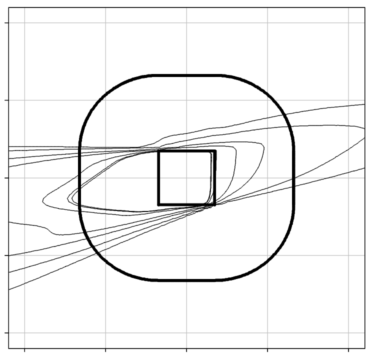
# Evaluating the Effectiveness of Methyl Bromide Soil Buffer Zones in Maintaining Acute Exposures Below a Reference Air Concentration



**Bruce Johnson**

**April 2001**

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DATE: October 6, 2005

SUBJECT: ERRATA IN "EVALUATING THE EFFECTIVENESS OF METHYL BROMIDE SOIL BUFFER ZONES IN MAINTAINING ACUTE EXPOSURES BELOW A REFERENCE AIR CONCENTRATION" (JOHNSON 2001)

## Summary

The methods section in "Evaluating the Effectiveness of Methyl Bromide Soil Buffer Zones in Maintaining Acute Exposures Below a Reference Air Concentration" (Johnson 2001) states on Page 7 "Rural exponents and calms processing were used." Calms processing was not used. The impact of not using calms processing compared to calms processing is to increase estimated air concentrations in some situations. Consequently, the impact on buffer zones is to increase estimated buffer zones in those same situations. If calms processing had been used, the apparent net result would be to increase the estimated level of protectiveness of the buffer zone developed by Department of Pesticide Regulation. Since the level of protectiveness determined in Johnson (2001) ranged from 89.2% to 100% under 25 simulated scenarios, a higher level of protectiveness would strengthen the overall conclusion in Johnson (2001) that methyl bromide buffer zones for soil applications are protective most of the time.

## Details

Industrial Source Complex Short Term Version 3 (ISCST3) model allows for specification of time periods with several methods. The method used in the ISCST3 control files in Johnson (2001) specified 24 hours by using the 'Period' keyword. Another and almost equivalent way to specify the time in this case is with the number, '24', implying 24 hours. When the keyword 'Period' is used, the model does not do calms processing. When the averaging interval is specified with '24', then ISCST3 does do calms processing (assuming that the keyword 'NOCALMS' has not been used).

The general impact of this difference is that buffer zones estimated with no calms processing will be somewhat longer than buffer zones estimated with calms processing. An equivalent way to say this is that the average downwind air concentrations will be somewhat higher for no calms processed- compared to calms-processed simulations.

Table 1. Extract of FORTRAN code from CALC2.FOR, a subroutine in the ISCST3 model. This extract shows how the program calculates concentrations for calms processing. The denominator of the fraction used for averaging is determined in the 4th line, beginning with 'SNUM ='. In words, SNUM is set to the maximum of (1) number of period hours (24 in the current case) minus the number of calm and missing hours OR (2) the integer portion of the number formed by multiplying 24 by 0.75 and adding 0.4. The latter value is the integer portion of 18.4 or 18. Thus under calms processing, the number of hours in the denominator for 24 hour periods is never less than 18. The subsequent lines show how SNUM is used in the denominator to get the average.

```
      IF (KAVE(IAVE) .NE. 1) THEN
C        Calculate Denominator Considering Calms and Missing,
C        Skipping Averaging if Averaging Period is 1-Hour
         SNUM = AMAX0((NUMHRS(IAVE)-NUMCLM(IAVE)-NUMMSG(IAVE)),
     &               NINT(NUMHRS(IAVE)*0.75+0.4))
C        Begin Source Group LOOP
         DO IGRP = 1, NUMGRP
C           Begin Receptor LOOP
            DO IREC = 1, NUMREC
               AVEVAL(IREC,IGRP,IAVE,1) = (1./SNUM)*
     &                                AVEVAL(IREC,IGRP,IAVE,1)
            END DO
C           End Receptor LOOP
         END DO
C        End Source Group LOOP
      END IF
```

Calms processing is specified in the Code of Federal Regulations (2003). When simulating 24-hour blocks of time, calms processing only affects those days when there are 7 or more calm hours (Table 1). I have extracted the actual code from the ISCST3 subroutine called CALC2.FOR. This code shows how the denominator for the averaging procedure is calculated. When there are 17 or less noncalm hours (i.e. 7 or more calm hours), calms processing divides the total of the hourly concentrations from the noncalm hours by 18 (there is no concentration for calm hours). For noncalms processing, the same total is divided by the number of noncalm hours. Thus for cases with 17 or less noncalm hours, the average will be higher with noncalms processed concentrations because the denominator will be smaller than for the calms-processed concentrations. To get some insight into the potential magnitude of effects, I have constructed Table 2. The only true way to determine the impact of calms compared to noncalms processing is to re-simulate all of the earlier work. However, Table 2 gives an inkling of the possible effect. To construct Table 2 I wrote COUNTCALM.FOR, which runs through each five-year data set to construct a frequency distribution of the number of calm hours per calendar day (i.e. per 24 hour period). Some days in these data sets are 'missing', which means that there were too many missing values for one or more sensors to interpolate and thus, the entire day is omitted from simulation. There were 139 missing days. Also, there were 19 days where the entire 24 hours were calm hours. These days are also not simulated by ISCST3. There were a total of 7147 days which had 1 or more noncalm hours. Of these 7147 days, 18.22% had no calm hours.

The calm hours processing algorithm does not produce a different concentration than noncalms processing when the number of calm hours ranged from 0 to 6. Of the 7147 days, 68.73% (from the cumulative distribution column of Table 2) of the days had 6 or less calm hours and hence, would yield identical simulation results, calms or noncalms processing. For the

Table 2. Distribution of number of calm hours per day for 5 years of data from each of Fresno, Merced, Ventura and Montery CIMIS stations (station numbers 2,56,101,116, respectively). ISCST3 calculates no concentrations when there are 24 calm hours. There were total of 7147 days which had at least one non-calm hour. Calms processing reduction percentage is calculated as P=100*(1.-((24-c)/18)), where c=number of calm hours and P=0 when c<7 and estimates the reduction in that day's concentration that would occur using calms processing compared to not using calms processing.

| | Frequency of Days | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| #calm hours per day | Fresno | Merced | Ventura | Monterey | Total | Percent of total days with at least 1 non-calm hour | Cumulative percent of total days with at least 1 non-calm hour | Calms processing percentage reduction in concentration |
| 0 | 345 | 435 | 235 | 287 | 1302 | 18.22 | 18.22 | 0 |
| 1 | 192 | 221 | 127 | 146 | 686 | 9.60 | 27.82 | 0 |
| 2 | 178 | 156 | 145 | 162 | 641 | 8.97 | 36.78 | 0 |
| 3 | 178 | 158 | 158 | 161 | 655 | 9.16 | 45.95 | 0 |
| 4 | 131 | 112 | 180 | 162 | 585 | 8.19 | 54.13 | 0 |
| 5 | 129 | 113 | 165 | 150 | 557 | 7.79 | 61.93 | 0 |
| 6 | 121 | 84 | 121 | 160 | 486 | 6.80 | 68.73 | 0 |
| 7 | 97 | 76 | 112 | 154 | 439 | 6.14 | 74.87 | 5.6 |
| 8 | 74 | 74 | 135 | 134 | 417 | 5.83 | 80.71 | 11.1 |
| 9 | 65 | 41 | 131 | 97 | 334 | 4.67 | 85.38 | 16.7 |
| 10 | 52 | 62 | 109 | 73 | 296 | 4.14 | 89.52 | 22.2 |
| 11 | 40 | 49 | 83 | 53 | 225 | 3.15 | 92.67 | 27.8 |
| 12 | 33 | 39 | 54 | 30 | 156 | 2.18 | 94.85 | 33.3 |
| 13 | 29 | 41 | 19 | 12 | 101 | 1.41 | 96.26 | 38.9 |
| 14 | 21 | 34 | 9 | 11 | 75 | 1.05 | 97.31 | 44.4 |
| 15 | 20 | 26 | 8 | 6 | 60 | 0.84 | 98.15 | 50.0 |
| 16 | 15 | 21 | 2 | 9 | 47 | 0.66 | 98.81 | 55.6 |
| 17 | 8 | 17 | 2 | 4 | 31 | 0.43 | 99.24 | 61.1 |
| 18 | 6 | 9 | 1 | 1 | 17 | 0.24 | 99.48 | 66.7 |
| 19 | 3 | 8 | 0 | 0 | 11 | 0.15 | 99.64 | 72.2 |
| 20 | 0 | 11 | 0 | 0 | 11 | 0.15 | 99.79 | 77.8 |
| 21 | 1 | 8 | 0 | 0 | 9 | 0.13 | 99.92 | 83.3 |
| 22 | 0 | 2 | 0 | 1 | 3 | 0.04 | 99.96 | 88.9 |
| 23 | 0 | 2 | 0 | 1 | 3 | 0.04 | 100.00 | 94.4 |
| 24 | 0 | 7 | 10 | 2 | 19 | | | |
| Missing days | 89 | 20 | 20 | 10 | 139 | | | |
| Total | 1827 | 1826 | 1826 | 1826 | 7305 | | | |
| Total of Non-missing days | 1738 | 1806 | 1806 | 1816 | 7166 | | | |
| Total Days with at least 1 non-calm hour | 1738 | 1799 | 1796 | 1814 | 7147 | | | |

