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SUBJECT: DEVELOPMENT OF ADDITIONAL METHYL ISOTHIOCYANATE BUFFER ZONES FOR THE METAM SODIUM MITIGATION PROPOSAL

Background

The Department of Pesticide Regulation (DPR) is drafting a risk management strategy to meet its regulatory goal of ensuring no exposures causing methyl isothiocyanate (MITC) associated eye or respiratory irritation result from the use of metam sodium (MS) and other MITC generating pesticides (Gosselin, MITC Risk Management Directive, December 2002). Buffer zones restricting where and under what circumstances MS applications can be made are an integral part of the risk management strategy. A previous memorandum (Barry, 2006) documented development of MITC buffer zones using the Probabilistic Exposure and Risk model for Fumigants, version 2 (PERFUM2) modeling system (Reiss and Griffin, 2005) for an 8-hour time weighted average (TWA) air concentration threshold of 220 ppb for applications smaller than 40 acres. Barry (2006) provides background information on the application methods and development of flux profiles. This memorandum documents the development of MTIC buffer zones under several additional conditions: (1) screening meteorological conditions, (2) using the FEMS (Fumigant Emissions Modeling System v5.074) model system (Sullivan et al., 2006) to both generate buffer zone estimates for companion to those generated using the PERFUM model system and also to generate buffer zones for acreage larger than the capability of the PERFUM model system, and (3) an additional air concentration threshold of 22ppb 8-hr time TWA.

Buffer Zone Development Methods

Screening Conditions

Screening condition buffer zones are developed under a simplified set of input conditions with respect to the meteorological conditions and the flux. Typically screening meteorological conditions are "…worst-case meteorological conditions to provide conservative estimates of the air quality impacts of a specific source…" (U.S. EPA, 2003) in order to be assured that they will produce protective buffer zones in the absence of more detailed input conditions. The screening flux is the critical flux that produces the largest buffer zones when used with appropriate screening meteorological conditions (Barry et al., 2004). For example, a night flux is only used with night screening meteorological conditions and a day flux is only used with day screening meteorological conditions. DPR methyl bromide (mebr) buffer zones were developed under screening conditions (Segawa et al., 2000). Subsequent analysis demonstrated that DPR mebr screening buffer zones were protective at approximately the 95% level meaning that over the long term for every 100 mebr applications made, the screening buffer zones are long enough for 95 of those applications (Johnson, 2001).

The critical flux values used to generate the screening buffer zones for MITC were developed from the sprinkler and shank application method flux profiles shown in Appendix A of Barry (2006). Rolling 8-hr average fluxes were calculated for all 96-hr flux profiles. Rolling average flux values for each application method are shown in Table 1. The relationship between the hour of day and the flux profile was maintained. The day scenario assumes 4 or more hours of the 8-hr averaging interval occurs under daylight. Conversely, the night scenario assumes 4 or more hours of the 8-hr averaging interval occurs at night. Maintaining the alignment of critical flux with hour of the day required that for intermittent sprinkler methods that both a day and a night table be produced because the day and night flux values were similar. The intermittent sprinkler application method has the same critical flux for day and night because of the timing of the flux sampling intervals. The standard methods have 8-hr rolling night flux values large enough that it is not necessary to show 8-hr rolling day flux values.

The Industrial Source Complex 3 (ISCST3) air dispersion model (U.S. EPA, 1995) was used to simulate for square fields of sizes 1 to 80 acres screening scenario downwind centerline air concentrations and generate the screening buffer zones. The simulations to produce the screening buffer zones used the flux values shown in Table 1 as the uniform flux for the entire 8-hr run for each scenario. The flux values have a MS base effective broadcast application rate of 320lbs/acre. This means that the flux values shown in Table 1 are those associated with an application of each method made at the MS broadcast application rate of 320lb/acre. The meteorological data was also uniform for the entire 8-hr run. Day scenario screening meteorological conditions were wind speed 1m/s and atmospheric stability class D (neutral). Night scenario screening meteorological conditions were wind speed 1m/s and atmospheric stability class F (high stable). The generated buffer zones are shown in Tables 2 for field sizes 40 acres or less and Table 3 for large fields.

