2.9	4.3	2.9

Table A2. Model estimated air concentration (ppb) of 1,3-D at the edge of a single 80-acre application with a rate of 332 lbs/acre using 2019-2023 weather data

c. No buffer zone

Field Fumigation Method (FFM)	FFM Group	Average Air Conc (ppb)			
		Inland	Inland	Coastal	Coastal
		Nov-Feb	Mar-Oct	Nov-Feb	Mar-Oct
Nontarp/shallow/broadcast or bed	1201	13.8	10.6	14.8	10.7
Nontarp/18 inches deep/broadcast or bed	1206	9.1	6.7	9.7	6.8
Chemigation (drip system)/tarp	1209	22.9	18.0	24.4	17.9
Nontarp/24 inches deep/broadcast	1224	5.3	3.8	5.5	3.9
Totally Impermeable Film (TIF) tarp/shallow/broadcast	1242	4.5	3.4	4.8	3.4
TIF tarp/shallow/bed	1243	6.3	4.5	6.1	4.3
40% TIF tarp/18 inches deep/broadcast	1250	6.5	4.8	7.0	4.9
40% TIF tarp/24 inches deep/broadcast	1264	4.0	2.9	4.3	3.0

d. Buffer zone 100 ft for 48 hours

Field Fumigation Method (FFM)	FFM Group	Average Air Conc (ppb)			
		Inland	Inland	Coastal	Coastal
		Nov-Feb	Mar-Oct	Nov-Feb	Mar-Oct
Nontarp/shallow/broadcast or bed	1201	10.2	7.5	10.9	7.8
Nontarp/18 inches deep/broadcast or bed	1206	8.2	6.1	8.7	6.2
Chemigation (drip system)/tarp	1209	11.9	8.9	12.7	9.3
Nontarp/24 inches deep/broadcast	1224	5.3	3.8	5.5	3.9
Totally Impermeable Film (TIF) tarp/shallow/broadcast	1242	4.2	3.2	4.4	3.2
TIF tarp/shallow/bed	1243	5.0	3.8	5.4	3.9
40% TIF tarp/18 inches deep/broadcast	1250	6.0	4.4	6.5	4.6
40% TIF tarp/24 inches deep/broadcast	1264	3.9	2.9	4.2	3.0