remaining 31.27%, there would be some downward concentration adjustment, ranging from a decrease of 5.6% (most likely) to a decrease of 94.4% (least likely). These adjustments are to the concentration. The translation of concentration to buffer zone is non-linear and difficult to gauge

For any particular day with more than six calm hours, the decrease in concentrations that would result from using calms processing would lead to shorter buffer zones. Unfortunately, the change in concentration and buffer zone distance is not directly proportional because the function describing concentration over distance not linear.

Thus 31.27% of the estimated required buffer zones in Johnson (2001) would decrease to some extent. The decrease in required buffer zones would increase the level of protectiveness. Johnson (2001) concluded that under 25 simulation scenarios, the buffer zones were protective from 89.2% to 100% of the time. Were this simulation effort to be repeated with calms processing, the level of protectiveness would increase.

**References**

Code of Federal Regulations. 2003. Appendix W to Part 51–Guideline on Air Quality Models Pt. 51, App. W 40 CFR Ch. I (7–1–03 Edition).

Johnson, Bruce. 2001. Evaluating the effectiveness of methyl bromide soil buffer zones in maintaining acute exposures below a reference air concentration. California Environmental Protection Agency, Department of Pesticide Regulation, Environmental Monitoring Branch, and Environmental Hazards Assessment Program, 1001 I St. Sacramento California. 95812 EH00-10. <http://www.cdpr.ca.gov/docs/empm/pubs/ehapreps/eh0010.pdf>.

Appendix – Listing of COUNTCALM.FOR program.

```
C     Last change:  BRJ   3 Oct 2005    4:21 pm
        PROGRAM COUNTCALM
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C GET DISTRIBUTIONS OF #CALM HOURS PER DAY FROM MET DATA
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        IMPLICIT NONE
        INTEGER YR(24),MO(24),DD(24),HH(24),DAY(24)
        REAL SPEED(24)
        INTEGER CALMCOUNT,NOCALMCOUNT
        INTEGER DAYCALM(2000),DAYMIS,DAYCOUNT  !DAYMIS COUNTS MISSING DAYS,
DAYCOUNT COUNTS TOTAL DAYS
        INTEGER DAYNOTMIS  !DAYNOTIS COUNTS DAYS WITH USABLE DATA (I.E. NOT
MISSING)
        INTEGER I ,K
        CHARACTER*1 MISFLAG(24)   !MISSING VALUE FLAG EACH HOUR (SHOULD ALL BE
SAME)
        CHARACTER*159 LINE
        INTEGER HISTOCALM(26) !HISTOCALM (1) = # DAYS WITH 0 CALMS, ETC,
HISTOCALM(25)= 24 HRS CALMS,
        !HISTOCALM (26)= # MISSING DAYS
        CHARACTER*12 FIN
        INTEGER TOTDAY  !SUM OF 25 HISTOCALM ENTRIES FOR CHECKING

        FIN(1:12)='            '

C        FIN='8488002.2P8'
C        FIN='93_97056.2P8'
C       FIN='9599101.2P8'
        FIN='9599116.2P8'

        OPEN(UNIT=1,STATUS='OLD',FILE=FIN)
        DAYCOUNT=0
        DAYNOTMIS=0
        DAYMIS=0
        DO I=1,2000
         DAYCALM(I)=0
        END DO

1       CONTINUE


         DO I=1,24
          READ(1,50,END=1000)LINE
50        FORMAT(A159)
```

```
          READ(LINE,100)YR(I),MO(I),DD(I),HH(I),DAY(I),MISFLAG(I),
     1                          SPEED(I)
100       FORMAT(T6,I2,1X,I2,1X,I2,1X,I2,1X,I3,T105,A1,T128,F9.0)
         ENDDO
         DAYCOUNT=DAYCOUNT+1

         !A BIT OF CHECKING

         DO I=1,24
          IF(HH(I).NE.I.OR.DD(I).NE.DD(1).OR.MO(I).NE.MO(1).OR.
     1       YR(I).NE.YR(1).OR.MISFLAG(I).NE.MISFLAG(1))THEN
             WRITE(6,200)LINE(1:80),LINE(81:159)
200          FORMAT(1X,'BAD RECORD ',/1X,A80/1X,A80)
             STOP
          ENDIF
         END DO
         IF(MISFLAG(1).NE.'#')THEN  !OK NOT MISSING, SO PROCESS
           CALMCOUNT=0
           NOCALMCOUNT=0
           DAYNOTMIS=DAYNOTMIS+1
           DO I=1,24
            IF(SPEED(I).LT.0.1)THEN
              CALMCOUNT=CALMCOUNT+1
            ELSE
              NOCALMCOUNT=NOCALMCOUNT+1
            ENDIF
           END DO
           K=CALMCOUNT+NOCALMCOUNT
           IF(K.NE.24)THEN
            WRITE(6,300)K
300         FORMAT(1X,' BAD K ',I4)
            STOP
           ENDIF
           !=================================
           DAYCALM(DAYCOUNT)=CALMCOUNT         !KEEP TRACK RIGHT HERE
           !=================================
         ELSE   !WE GOT A MISSING DAY HERE
           DAYMIS=DAYMIS+1
           DAYCALM(DAYCOUNT)=-1  !-1 INDICATES MISSING VALUE
         ENDIF
         GOTO1
C ---THIS IS THE END OF THE BIG READ LOOP

1000    CONTINUE  !DONE READING, NOW A BIT MORE PROCESSING, THEN REPORT
        CLOSE(1)
        DO I=1,26
         HISTOCALM(I)=0
        END DO
        DO I=1,DAYCOUNT
         IF(DAYCALM(I).EQ.-1)THEN
```

```
          HISTOCALM(26)=HISTOCALM(26)+1  !COUNT MISSING DAYS
         ELSE
          HISTOCALM(DAYCALM(I)+1)=HISTOCALM(DAYCALM(I)+1)+1
         ENDIF
        END DO
        TOTDAY=0
        DO I=1,26
         TOTDAY=TOTDAY+HISTOCALM(I)
        END DO
        OPEN(UNIT=1,STATUS='UNKNOWN',FILE='COUNTCALM.OUT')
        WRITE(1,1100)FIN,DAYCOUNT,DAYMIS,DAYNOTMIS,TOTDAY
1100    FORMAT(1X,A12,1X, 'DAYCOUNT,DAYMIS,DAYNOTMIS,TOTDAY'/1X,4I8)
        WRITE(1,1150)
1150    FORMAT(1X,'# CALM HOURS  FREQUENCY (#DAYS){25 IS MISSING DAYS}')
        DO I=1,26
         WRITE(1,1200)I-1,HISTOCALM(I)
1200     FORMAT(1X,3X,I3,10X,I4)
        ENDDO
        WRITE(1,1250)TOTDAY
1250    FORMAT(1X,'SUM OF HISTOGRAM BINS = ',I4)
        DO I=1,DAYCOUNT
         WRITE(1,1300)I,DAYCALM(I)
1300     FORMAT(1X,I4,I10)
        END DO
        CLOSE(1)
        STOP
        END PROGRAM
```