Buffer zones generated using the FEMS modeling system (v5.074)

The FEMS modeling system (Sullivan et al, 2006) was used to generate buffer zones for square fields of sizes 1 to 50 acres for sprinkler methods and sizes 1 to 80 acres for shank methods. Both PERFUM2 and FEMS use the ISC model to estimate air concentrations. However, there are three important differences between the PERFUM model and modeling process and the FEMS model and modeling process.

The first difference is in the flux profiles. The FEMS default flux profiles were used. The flux was not randomized for these FEMS runs; the mean flux value for each sampling period was used in all runs. These flux profiles differ in some averaging periods from those shown in Appendix A of Barry (2006). Specifically, the first two days of all flux profiles in Barry (2006) are those obtained from U.S. EPA while the last two days are the Sullivan flux estimates. See Barry (2006) for further discussion on the construction of the 4-day flux profiles. Tables 4 through 7 show the U.S. EPA flux profiles versus the FEMS default flux profiles.

The second difference is in the meteorological data sets and how those data sets are used in the modeling. PERFUM uses Ventura meteorological data from the California Irrigation Management and Information System (CIMIS) network for the years 1995 to 1999 while FEMS uses Ventura meteorological data from the National Weather Service (NWS) Automated Surface Observing System (ASOS) station for the years of 2000 to 2004. PERFUM and FEMS both use Bakersfield NWS ASOS–1999 to 2003. However, FEMS uses the meteorological data differently than PERFUM. PERFUM cycles a 4-day flux profile through the 5 years of meteorological data in such a way that the result is 1825 (365 days/years times 5 years) realizations of each day of the flux profile (for sake of discussion, assume 1825 days in 5 years). The PERFUM model effectively runs each day of the flux profile on each day of the meteorological record. Thus, each maximum direction buffer zone distribution has 1825 buffer zones as members. However, with respect to the meteorology the PERFUM output is deterministic. Specifically, if the PERFUM model is run a second time with the same inputs, the same outputs will result. In contrast, for these FEMS runs the FEMS model is stochastic with respect to the meteorological data. The FEMS model uses the 5 years of weather data as a base from which to randomly create the number of realizations of an application designated by the user. The FEMS documentation uses the term “years” in the following sense: one year refers to a single run of the ISC model using n days of weather with the n days in the flux profile. For example, a flux profile consisting of one day divided into 3 eight hour periods, totaling a single 24-hour day, would run with 24 hours of meteorological data. In the FEMS terminology, that single run of 24 hours would be called a year. Each “year” corresponds to the realization of an “application.” In this FEMS analysis, 5000 “years” (or 5000 applications) were used to generate the buffer zone distributions. The FEMS model does not cycle through the meteorological data, instead it randomly chooses a day from a year in which to start an application. Then it randomly perturbs the hourly records in the 4 days of meteorological data to produce a new 4-day set. Results from the FEMS runs will never be exactly the same even if the same inputs are used. Thus, even though PERFUM and FEMS use the same Bakersfield NWS ASOS 1999 to 2003 as a base, the actual meteorological data used by the two models will not be exactly the same.

The third important difference between FEMS and PERFUM2 is the method that FEMS uses to report buffer zone results. FEMS counts exceedances of the chosen threshold at each of the FEMS receptors for each of the averaging time periods of the application process and reports the distance at which various exceedance rates occur. In contrast, the PERFUM2 model constructs the maximum direction buffer zone distributions at the conclusion of the model run. For each averaging period thePERFUM2 distributions consist of the 1825 buffer zone lengths (meters) that were produced during the 5-year model run. The percentile in PERFUM2 is found simply by ordering the buffer zone lengths and locating the appropriate position in the distribution. For example, the 95th percentile of the maximum direction buffer zone length is that distance below which 95% of the members of the entire distribution of buffer zone lengths for that sampling period would fall below. Thus, the chosen 95 percentile buffer zone is long enough that in long-term averaging 95 out of 100 applications made under the same conditions will not have air concentrations above the chosen threshold at the buffer zone distance. An implied, but important assumption in using both models, is that the meteorology which is used is representative of meteorology at that site.