**EXECUTIVE SUMMARY**
**OF REPORT EH 00-10**
**EVALUATING THE EFFECTIVENESS OF METHYL BROMIDE SOIL BUFFER ZONES IN MAINTAINING ACUTE EXPOSURES BELOW A REFERENCE AIR CONCENTRATION**

**Environmental Monitoring Branch**
**Department of Pesticide Regulation**
**April, 2001**

## Background

Methyl bromide is one of the mostly widely used pesticides in California–about 15 million pounds are applied annually in the State. It is a gaseous fumigant that is used for soil fumigation to control insects, mites, rodents, nematodes, termites, weeds, and organisms that cause plant diseases. It is used prior to planting a variety of fruit, nut, vegetable, and ornamental crops.

Methyl bromide is injected into the soil with specialized application equipment a few weeks prior to planting. Tarpaulins are often used to cover the treated area and contain the gas until the fumigation is complete. Depending upon the crop, field applications may occur annually, or once every several years.

Because methyl bromide has the potential to produce harmful human health effects when inhaled, the Department of Pesticide Regulation (DPR) and the county agricultural commissioners have implemented extensive use restrictions designed to ensure that workers and the general public will not be exposed to unacceptable levels. For the purposes of DPR's regulatory program, an unacceptable level is any detected concentration that exceeds DPR's "reference concentration" of 210 parts per billion (ppb) (815 $ug/m^3$ ). The term reference concentration refers to the exposure level that DPR believes represents an acceptable level of risk. Reference concentrations are typically 100 times lower than doses that do not cause adverse effects—or the no-observed-effect level [NOEL]—identified in animal studies. The 100-fold factor accounts for variation in sensitivity between individuals and assumes that people are more sensitive than experimental animals to the effects of methyl bromide.

A key approach used to implement the methyl bromide use restrictions is the establishment of a "buffer zone" around a fumigated field. The buffer zone is an area that surrounds a fumigated field. Within this area, activities are restricted to protect human health and safety.

### Purpose:

This study was conducted to evaluate the effectiveness of the methyl bromide buffer zones established by DPR in 2001. To calculate the size of buffer zones, DPR adapted the U.S. EPA Industrial Source Complex-Short Term 3 (ISCST3) model, commonly used for predicting emissions of industrial air pollution. The ISCST3 model predicts air concentrations based on the magnitude of emissions during a period of time (flux), weather conditions at the time of emission (e.g., wind speed, wind direction, atmospheric stability), and terrain over the downwind area (elevation, urban or rural geography). DPR inputted into the ISCST3 model the following data: 1) a flux value (an estimate of the amount of methyl bromide gas rising from a field over time following a fumigation); 2) the number of acres treated; 3) a standardized set of weather conditions. The calculation resulted in a prescribed buffer zone for specific combinations of field sizes and flux magnitudes. Prescribed buffer zone sizes range from 30 to 3400 feet measured from the edge of the fumigated field, depending on field size and flux (which is related to the amount of methyl bromide used and the method of application).

The intent of the buffer zone is to prevent unacceptable exposures under a wide range of weather conditions. The prescribed buffer zone must take into account these factors by establishing a distance that is protective under different scenarios. For instance, the amount of methyl bromide gas rising from a field declines from time of application, and but the rate of decline can be influenced by such factors as application depth, tarpaulin permeability, and soil moisture, texture, and density. In addition, identical applications may show variations at different times of the year due to differences in meteorological conditions. To calculate buffer zone sizes adequate for most agricultural applications, varying field sizes and methyl bromide flux rates were inputted in all computer simulations with a standard meteorological condition, which approached, but did not represent the worst-case situation.

Within this current study, DPR took two approaches to test the effectiveness of the prescribed methyl bromide buffer zones around a treated field. One method evaluated how often the reference concentration of 210 ppb was exceeded at the outer edge of the prescribed buffer zone. A second method evaluated the effectiveness of the buffer zone distances in maintaining acute exposures below the 210 ppb level. This report also responds to comments made by a National Academy of Sciences panel during its peer review of DPR's methyl bromide risk assessment.

## Study Methods

Meteorological data were obtained from the California Irrigation Management Information System weather station network for the five counties with the highest methyl bromide soil application use as documented by California's pesticide use report. The data were screened using U.S. EPA methodology to produce four data sets, each consisting of five years of daily meteorological data for Fresno, Merced, Monterey, and Ventura counties. When combined, the entire data set provided 20 years of daily meteorological data.

Model simulations–the generation of hypothetical data values based upon specific flux, acreage, and historical weather conditions–consisted of daily (24 hour) simulations using the ISCST3 version 99155 model. Simulations covered five field sizes (1, 10, 20, 30 and 40 acres) and five flux values (30, 80, 130, 180 and 225 pounds per acre-day [lbs/acre-day]) to yield 25 combinations of acreage and flux. For each of the 25 acreage/flux combinations, 20 years of daily meteorological data were applied to generate 7,166 data points. Each day of calculation produced either distances to the 210 ppb (815 $ug/m^3$) reference concentration or air concentrations calculated at the buffer zone distance.

Two cumulative frequency distributions were calculated for distances and air concentrations. One was the cumulative frequency distribution for the maximum air concentration or maximum distance to the reference concentration for each of the field size, flux, and meteorologically defined day combination. This represented a worst-case scenario at each of the simulated field size, flux, and meteorologically defined day combinations.

A second, more comprehensive cumulative frequency distribution was calculated for all distances to the reference concentration, or all concentrations at the buffer zone distance at each of the simulated field size, flux, and meteorologically defined day combinations using all directional vectors surrounding the field size. In other words, these comprehensive cumulative frequency distributions are representative of every direction around a 360 degree arc surrounding every field size. They include values representing all wind directions during the meteorological conditions defining that specific day.

**<u>Results</u>**

The methyl bromide buffer zones were effective in capturing air concentrations greater than the reference concentration of 210 ppb (815 ug/$m^3$) for fields ranging from 1 to 40 acres in size using the tested range of flux rates. The level of effectiveness ranged from 100% to 89.2% under the worst case maximum daily distance scenario, and from 100% to 98.6% when the cumulative frequency distribution for distances radiating in all directions from a field was evaluated. The lowest efficiencies were observed in the 40-acre field x 30 lbs/acre-day combination under both testing scenarios when the efficiencies were 89.2% for maximum daily distance and 98.6% for the all directions case, respectively.

The second method of evaluating the effectiveness of the methyl bromide buffer zones using cumulative frequency distributions of the maximum air concentrations at the buffer zones, and air concentrations at the buffer zone distances radiating in all directions from the field produced identical results. In the context of evaluating buffer zone adequacy, air concentration and distance are surrogates for each other due to the unique ISCST3 solution for any given daily meteorological parameter set.

This exercise provided an independent quantitative validation of the prescribed methyl bromide buffer zones, developed using the DPR standard meteorological condition. Buffer zones were effective in including at least 89.2% of air concentrations exceeding 210 ppb (815 ug/$m^3$) under a worst case scenario where only maximum value of distance and/or air concentrations exceeding the reference concentration when all distances and/or air concentrations were considered.

*Outliers*

Outlier values most often resulted from meteorological data that were acquired on days that were colder, winter days with stable conditions and lower wind speeds and a higher number of calm hours.