The FEMS approach is different. The FEMS model does not construct distributions of buffer zone lengths. Instead it counts exceedances of the designated air concentration threshold at each of the receptors that are placed around the source. The FEMS output reports the farthest distance at which various exceedance rates occurred during the run. Table 8 shows an example FEMS output. The percentiles shown on the left column must be correctly interpreted to be meaningful. The right-hand column lists buffer zone lengths corresponding to the percentiles in the left-hand column. However, in the FEMS context the meaning of "percentile" is based on exceedance rates of the buffer zones in terms the total number of averaging periods. The straight numerical percentile given in the FEMS table is not the same as in PERFUM2. Thus, to choose a buffer zone in FEMS that has the same meaning as a buffer zone from PERFUM2, the correct "percentile" in FEMS must be chosen.

In order to develop a correspondence between an exceedance rate as defined in FEMS to an exceedance rate based on the application, it is necessary to assume that each exceedance counted in FEMS occurs during a different application. Since FEMS counts exceedances based on the averaging period time, under the assumption above it will be possible to obtain exceedance counts which are larger than the number of applications. For example, in a 5000 year (application) simulation, if for a given receptor the reference concentration were exceeded during every period, then the number of exceedances counted by FEMS would be 5000*3(periods/application)=15000. This is larger than the 5000 applications simulated by the run.

The formula used by FEMS to calculate the percentile based on exceedances is a straightforward implementation of the idea of using the averaging times as the denominator for the percentile. The formula below is from the FEMS documentation. This is the FEMS percentile equation:

$$Percentile = \left[1 - \left[\frac{(\#exceedances / \#simulations)}{(24hrs / averaging\ time) * basis * (\#App / year)} \right] \right] * 100$$

where:

#exceedances = the count of occurences that the reference concentration was exceeded in any averaging time during the entire sequence of simulations.

#simulations = the number of "years" or, in this case since there is one application/year it is the number of applications. The minimum number of simulations is 200.

averaging time = the threshold averaging time or in other words, the exposure duration time associated with the health reference concentration (must be less than or equal to 24 hours), e.g. 8 hrs for MITC

basis = the window of tallying. For example, if the entire 4-day flux profile is tallied over then the basis is 4.

#App/year = the number of times FEMS will initiate an application per calendar year.

This equation is clearer if the number of simulations is placed into the denominator. This results in the following formula:

$$Percentile = \left[1 - \left[\frac{(\#exceedances)}{(24hrs / averaging\ time) * basis * (\#App / year) * (\#simulations)} \right] \right] * 100 = \left[1 - \frac{\#exceedances}{total\ \#averaging\ periods} \right] * 100$$

The denominator now contains the total number of averaging periods. In order to calculate a percentile based on the number of applications, it is necessary to divide by the number of applications, instead of the total number of averaging periods. The number of applications is defined as #simulations in the equation above. Therefore, the percentile which is based on applications will use #simulations in the denominator. Since it is possible to have more than one application per year, this factor must be included as well. The percentile is labeled as $Percentile_{App}$, to denote that it is a percentile based on applications:

$$Percentile_{App} = \left[1 - \frac{\min(\#App/year * \#simulations, \#exceedances)}{\#App/year * \#simulations}\right] * 100$$

The minimum function in the numerator is necessary to avoid getting negative numbers when the number of exceedances is larger than the total number of applications.