*Verification of Model Results*

The program-estimated daily required buffer zones closely matched manually derived required buffer zones. Similarly, the comparison between the maximum concentration along the buffer zone and manually derived values was also very close.

## Conclusion

This study indicates that the proposed buffer zones achieve the desired result–protection of the public from exposure to unacceptable levels of methyl bromide for most applications. In a small number of applications, the 100-fold safety margin would be reduced. However, it should be noted that although the four counties whose meteorology was used in this study are among the areas of heaviest methyl bromide use, a significant portion of the methyl bromide use in the state (62 percent) occurs in the State’s other 54 counties. The four counties used in this study (two coastal and two inland valley) represent varying meteorological conditions, but it is possible that they may not accurately represent statewide conditions and that regional variations may produce differing results.

Another reasonable question is whether there are meteorological conditions that are not captured by the methodology in this study that could lead to high methyl bromide concentrations. For instance, calm meteorological conditions are not simulated by the ISCST3 model (or its replacement model, AERMOD), and yet calm conditions could conceivably lead to high methyl bromide concentrations.

# Evaluating the Effectiveness of Methyl Bromide Soil Buffer Zones in Maintaining Acute Exposures Below a Reference Air Concentration

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**September 2000**

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**EH00-10**

## Table of Contents

## 1 Introduction.

A method used to mitigate human health hazards associated with the use of soil fumigants is to require buffer zones around the fumigated area. The idea is to prevent people from inhabiting the buffer zone areas where the concentrations may be higher than a reference concentration. In the case of methyl bromide, the reference concentration is 815 ug/m$^3$ for 24 hours. The Department of Pesticide Regulation has promulgated flux and area dependent buffer zones to mitigate the acute concentrations. This mitigation depends on several factors in order to be effective. Concentrations must decline as a function of distance from the field. This is generally true for single, ground level, area sources.

The mitigation also requires that concentration variations are not so great as to exceed the reference concentration. Variability in concentrations occurs both over space and over time. Variability in concentrations will occur spatially around a field due to variations in the wind direction and differences in the path length of the wind over the treated field. A different cause of spatial variation in concentrations is the spatial variation of flux throughout the field. Flux variability can be caused by inhomogeneities in soil moisture, soil texture, soil bulk density, application depth and application uniformity, covering tarp permeability or rips, or other factors. Variation in concentration also occurs over time. Following application, flux initially shows an increase, usually followed by a longer decline. Temperature, barometric pressure, soil moisture can influence the amplitude and shape of this general function, producing diurnal highs and lows, stretching the function longer or shorter, or changing the overall amplitude.

Variation will also occur between identical applications made at different times of the year due to differences in meteorological conditions. Warm sunny conditions may produce lower concentrations than overcast conditions. Clear, cold, nighttime stable conditions may produce the highest concentrations.

It is difficult to quantify the variability of many of the factors listed above. The variability of one factor, however, is amenable to quantification: meteorology. It is the aim of this current project, to quantify the variability, which can be attributed to meteorology. Given a constant flux rate, how would day-to-day changes in measured surface meteorological parameters affect the distance to the methyl bromide reference level? As described in Segawa et al. (2000), a method to assess the acute protection level for the methyl bromide buffer zones consists of a simulation effort, which utilizes the day-to-day measured variation in meteorological conditions to produce a day-to-day variation in the ‘required buffer zone’. The required buffer zone is defined as the farthest distance from the field where the reference concentration occurred. The natural way to approach this analysis is to calculate a required buffer zone for each day in a large meteorological data set and form a cumulative frequency distribution of the results. The prescribed buffer zone distance can then be compared to the cumulative frequency distribution in order to evaluate how often the buffer zone may be exceeded due to variation in meteorological conditions.

Analogously, the maximum concentrations at the prescribed buffer zone distance can be simulated for each day of meteorology. The resulting cumulative frequency distribution can be tabulated and compared to the health reference level of 815 ug/m$^3$. The result of this comparison is an estimated percentage of exceedance or its complement, compliance.

The Department of Pesticide Regulation has utilized the Industrial Source Complex Short Term (ISCST3) model for several years. This model has been developed and promulgated by the United States Environmental Protection Agency (USEPA). In June 2000, the USEPA added AERMOD to the list of approved models. The current study began prior to that action. Consequently, ISCST3 has been used. In addition, however, there are a number of issues relevant to the use of AERMOD. These issues include availability of upper air data for the meteorological analysis, lack of validation for area sources, the potential for software bugs in new software, the lack of use of the meandering plume algorithm for area sources. The Department prefers a go-slow approach with regard to the use of new models. The Department has a significant and successful track record with the use of ISCST3. Therefore, this study will utilize ISCST3.

Recent input from the National Academy of Sciences, and others reviewing the methyl bromide regulations indicate an interest in determining frequency distributions, which calculate distances to the health reference level in all directions from a field, or analogously calculate all concentrations at the buffer zone distance around a field. These single day distributions are then aggregated and compared to the prescribed buffer zones, in the case of distances, and to the health reference in the case of aggregated concentrations along the buffer zone distance.

In this project, the word frequency and fraction are synonyms and refer to numbers, which like probabilities, range from 0.0 to 1.0. These terms will generally refer to cumulative frequency distributions, which relate the frequency on the ordinate axis (y-axis) of events less than a given value for the parameter of interest, concentration or distance, on the abscissa (x-axis). The term, percentile, is the same as frequency or fraction, except on a scale of 0 to 100%. A percentile is 100x a frequency.

## 2 Objectives

The objectives for this work are to

1. Determine the highest use counties for soil applications of methyl bromide.

2. Establish a database of meteorological data for use in modeling for this project, as well as other modeling projects in agricultural areas.

3. Establish a set of procedures for utilizing the California Irrigation Management Information System (CIMIS) meteorological data for ISCST3 modeling.

4. Use the ISCST3 model to determine cumulative frequency distributions of required daily buffer zone sizes for methyl bromide applications which span the range of acreages and flux rates currently being proposed (Segawa et al. 2000). These ranges are 30 to 225

lbs/acre-day and 1 to 40 acres.

5. Assess the currently suggested buffer zones within the context of the cumulative distributions determined in this work and inform management on policy issues pertinent to this assessment.

6. Assess the distribution of concentrations at the buffer zone distance, as suggested by the National Academy of Sciences.

## 3 Personnel

Project leader - Bruce Johnson
Senior Staff Scientist - Terrell Barry
Study Design/Data Analysis - Bruce Johnson

## 4 Methods.

### *4.1 Meteorological data.*

The 1995-1997 pesticide use report was queried for agricultural use of methyl bromide by county where the units applied to were acres. The latter criteria restricts the query to soil applications instead of commodity or non-soil uses. The highest 5 counties in terms of pounds applied were Monterey, Kern, Ventura, Merced and Fresno (Table 4.1). In an overall sense, mass applied is more directly related to air concentration than acres applied to or number of applications. Acres applied to or number of applications are both correlated with pounds applied (0.77 and 0.87, respectively). These 5 counties comprise 48% of the three year soil fumigation use of methyl bromide at 21.5 M pounds out of 44.9 M pounds.

A total of 127 whole years of hourly meteorological data (January through December) were downloaded from the Department of Water Resources (DWR) California Irrigation Management Information System (CIMIS) from stations in these five counties. The CIMIS stations were 001,002 (Fresno), 005,031,054,093,125 (Kern), 0056 (Merced), 016, 019, 037, 089, 116 (Monterey), and 101 (Ventura). The CIMIS network consists of meteorological stations located throughout California in agricultural areas. Stations provide hourly temperature, wind direction, standard deviation of wind direction, wind speed, and net radiation. The CIMIS stations record quality control information along with each measurement. Missing or suspect data are flagged. Subsequent analysis suggested not using the Kern data. This subsequent analysis will be discussed below. In a review of the initial protocol (Menebroker 2000), Air Resources Board (ARB) staff suggested that station 54 in Kern was not located in the primary agricultural areas of Kern. A search of the remaining data indicated that there were no stations left with 5 years of data satisfying the data requirements. Therefore, a composited data set consisting of station 93 (1993) and station 125 (1996-1999) was created. These two stations are approximately 6 miles apart. However, the composited data would skip two years.