The 95th percentile based on applications will be used to show how to derive the corresponding FEMS percentile for MITC buffer zone generation. The 95th percentile based on applications means that 1 out of 20 applications has at least 1 period which exceeded the reference concentration. For 5000 applications, this means that 250 applications had at least 1 period in which the reference concentration was exceeded. If the number 250 is plugged into the equation above, the resulting value for $Percentile_{App}$ is 95%. Thus, the number of exceedances is 250 and by the assumption above, these occurred in different applications. This number of exceedances can be plugged into the first equation above to determine the corresponding FEMS percentile:

$$Percentile = \left[1 - \left[\frac{(\#exceedances/\#simulations)}{(24hrs/averaging\ time)*basis*(\#App/year)}\right]\right]*100 = \left[1 - \frac{250/5000}{(24/8)*1*1}\right]*100 = 98.33 \approx 98.5\%$$

The values used above for the MITC buffer zone generation are as follows:

#exceedances = 250 = 0.05*5000

#simulations = 5000

averaging time = 8 hrs

basis = 1 day (FEMS uses the maximum air concentration day)

#App/year = 1

Thus for 5000 runs (translates to 5000 applications) where the long term average exceedance rate at the buffer zone distance is specified as 1 in 20 applications results in a 95% level of protection per application and corresponds to approximately the 98.5% level used in the FEMS approach.

Table 9 translates the results shown in Table 8 into terminology that matches the terminology that DPR typically uses in buffer zone development. In Tables 8 and 9 the summarization window (scenario period in the FEMS user's manual) is one day and the air concentration threshold is an 8-hour TWA, producing three intervals in which to tally exceedances of the air concentration threshold per application. As discussed above, for MITC buffer zones the FEMS percentile chosen was 98.5, rounding up rather than down. In Tables 8 and 9 the 98.5 percentile buffer zone of 530 meters is the receptor location where 0.045 intervals per year (application) over the 5000 runs exceeded the 220 ppb 8-hr time. This generally means that a total of 225 years (applications) showed exceedances in 5000 runs, which is equivalent to 4.5 exceedances per 100 applications. Thus, approximately 95% of applications in long term averaging are protected by a buffer zone of 530 m.

However, it should be noted that in FEMS, operationally, for the 1-day summarization window there are 15000 8-hr averaging periods in 5000 runs. The exceedances are counted over the 15000 8-hr averaging periods without regard to how those averaging periods are associated with individual years (applications). The 98.5 percentile is where 675 exceedances in the 15000 8-hr averaging periods were counted. The assumption in the calculations shown in the previous paragraph, in the FEMS summary, in Tables 8 and 9, and in the interpretation of the FEMS percentiles is that for the most part only one of the three 8-hr averaging periods per year (application) shows an exceedance. This is probably a reasonable assumption for most flux profiles. However, it would be possible to have more than one exceedance per year, in which case less than 225 years (applications) would show an exceedance.

The FEMS generated buffer zones are shown in Tables 10 through 13. FEMS estimates the actual buffer zone length for all buffer zones. There is no upper limit of 1440 m as in PERFUM. Therefore, some FEMS buffers will be "longer" simply because estimate is given rather than some upper limit.

Air concentration threshold of 22 ppb 8-hr time weighted average

Simulations to generate buffer zones for the 22 ppb 8-hr TWA threshold were conducted using PERFUM2 according to the methods presented in Barry (2006) and using FEMS according to the description of methods above. Tables 14 through 19 show the results.

References

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Table 1. Critical flux values used in generation of the screening buffer zones. All critical flux values have been adjusted to a base effective broadcast application rate of 320 lb/acre.

Application Method	Day/Night	Flux (ug/m^2sec)
Intermittent Chemigation	Day	40.2
Intermittent Shank	Day	59.3
Standard Chemigation	Night	149.5
Standard Shank	Night	147.0
Intermittent Chemigation	Night	40.2
Intermittent Shank	Night	46.3

Table 2. Metam sodium application screening buffer zones (meters).