USEPA guidelines on data acceptability require a minimum of 90% of the data be valid (p.5-6, USEPA 1987). Table 4.2 shows the year by year and monthly analysis of missing days for each station. For this study, I defined a missing day whenever five or more hours of any of the variables downloaded were missing from a single day. Where 4 or fewer hours during a 24 hour period were missing, linear interpolation was used to fill in the missing values in accordance with recommendations in USEPA (2000). These recommendations do not specifically describe a limit on missing values during a 24 hour time period. However, USEPA (2000) states that interpolation 'may be used for more extended periods (several hours) for selected variables' and this procedure qualifies as a 'best estimator' (p.6-31). While the 1987 EPA guidelines required 90% good data on both a yearly and monthly basis, recent EPA guidelines have relaxed this requirement. The guidelines now require 90% on a quarterly basis (USEPA 2000). For quarters, roughly up to 9 days can be missing, and stay within the EPA guidelines. Amongst the years shown below, there were 3 quarters which exceeded the missing requirement. These quarters occurred in Fresno, Merced and Ventura and were the first quarter of a year. The following lists the stations, years, and specific quarters, which did not satisfy the 90% requirement, as in Fresno for 1987, the first quarter.

Fresno, Station 02, 1984-1988, 87Q1
Kern: Station 54, 1995-1999.
Kern: Station 93: 1993 & Station 125: 1996-1999
Merced: Station 56: 1993-1997, 96Q1
Monterey: Station 116: 1995-1999
Ventura: Station 101: 1995-1999, 95Q1

As a matter of judgment, I believe that the selected years are sufficiently close to the guidelines and the volume of information is large enough that any simulation based on them will not be substantially changed were the data complete. Station descriptions from the CIMIS web site are shown in Table 4.3. General siting information is contained in Appendix 1. In brief, the stations are located on irrigated pastures with grass between 10-15 cm tall, and no obstructions within 100 yards. The locations of stations 2, 54, 56, 93, 101, 116 and 125 can be found in Figures 4.1 and 4.2.

### *4.2 Stability classification.*

The stability classification follows USEPA procedures (USEPA 1987, 2000). The basic scheme uses the standard deviation of wind direction to perform an initial stability classification. The initial stability classification is modified according to whether conditions are night or day, and the wind speed. The final stability is determined by allowing no more than one stability class change per hour. For determining night and day, the net radiation is used. Negative net radiation is defined as night and positive is defined as day.

The cutoff points for standard deviation of wind direction used to determine the initial stability classification are based on a 10m high wind measurements and 15 cm roughness index USEPA

(1987 revised 3/99 and 2/00). Guidelines for modifying these cutoff points are provided for conditions other than 10m measurement height and 15cm roughness height (USEPA 2000, p.6-21). CIMIS measurements are taken at a 2m height. CIMIS instrument stations are usually located in irrigated pastures, where USEPA (1987, Table 6-2) suggests a 3 cm roughness height for 'Open flat terrain; grass, few isolated obstacles'. Applying the adjustment equations from USEPA (2000, p6-21) for roughness and measurement height to the cutoff points, resulted in 18.0, 16.2, 11.9, 7.9, 5.1 degrees for the adjusted cutoff points (Table 4.4).

According to the Guidelines, when modifications are made, the results should be spot-checked. The midafternoon values should exhibit categories A and B, while categories E and F should occur just before sunrise. To spot check the stability estimates, I compared the sigma-theta (ST) scheme, as described above, with a Pasquill-Gifford (PG) scheme, and an adjusted wind speed Pasquill-Gifford (PGA) scheme. The PG method uses solar insolation intensity, which is determined by sun angle, latitude, and season on clear days, in conjunction with wind speed to determine stability (USEPA 2000, Table 6-3 & 6-5). I also estimated stability using PG, except recalculating the wind speed with equation 6.2.21 (USEPA 2000, p6-8) in conjunction with Table 6-2 of USEPA (2000, p.6-9) to extrapolate the wind speed from the measured height of 2m to 10m. Equation 6.2.21 is

$$U_z = U_r \left(\frac{Z}{Z_r}\right)^p$$

where Uz is the wind speed at height z (10m), Ur is the wind speed at height r (2m) and p is the rural exponent (provided in Table 6-2 of USEPA 2000), which depends upon the stability class. I used the PG stability class estimate to determine p and then reestimated the stability class with the adjusted wind speed. A random two-day period from each season of 1995 Merced data was chosen for this test. The four random Julian days chosen were 55, 170, 195 and 300.

The winter time comparison shows the ST scheme maintaining the night time F stability four hours past the PG and PGA schemes (Figure 4.3A). A check of the net radiation indicated that the net radiation was negative during these hours. CIMIS station personnel informed me that infrequently, very low solar radiation can result in negative net radiation during the day (Simon Eching, personal communication). During daytime of the second day, the ST scheme estimated A stability during the afternoon hours, while PG and PGA estimated B stability. The A stability probably is related to adjustments of the cutoff points which tend to increase the frequency of both A and F stabilities (Table 4.4). Aside from the morning of day 55, the stability estimates were generally within one class.

The spring comparison indicated that the ST scheme lagged behind the PG and PGA schemes in returning to F stability (Figure 4.3B). The ST scheme at hour 19 was B, whereas the PG scheme was D. They incremented in parallel until both reached F. A similar pattern occurred on the second spring day, during the four hour period starting with hour 43. The PGA scheme dropped to D and E during the hours of 22-26, compared to ST and PG, which remained at F, except for ST at hour 22, where it was E.

The summer comparison on Julian Day 195-196 indicated general agreement within one stability class for all three methods (Figure 4.3C). There was one exception at hour 15, where ST estimated D, while PG estimated B and during the second night at hour 45 and 47 where ST estimated D, while PG estimated F.

Fall comparison on Julian Day 300 were all within one stability class (Figure 4.3D). The late afternoon of the first day, the ST method lagged one hour behind the PG and PGA methods in ascending to F stability and on the second day, the ST method preceded by one hour the PG and PGA methods in ascending to F stability.

According to the EPA guidelines (USEPA 2000), the turbulence based methods estimate the same stability category about 50% of the time and are within 1 stability category 90% of the time when compared to the PG method. For the ST compared to PG, over the eight selected days, 58% were the same and 90% were within 1 stability class. For the ST compared to the PGA, 45% were the same, and 91% were within 1 stability class. These comparisons demonstrate that the ST method provides a reasonable estimate of stability within the general guidelines provided in USEPA (2000). Some differences may result due to reliance upon the net radiation for determining night and day for the ST method, instead of calculating it based on latitude and season, and Julian day, as in the PG and PGA methods and some differences may result because of the modified cutoff points. However, there is acceptable agreement between the ST method and the PG and PGA methods for determining stability.

### *4.3 Treatment of calms.*

The CIMIS weather stations utilize Met-One 014A for measuring wind speed. The threshold speed is 1 mile per hour. The wind direction is measured by a Met-One 024A, which also has a threshold of 1 mph. The equation used for determining the wind speed with the 014A is

V=(RPM/16.767) + 1, where V=velocity in mph, and RPM=revolutions per minute

With this formula, the minimum possible reported wind speed is 1 mph.

The EPA guidelines define calm as 'Any average wind speed below the starting threshold of the wind speed or direction sensor, whichever is greater.' (P.5-2 USEPA 2000). A calm is also defined as 'For purposes of air quality modeling, calm is used to define the situation when the wind is indeterminate with regard to speed or direction.' (P.432, 40 CFR). As acknowledged in several places, the Gaussian plume model cannot properly calculate concentrations with very low wind speeds (USEPA 2000, Smith 1992, Lines et al. 1997). In addition, when winds are below thresholds for direction, the reported apparent directions may be unvarying or slightly varying for long periods of time because wind speeds are below the threshold required to activate the direction sensor. For these reasons, the EPA guidelines are structured to eliminate calms from ISCST3 calculations.