Method/Flux/Scenario		Application rate			
	Acres	320	240	160	80
Chemigation Sprinkler Intermittent Watering-In 40.2 ug/m^{2}sec Day	1	39	22	0	0
	5	98	59	23	0
	10	149	91	37	0
	20	233	138	57	0
	40	367	215	91	0
Chemigation Sprinkler Intermittent Watering-In 40.2 ug/m^{2}sec Night	1	320	207	103	22
	5	328	208	103	22
	10	518	333	167	37
	20	864	531	269	62
	40	1529	905	434	100
Chemigation Standard Sprinkler 149.0 ug/m^{2}sec Night	1	1493	1088	681	287
	5	1719	1304	797	291
	10	2852	2153	1346	461
	20	4908	3709	2309	756
	40	8512	6493	4167	1333
Shank Intermittent Watering-In 59.3 ug/m^{2}sec Day	1	76	45	21	0
	5	185	119	57	0
	10	284	180	89	15
	20	442	278	134	23
	40	693	437	208	39
Shank Intermittent Watering-In 46.3 ug/m^{2}sec Night	1	387	257	135	32
	5	403	260	135	32
	10	643	413	213	50
	20	1107	668	341	86
	40	1970	1170	555	142
Shank Standard 147.0 ug/m^{2}sec Night	1	1472	1075	673	283
	5	1698	1290	787	287
	10	2816	2129	1329	454
	20	4847	3671	2280	743
	40	8405	6428	4116	1309

Table 3. Metam sodium application screening buffer zones (meters)–large acreage.

	Application rate				
Method/Flux/Scenario	Acres	320	240	160	80
Chemigation Sprinkler Intermittent Watering-In 40.2 ug/m^2sec Day	50	426	249	103	<10
Chemigation Sprinkler Intermittent Watering-In 40.2 ug/m^2sec Night	50	1836	1084	507	120
Shank Intermittent Watering-In 59.3 ug/m^2sec Day	60	932	571	274	50
	80	1180	698	333	64
Shank Intermittent Watering-In 46.3 ug/m^2sec Night	60	2864	1639	763	191
	80	3847	2139	973	237

Table 4. Standard chemigation sprinkler. Base application rate is 320lb/acre broadcast.

Averaging Period	U.S. EPA flux ug/m^{2}sec	FEMS Flux ug/m^{2}sec
1	35.8	39.3
2	91.7	75.7
3	41.4	112.1
4	119.3	148.4
5	66.7	83.4
6	232.3	358.1
7	6.3	9.0
8	7.2	31.1
9	62.3	53.1
10	41.4	75.2
11	41.0	63.0
12	51.0	7.7
13	39.2	39.2
14	35.8	35.8
15	32.3	32.3
16	28.8	28.8
17	18.3	18.3
18	17.8	17.8
19	15.9	15.9
20	20.1	20.1
21	24.3	24.3
22	28.5	28.5
23	15.6	15.6
24	12.5	12.5

Table 5. Intermittent chemigation sprinkler. Base application rate is 320lb/ac broadcast.

Averaging Period	U.S. EPA flux ug/m^2sec	FEMS Flux ug/m^2sec
1	60.5	12.3
2	12.6	6.1
3	53.4	71.7
4	26.9	48.0
5	11.4	8.0
6	9.7	3.3
7	21.2	3.7
8	3.2	1.7
9	17.5	29.7
10	13.2	15.8
11	5.5	2.5
12	1.8	1.3
13	1.3	1.3
14	1.3	1.3
15	8.3	8.3
16	19.5	19.5
17	5.8	5.8
18	5.9	5.9
19	0.9	0.9
20	0.9	0.9
21	1.6	1.6
22	10.4	10.4
23	7.0	7.0
24	2.4	2.4

Table 6. Standard shank. Base application rate 160lb/ac broadcast.

Averaging Period	U.S. EPA flux ug/m^{2}sec	FEMS Flux ug/m^{2}sec
1	3.5	3.2
2	21.4	27.1
3	15.9	19.4
4	51.1	82.4
5	62.5	57.0
6	32.9	40.1
7	3.5	23.2
8	5.2	6.3
9	5.0	6.3
10	82.7	118.3
11	64.3	101.0
12	63.3	51.5
13	2.0	0.0
14	1.8	1.8
15	1.3	1.3
16	15.5	15.5
17	27.4	27.4
18	14.9	14.9
19	2.5	2.5
20	1.7	1.7
21	1.0	1.0
22	0.3	0.3
23	5.0	5.0
24	5.0	5.0

Table 7. Intermittent shank. Base application rate 160lb/acre broadcast.

Averaging Period	U.S. EPA flux ug/m^2sec	FEMS Flux ug/m^2sec
1	6.0	4.3
2	28.4	36.3
3	30.9	26.0
4	15.4	15.7
5	3.9	4.9
6	10.3	2.8
7	2.6	0.8
8	4.0	6.7
9	6.5	12.2
10	3.3	4.4
11	1.6	1.7
12	2.3	2.7
13	0.5	0.5
14	1.5	1.5
15	2.4	2.4
16	1.6	1.6
17	0.7	0.7
18	0.2	0.2
19	0.2	0.2
20	0.2	0.2
21	0.2	0.2
22	0.2	0.2
23	0.2	0.2
24	0.2	0.2

Table 8. FEMS output example. This output is taken directly from the FEMS output file and is for a 1-day summarization basis, 8-hour TWA threshold of 660 ug/m^3. The Percentile column represents 100 percentage of exceedances, as calculated by the FEMS percentile equation (See text). The right hand column is the distance, in meters, of the receptor from the source which had the maximum number of exceedances at that distance.

BUFFER ZONES (METERS) FOR 100.00 % OF MAXIMUM APPLICATION RATE

Percentile	660 THRESHOLD (UG/M3)
25.00	0
50.00	0
75.00	130
85.00	190
90.00	250
95.00	330
97.50	460
98.00	500
98.50	530
99.00	570
99.25	630
99.50	730
99.60	780
99.80	870
99.90	930
99.92	1010
99.94	1120
99.96	1240
99.98	1420
99.99	1790

Table 9. Expansion of FEMS output example interpreted in terms of "applications" rather than "years." The summarization window is one day and the air concentration threshold is an 8 hour TWA, producing three intervals per application in which to tally exceedances of the air concentration threshold. For comparison with Barry (2006) PERFUM generated MITC 95 percentile maximum direction buffer zones, the corresponding FEMS percentile is 98.5. The buffer zone of 530 meters is the receptor location where on average 0.045 (≈0.05) periods per application over the 5000 runs exceeded the 220 ppb 8-hr time. Thus, approximately 95% of applications in long term averaging are protected by a buffer zone of 530 m.

Percentile as calculated by FEMS using the FEMS percentile equation	Buffer zone (m)	Number of 8-hr periods exceeding the threshold per application	Exceedance of health reference concentration per 100 Applications
25.00	0	2.25	100
50.00	0	1.5	100
75.00	130	0.75	75
85.00	190	0.45	45
90.00	250	0.30	30
95.00	330	0.15	15
97.50	460	0.075	7.5
98.00	500	0.06	6.0
98.50	530	0.045	4.5
99.00	570	0.03	3.0
99.25	630	0.0225	2.25
99.50	730	0.015	1.5
99.60	780	0.012	1.2
99.80	870	0.006	0.6
99.90	930	0.003	0.3
99.92	1010	0.0024	0.24
99.94	1120	0.0018	0.18
99.96	1240	0.0012	0.12
99.98	1420	0.0006	0.06
99.99	1790	0.0003	0.03

Table 10. Chemigation (Sprinkler). FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Bakersfield NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 220 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	0	0	0	0
	5	0	0	0	0
	10	0	0	0	0
	20	10 (33)	0	0	0
	40	50 (164)	0	0	0
	50	70 (230)	0	0	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	120 (394)	90 (295)	50 (164)	0
	5	340 (1115)	260 (853)	160 (525)	70 (230)
	10	540 (1772)	390 (1279)	280 (919)	120 (394)
	20	790 (2592)	570 (1870)	430 (1411)	190 (623)
	40	1260 (4134)	1000 (3281)	670 (2198)	330 (1083)
	50	1470 (4823)	1190 (3904)	800 (2625)	400 (1312)