CIMIS data loggers sample once per minute and average 60 measurements every hour to derive the hourly estimate. For CIMIS wind speed data the lowest possible one hour average is 1 mph. In such a case all measurements during the hour would be below the threshold of the wind direction sensor. As the hourly average increases, the proportion of measurements below the threshold decreases. A stochastic simulation study was conducted to determine the fraction of measurements which would likely be in the calm range making up the one hour CIMIS average. Full details of this study can be found in Appendix 2. The results of this study provided a basis for defining an hour as being calm with respect to wind speed, with the MET014A equipment, as 2.8 miles per hour, or 1.25 m/s.

In accordance with recommendations from the ARB (Menebroker 2000), the percentage of calm hours was analyzed for each of the 5 counties. The percentages for Kern (composited stations 93 and 125), Merced, Monterey, Ventura and Fresno were 37%, 20% 20%, 22% and 19%, respectively. ARB uses an informal guideline to handle calms percentages. When the percentage of calms is less than 10%, ARB recommends accepting the meteorological data. ARB recommends using judgment on a case-by-case basis when the percentage is between 10% and 30%, and when the percentage of calms exceeds 30%, ARB looks for alternative meteorological data sets or alternative modeling approaches (Menebroker 2000, Servin 2000). In this case, I opted for dropping the composited data set consisting of stations 93 and 125 because the percentage of calms exceeded 30%. Though devising alternative modeling approaches is beyond the scope of this current project, it is hoped that such approaches can be developed for use with Kern meteorological data. The remaining four stations exhibited about 20% calms. This value is comparable, for example, to National Weather Service data for Fresno from 1984-1992, California, which has been processed according to EPA guidelines and which exhibits a 15% calms rate.

### *4.4 Meteorology Summary.*

The simulation used five year sets of meteorology from the four CIMIS stations which were located in four of the highest five counties of methyl bromide use. The cutoff points for determining stability classes were modified according to EPA guidelines and calms were defined based upon characteristics of the wind sensor instrument.

### *4.5 Simulation.*

The simulation consisted of daily (24 hour) simulations using ISCST3 version 99155. Rural exponents and calms processing were used. The simulations were designed to cover the proposed buffer zone table, which consists of 1 to 40 acres and 30 to 225 lbs/acre-day flux (Segawa et al. 2000). Five acreages spanning 1 to 40 acres were used (1, 10, 20, 30, 40). For the actual simulation, the maximum flux value of 225 lbs/acre-day was used. This is equivalent to 292.2 ug/m2s. To obtain simulation results at lower flux values, a post-processing computer program scaled the concentrations down proportionately, taking advantage of the gaussian property that flux and concentration are proportional. This procedure was used, both to save time and storage space, since a single run through 20 years of meteorological data required about 30 hours and resulted in 8 GB of output files.

The post-processing was equivalent to five flux values: 30, 80, 130, 180, 225 lbs/acre-day. These 25 combinations of acreage and flux cover the acreage x flux buffer zone table of Segawa et al. (2000, Table 1 in Segawa et al.). Table 4.5 presents the selected flux x acreage combinations and the corresponding proposed buffer zones. Discrete receptor grids were constructed for each acreage. They consisted of transects going away from the edge of the field (Figure 4.4). Transects were constructed such that at the corners, the angle between transects was 5 degrees and along the edges, the transects were spaced at approximately 10m. The number of points per transect was 50. These conditions were examined for sensitivity to concentration detection. The transects were sufficiently long enough to capture the concentration of 815 ug/$m^3$ in all cases. The transects utilized in the simulations are summarized in Table 4.6.

### *4.6 Post-processing details: daily maximum.*

The daily output files were post processed in order to determine the required buffer zone for that day of simulation. For each transect, a cubic spline interpolation (Press et al. 1996) was utilized to estimate the distance from the field at which 815 ug/$m^3$ occurred. The maximum such distance was recorded. That maximum distance represented the required buffer zone for that size field for that flux rate for that day. For each of the 25 acreage x flux combinations, the 7166 daily required buffer zones from the 20 years of meteorological data were collected, ordered and formed into a cumulative histogram.

In addition to the daily required buffer zone, discussions with review panelists from the National Academy of Sciences, led to some interest in determining the distribution of maximum concentrations at the buffer zone distance. For each day at the buffer zone distance the maximum concentration was determined. As with the required buffer zones, these daily maximum concentrations were aggregated and formed into a cumulative histogram. The programming utilized the same cubic spline routines and looped through each transect to determine what the concentration at the buffer zone distance was, recording the maximum of those concentrations.

### *4.7 Validation of post-processing.*

While verification and checking occurred throughout the program development process, a formalized verification procedure was used to validate the calculations and algorithms in the finished post-processing program. This procedure consisted of randomly choosing 2 days from each of the 25 combinations of acreage and flux. For each of these 50 days, a large Cartesian receptor grid was established centered on the center of the field. The ISCST3 model was run with the appropriate flux and acreage. A ‘PLT’ file, which is a file in format suitable for contour plotting, was created by ISCST3 and input into Sigmaplot Version 6.0 (SPSS 2000). To validate the daily required buffer zone, an isopleth of 815 ug/m$^3$ was created. The farthest distance was manually measured and converted into meters. These manually measured distances were compared via regression to the distances estimated by ISCST3 and the post-analysis program.

For maximum concentration along the buffer zone, the same 50 graphs were utilized. The buffer zone distance was approximated by drawing a square concentric to the square field, such that the orthogonal distance from the center of each side of the field to the larger square was the buffer zone distance. For the corners, a compass was utilized to draw a circular arc, at the buffer zone distance from the corner of the field. Sigmaplot includes a feature which allows for arbitrary isopleth levels to be drawn. Sufficient isopleth levels were drawn so that the maximum concentration along the buffer zone could be manually estimated. These manual estimates were again compared to the corresponding estimates from the post processing program.

### *4.8 Producing distributions for all directions from field*

Because the NAS review panelists also indicated an interest in distributions of concentrations in all directions from an application, the post processing program described above was modified to produce a required buffer zone distance for each transect for each day and to estimate the concentration at the buffer zone distance for each transect for each day. The key difference between this analysis and the daily maximum analysis is the inclusion of transects in all directions for each day. These procedures yielded distributions which approximate the distributions of required buffer zones in all directions and concentrations along the buffer zone distance in all directions. Cumulative distributions were produced reflecting all directions.

### *4.9 Box plots and analysis of outliers for maximum daily concentrations at buffer zone distance*

Box and whisker plots were produced for the data sets consisting of maximum daily concentrations at the buffer zone distance using Minitab Statistical Software (V13.3). These plots show the lowest value within the lower bound, 25$^{th}$ percentile, median, 75$^{th}$ percentile, and highest value within the upper bound and outliers. The definition of upper and lower bound was based on Emerson and Strenio (1983), who present the formulas

$$lower\ \ bound = F_L - \frac{3}{2}[F_U - F_L]$$

$$upper\ \ bound = F_U + \frac{3}{2}[F_U - F_L]$$

where $F_U$ and $F_L$ are the upper and lower 25$^{th}$ concentration percentiles, respectively. Outliers are values, which are below the lower bound or above the upper bound. Based on the box plot analysis, hourly meteorology for days producing outliers (97$^{th}$ percentile and above) in the 20 acre, 130 lbs/a-d distribution of maximum concentrations along the buffer zone were compared to hourly meteorology for concentrations corresponding to the middle one half of the distribution (25$^{th}$ to 75$^{th}$ percentile).