Table 11. Chemigation (Sprinkler). FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Five years Ventura NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 220 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	0	0	0	0
	5	0	0	0	0
	10	0	0	0	0
	20	0	0	0	0
	40	50 (164)	0	0	0
	50	70 (230)	0	0	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	120 (394)	90 (295)	50 (164)	0
	5	340 (1115)	240 (787)	170 (558)	70 (230)
	10	520 (1706)	380 (1247)	270 (886)	120 (394)
	20	810 (2657)	610 (2001)	420 (1378)	200 (656)
	40	1280 (4199)	1020 (3346)	660 (2165)	320 (1050)
	50	1550 (5095)	1190 (3904)	780 (2559)	370 (1214)

Table 12. Shank injection. FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Bakersfield NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 220 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	0	0	0	0
	5	0	0	0	0
	10	0	0	0	0
	20	0	0	0	0
	40	10 (33)	0	0	0
	80	90 (295)	0	0	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	80 (262)	50 (164)	0	0
	5	260 (853)	180 (590)	130 (426)	0
	10	370 (1214)	280 (919)	190 (623)	60 (197)
	20	530 (1739)	430 (1411)	290 (951)	125 (410)
	40	800 (2625)	660 (2165)	430 (1411)	200 (656)
	80	1370 (4495)	1030 (3379)	650 (2132)	310 (1017)

Table 13. Shank Injection. FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Ventura NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 220 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	0	0	0	0
	5	0	0	0	0
	10	0	0	0	0
	20	0	0	0	0
	40	20 (66)	0	0	0
	80	100 (328)	0	0	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	70 (230)	50 (164)	0	0
	5	230 (755)	160 (545)	100 (328)	0
	10	350 (1148)	260 (853)	180 (590)	40 (131)
	20	520 (1706)	410 (1345)	270 (886)	100 (328)
	40	800 (2625)	660 (2165)	420 (1378)	180 (590)
	80	1340 (4396)	1000 (3281)	620 (2034)	290 (951)

Table 14. PERFUM 95 percentile Metam Buffers (meters)–5 years Bakersfield ASOS Maximum Direction Buffers. 8-hr 22 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	230	160	100	15
	5	660	470	290	115
	10	1095	755	455	190
	20	>1440	1255	740	310
	40	>1440	>1440	1225	495
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	930	760	560	310
	5	>1440	>1440	>1440	860
	10	>1440	>1440	>1440	1395
	20	>1440	>1440	>1440	>1440
	40	>1440	>1440	>1440	>1440

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	225	165	95	15
	5	655	470	295	120
	10	1065	740	470	195
	20	>1440	1245	750	320
	40	>1440	>1440	1240	505
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	745	595	435	235
	5	>1440	>1440	1215	650
	10	>1440	>1440	>1440	1040
	20	>1440	>1440	>1440	>1440
	40	>1440	>1440	>1440	>1440

Table 15. PERFUM 95 percentile Metam Buffers (meters)–5 years Ventura CIMIS Maximum Direction Buffers. 8-hr 22 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	285	215	140	40
	5	800	600	400	170
	10	1305	950	625	280
	20	>1440	1435	995	440
	40	>1440	>1440	1430	715
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	1175	970	740	435
	5	>1440	>1440	>1440	1215
	10	>1440	>1440	>1440	>1440
	20	>1440	>1440	>1440	>1440
	40	>1440	>1440	>1440	>1440

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	260	190	125	40
	5	720	535	355	165
	10	1150	845	545	260
	20	>1440	1395	860	415
	40	>1440	>1440	1410	660
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	935	765	580	340
	5	>1440	>1440	1435	920
	10	>1440	>1440	>1440	1435
	20	>1440	>1440	>1440	>1440
	40	>1440	>1440	>1440	>1440