In order to evaluate the general relevance of the comparison within the 20 acre, 130 lb/a-d scenario, overlap between the meteorological days corresponding to the middle half of the 20 acre, 130 lbs/a-d distribution and the other 24 distributions was determined. Similarly, the overlap between the meteorological days of the 20 acre, 130 lbs/a-d outlier distribution (97$^{th}$ percentile and above) and the other 24 distributions at the same 97$^{th}$ percentile was also determined. Overlap was defined as the fraction of station x julian days which were common to both sets. Based on the overlap comparison, it was reasonable to make the single comparison between within the 20 acre, 130 lbs/a-d distribution to assess the differences between the middle and outlier portions of the distribution in terms of meteorological characteristics. Hotellings multiple T-test and simple T-tests were utilized to compare the two groups (Dixon 1992)

The meteorological variables used to compare the middle versus outlier sets were season, percentage of non-calm hours during the 24 hour period, and based on non-calm hours: average speed, fraction of hours with F stability, average temperature, average direction, average sigma-theta, wind range. Season was coded as 0, 1,1,2 for winter, spring, fall, and summer respectively as a simple index of solar radiation strength. The average value for each group was compared. Computer programs were written to extract this information from the daily meteorological files and output it in a format suitable for analysis using BMDP 3D (Release 7, Dixon, 1992)

## 5 Results

### *5.1 Validation of post-processing.*

The program-estimated daily required buffer zones correlated well with the manually derived required buffer zones (Figure 5.1.1). The relationship was straight line with a multiplicative constant of 1.0 and an $r^2$ of very close to 100%. Similarly, the comparison between the maximum concentration along the buffer zone, estimated by the post processing program and manual estimates was good. In this case the multiplicative coefficient was 0.98 and the $r^2$ was again close to 100% (Figure 5.1.2). The coefficient was statistically significantly less than 1.0 at the 5% level, which suggested that the post-processing overestimated the concentration slightly in comparison to the manual procedure.

### *5.2 Maximum daily distance to 815 ug/m$^3$.*

Figures 5.2.1 through 5.2.5 present the results from the daily required buffer zone calculations. Each figure is based upon a single acreage, showing the five different flux levels. For each acreage, the progression of cumulative distributions is reasonable in the sense that larger fluxes produce distributions, which are shifted more to the right, which means longer required buffer zones. For 1 acre, the entire 30 lbs/a-d distribution consisted of 0 length required buffer zones. This was true of most of the 80 lbs/a-d flux as well. The 225 lb/acre flux indicates that more than 90% of the values were below 420 feet, which is the proposed buffer zone for 225 lbs/a-d for 1 acre.

For 10 acres (Figure 5.2.2), more than 90% of the values were below 1600 feet, the proposed buffer zone at the maximum flux of 225 lbs/a-d. Similarly for 20, 30 and 40 acres, most of the values were below 2300, 2900 and 3400 feet, respectively, the proposed permit condition buffer zone distances at 225 lbs/a-d. At the lowest flux for each acreage, there were many zeros.

Key percentiles were selected and interpolated from the 25 cumulative distributions (Table 5.2.1). This table can be utilized to gauge the relative protection of the proposed buffer zone table. For example, for 40 acres at 225 lbs/a-d, the 95$^{th}$ percentile corresponds to 3625 feet, which is greater than the 3400 feet in the proposed buffer zone (Table 4.5)

To more precisely gauge the protective level of the 25 buffer zones, cumulative distribution level for each proposed buffer zone was interpolated from the corresponding cumulative distribution. These frequencies are shown in Table 5.2.2. The lowest percentiles occurred at 40 acres for 30 and 80 lbs/a-d, where the percentiles were 89 and 90%, respectively. The other percentiles exceeded 90%.

This analysis is based on the accuracy of the flux. Within the context of the permit conditions, the estimated flux is determined by the application type, which has been assigned an emission ratio. This emission ratio is a mean value, derived after adjustment for 50% recovery. The emission ratio represents the average maximum fraction of the applied material expected to offgas in 24 hours. A particular application may exhibit an emission ratio different from the assigned emission ratio. There is some evidence that the assigned emission ratios may overstate actual emission ratios on average because some of the individual study emission ratios are set to 100%. In individual cases, the influence of soil moisture, integrity of tarping, soil type, temperature, application integrity, equipment integrity, wind, and other factors may affect the actual emission ratio of an application. If the assigned emission ratios on average overstate the actual emission ratios, then the distributions presented in Figures 5.2.1-5.2.5 and the associated tables would underestimate the cumulative percentiles.

### *5.3 Maximum daily concentration along buffer zone.*

Figures 5.3.1 to 5.3.5 graphically depict the distributions resulting from the calculations of the maximum concentration along the buffer zone distance. In each figure, the vertical 815 ug/m$^3$ line is shown. For 1 acre, the 80 to 225 lbs/a-d distributions were mostly overlapped, with the major portion of each being below 815 ug/m$^3$. For 10 acres (Figure 5.3.2), 90% of the maximum concentrations were below 815 ug/m$^3$, though in a few instances concentrations exceeded 2000 ug/m$^3$. Unlike the cumulative distributions for daily required buffer zones, the maximum concentration distributions did not follow a progression based on flux. For example, in the 10 acre case the left most distribution was 30 lbs/a-d, whereas the rightmost distribution was 80 lbs/a-d. The remaining distributions were located between. The reason for this is that the buffer zone table values were derived from concentrations estimated along the downwind, centerline of

C stability, 1.4m/s wind speed. This standardized basis produces varying effects on the protectiveness of the buffer zone because the maximum concentrations based on actual meteorological data may be produced by stability classes or combinations of stability classes different from C and wind speeds different from 1.4 m/s. The remaining figures in this series indicate that more than 90% of the concentrations were below 815 $ug/m^3$ with the exception of the 30 lb/a-d and 80 lb/a-d distributions for 40 acres, where the percentiles were 89% and 90%, respectively.

An alternative view of these concentrations distributions is presented using box and whisker plots (Figures 5.3.6 –5.3.10). The asymmetry of the distributions is reflected in the outliers above the upper whisker. There were no outliers at the lower bound.

The distributions represented in Figures 5.3.1 to 5.3.5 have been processed to obtain key percentiles and their corresponding concentrations as numerical values (Table 5.3.1.).

The percentiles for each of the 25 combinations where the maximum concentration along the buffer zone was 815 $ug/m^3$ were calculated (Table 5.3.2). These percentiles are identical to the corresponding percentiles in Table 5.2.2, the percentiles of daily required buffer zones. To see why these percentiles must be the same, the logic of an individual daily result is presented in Table 5.3.3. For each daily simulation result, when the maximum distance to 815 $ug/m^3$ is less than the buffer zone distance, then the maximum concentration along the buffer zone must be less than 815 $ug/m^3$. Conversely, when the maximum distance to 815 $ug/m^3$ is greater than the buffer zone distance, then the maximum concentration along the buffer zone must be greater than 815 $ug/m^3$. The other two logical combinations are not possible. For example, it is not possible to have a daily outcome in which the maximum distance to 815 $ug/m^3$ is greater than the buffer zone distance, but where the maximum concentration along the buffer zone for the same day is less than 815 $ug/m^3$. Consequently, each day's results can be grouped into one of two categories depending on whether the required buffer zone is greater than the tabled buffer zone (or equivalently, whether the maximum concentration along the tabled buffer zone distance is less than 815 $ug/m^3$) or vice versa. This one to one relationship guarantees that the number of days in these categories is the same, whether one is considering maximum concentrations along the buffer zone or maximum distance to 815 $ug/m^3$. The cumulative distribution for either point of view is the same percentile for the maximum concentration along the buffer zone equal to 815 $ug/m^3$ because there will be the same number of days (or cases) above or below this value.