Table 16. Chemigation (Sprinkler). FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Bakersfield NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 22 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	100 (328)	70 (230)	50 (164)	0
	5	240 (787)	200 (656)	130 (426)	60 (197)
	10	350 (1148)	300 (984)	190 (623)	90 (295)
	20	500 (1640)	440 (1444)	270 (886)	130 (426)
	40	720 (2362)	640 (2100)	390 (1279)	200 (656)
	50	840 (2756)	730 (2395)	450 (1476)	220 (722)
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	730 (2395)	620 (2034)	460 (1509)	280 (919)
	5	1910 (6266)	1570 (5151)	1180 (3871)	700 (2297)
	10	3190 (10466)	2610 (8563)	1900 (6234)	1100 (3642)
	20	5020 (16470)	4140(13583)	3060(10040)	1760 (5774)
	40	8410 (27592)	6920(22703)	5050(16568)	2850 (9350)
	50	9820 (32218)	8200(26903)	6010(19718)	3420 (11220)

Table 17. Chemigation (Sprinkler). FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Five years Ventura NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 22 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	120 (394)	90 (295)	60 (197)	0
	5	280 (919)	250 (820)	160 (525)	70 (230)
	10	400 (1312)	360 (1181)	230 (755)	110 (361)
	20	620 (2034)	530 (1739)	330 (1083)	160 (525)
	40	1050 (3445)	770 (2526)	490 (1608)	240 (787)
	50	1180 (3871)	870 (2854)	570 (1870)	260 (853)
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	740 (2428)	620 (2034)	470 (1542)	280 (919)
	5	2000 (6562)	1610 (5282)	1220 (4003)	710 (2329)
	10	3320(10892)	2640 (8661)	1990 (6529)	1150(3773)
	20	5300(17388)	4360(14304)	3130(10269)	1840(6037)
	40	9010(29560)	7400(24278)	5460(17913)	3040(9974)
	50	9680(31758)	8350(27395)	6100(20013)	3450(11319)

Table 18. Shank injection. FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Bakersfield NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 22 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	80 (262)	60 (197)	30 (98)	0
	5	220 (722)	160 (525)	110 (361)	50 (164)
	10	340 (1115)	230 (755)	180 (590)	80 (262)
	20	500 (1640)	370 (1214)	270 (886)	130 (426)
	40	760 (2493)	590 (1936)	410 (1345)	200 (656)
	80	1180 (3871)	940 (3084)	610 (2001)	300 (984)
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	530 (1739)	450 (1476)	330 (1083)	190 (623)
	5	1470 (4823)	1140 (3740)	870 (2854)	500 (1640)
	10	2280 (7480)	1850 (6069)	1370 (4495)	780 (2559)
	20	3610(11844)	2940 (9646)	2110 (6922)	1220 (4003)
	40	6190(20308)	4770(15650)	3540(11614)	1980 (6496)
	80	10350(33957)	8240(27034)	5870(19259)	2950(9678)

Table 19. Shank Injection. FEMS 5000 run one-day basis 98.5 percentile buffer zones in meters (feet). This scenario is approximately equivalent to the 95 percentile maximum direction buffer zones from PERFUM. Ventura NWS meteorological data with 5000 runs (wind direction and speed randomized). 8-hr 22 ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	120 (394)	80 (262)	50 (164)	0
	5	280 (919)	250 (820)	160 (525)	60 (197)
	10	450 (1476)	370 (1214)	230 (755)	110 (361)
	20	720 (2362)	540 (1772)	350 (1148)	160 (525)
	40	1110 (3609)	790 (2592)	580 (1903)	240 (787)
	80	1720 (5643)	1350 (4429)	930 (3051)	360 (1181)
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	570 (1870)	460 (1509)	330 (1083)	190 (623)
	5	1560 (5118)	1250 (4101)	930 (3051)	520 (1706)
	10	2410 (7907)	2010 (6594)	1440 (4724)	820 (2690)
	20	3900(12795)	3160(10367)	2190(7185)	1260(4133)
	40	6460(21194)	5070(16634)	3780(12401)	2000(6562)
	80	10710(35138)	8700(28543)	6250(20505)	3420(11220)