These percentiles do not take into account the fraction of the buffer zone perimeter above or below 815 $ug/m^3$. For example, Figure 5.3.11 is taken from the set of 50 verification studies and represents the simulation results for a 130 lb/a-d flux for a 30 acre field. In this case, the 815 $ug/m^3$ level was exceeded at the buffer zone distance of 488m (1600 feet). The plume which caused this exceedance stretches toward the west. The length of the perimeter of the buffer zone can be found as follows:

$$P = 2b\pi + 4s \quad (0.1)$$

where P is the perimeter in meters, b is the buffer zone distance in meters, and s is the length of the side of the field in meters. This equation is derived by breaking down the buffer zone into the sum of four arcs, each ¼ of the circumference of a circle with radius b, and the four sides parallel and equal to the sides of the square field. For this case, b=488m and s=348.4m (348.4x348.4=121383m2=30acres). Therefore, P=4460m. From Figure 5.3.11 the west edge of the buffer zone is enclosed in the plume and enclosed segment measures 242m. This results in a fraction of 242/4460=0.05. Thus, the percentiles calculated, for example in Table 5.2.2, or depicted in Figures 5.3.1-5.3.5, are not probabilities of exposure. Exposure probabilities would require additional modification, using factors such as 0.05, to account for actual areas exceeding 815 ug/m$^3$. In discussions with NAS, one panel member suggested using the relative areas, which exceed 815 ug/m$^3$. This would require calculating the area outside of the buffer zone in which calculated average concentrations were above 815 ug/m$^3$ and comparing that to the entire area outside the buffer zone around the field. This kind of calculation would result in a much smaller factor than 0.05. But there are significant ambiguities regarding the size of the area to use in the denominator.

### *5.4 Required buffer zone in all directions*

To estimate the impact of taking into account the proportion of the linear distance of each buffer zone which exceed 815 ug/m$^3$, Figures 5.4.1-5.4.5 depict the cumulative distributions of distances to 815 ug/m$^3$ in all directions. While the maximum values from these distributions (i.e. 100$^{th}$ percentile) are the same as the daily required buffer zone distributions, the shape of the distributions are generally pushed towards the left of the distance axis (x-axis). Consequently, percentiles reach higher values sooner than for the corresponding distributions depicted in Figures 5.2.1-5.2.5. The distributions based on all directions include the directions where the concentrations were lower than those concentrations in the maximum plume. Table 5.4.1 assesses the proposed buffer zones in terms of percentiles from these all direction distributions. Using these distributions results in all percentiles at 98% or greater. The lowest percentiles utilizing the maximum required daily buffer zone in Table 5.2.2 were 89% for 30 lbs/a-d and 80 lbs/a-d for 40 acres. Using the all direction distributions of Figure 5.4.5 yields corresponding estimates of 98.6% and 99.3%.

To some extent, the distributions from this analysis will depend on the density of transects and points along each transect. However, the tight correspondence between the daily maximums from the computer analysis versus the manual analysis (Figures 5.1.1 and 5.1.2) indicates that the densities used were sufficient to detect the maximums. Therefore, I believe that the densities are sufficient to characterize the shape of the distributions.

### *5.5 Concentration along buffer zone in all directions*

Figures 5.5.1-5.5.5 show the cumulative histograms of concentrations along the buffer zone in all directions from the field. As in the case of the distance distributions discussed above, the cumulative distributions in all directions are pushed to the left compared to the maximum concentration along the buffer zone distributions. The percentiles achieved at the 815 ug/m$^3$

level for the 25 selected acre/flux combinations (Table 5.5.1) are higher than the corresponding percentiles based on only the maximum concentration along the buffer zone, shown in Table 5.3.2. The lowest percentile considering direction is 98.6% (Table 5.5.1) for 30 lbs/a-d for 40 acres.

Figure 5.5.6 compares the cumulative distributions for the five flux levels for 20 acres using all directions versus using the maximum concentration along the buffer zone. The all direction distributions are to the left of the maximum concentration distributions. For example, at the 90$^{th}$ percentile, the five flux curves under all directions range roughly from 100 to 400 ug/m$^3$ compared to the five flux curves under maximum concentration at the 90$^{th}$ percentile, which range from roughly 700 to 800 ug/m$^3$.

The methodology utilized to derive the cumulative distributions gives equal weighting to each of the four CIMIS station locations and to the different months within the year. The actual use of soil applied methyl bromide can exhibit seasonal variation, which may differ between counties. In addition, the flux used for simulation was unvarying during each 24 hour period. Actual flux will not be a constant, but generally will increase, and then decrease with a longer tail. In an actual application, if the highest flux occurs during the daytime, then 24 hour concentrations estimated by using a constant flux would overestimate concentrations. This would occur because higher flux during the day would result in lower concentrations due to the greater atmospheric instability during the daytime. Conversely, however, if the maximum flux occurred during the night, then the use of 24 hour constant flux in the simulations might underestimate 24 hour concentrations. Night time stable conditions would produce higher concentrations, all other factors being equal.

This study indicates that within a broad perspective, the proposed buffer zones achieve the desired result most of the time. This study cannot recommend a particular percentile to achieve, nor can this study recommend utilizing maximum buffer zone concentration versus all direction concentration distributions as a policy basis. In part, the purpose of this study was to inform management regarding the elaboration of such frequency distributions, based on long term meteorological data amongst four different locations in counties of high methyl bromide soil use. This study fulfills that goal.

### *5.6 Analysis of outliers*

The overlap analysis between the each of the 25 distributions was conducted in order to determine if there was sufficient similarity between the 25 distributions that a single analysis comparing the meteorology of the middle distributional values and the outliers could be conducted and this single analysis would be meaningful for the other 24 possible comparisons. Overlap was defined as the fraction of station x julian days, which were common to two sets. In this case, the two sets were days, which corresponded to specified ranges of the frequency distributions.

The overlap values for the middle half of the distributions ranged between 64% and 99% (Table

5.6.1). The overlap analysis between the upper 3% of the same distributions ranged between 52% and 99% (Table 5.6.2). When the overlap is confined to 20 acres at 130 lbs/a-d flux, the overlap percentages with the other 23 simulation scenarios ranges from 69% to 99%, with a mean of 85% (sd=9%), for the middle distribution portions (Table 5.6.1) and from 61% to 99%, with a mean of 82% (sd=12%), for the upper 3% distribution portions (Table 5.6.2). With mean overlap percentages in excess of 80%, it is reasonable to rely on generalizing results from the single 20 acre 130 lb/a-d simulation middle to upper contrast

The parameters chosen to compare were all significantly different between the upper versus middle set with the exception of sigma theta (Table 5.6.3). The outlier group compared to the middle group generally can be described as consisting of days which were colder, winter days, with more stable conditions and lower wind speeds and during periods where there were higher number of calm hours (though calm hours were excluded from the simulation). The number of degrees of freedom used to test these differences was 3787 for the pooled t value and 225-284 for the separate t value. Because of autocorrelation, the degrees of freedom could be excessive. As a crude sensitivity analysis, the degrees of freedom were halved, and all of the tests remain significant at the 5% level.

The interpretation of the outliers in relation to the probability distributions presented in this project brings together several interrelated ideas and requires a discussion of the limitations of this work. The distributions in this work are a first attempt to gauge the effectiveness of the proposed buffer zones, in a statewide sense. The areas chosen to obtain meteorology represent areas of high use, but not all use. The top 5 counties represent 48% of the three years of use from 1995-97 (Table 1). The four counties whose meteorology was actually used in this study represent 38% of the pounds applied. Therefore 62% of the use is in counties other than those whose meteorology was represented in this study. One could argue that Central Valley is represented (Merced, Fresno) and coastal areas are represented (Monterey, Ventura) and therefore, the results of this study have wide applicability. An actual test of this would require gathering meteorological data from additional counties and either comparing the meteorological data or doing further simulation work based on the meteorological data to produce distributions akin to those in this paper. It is beyond the scope of this work to conduct that research. I am not aware of studies designed to assess the similarity of meteorology within California regions, such as air districts defined by the California Air Resources Board.

Another area, which could be investigated, further is differences between the four counties used in this study. If differences between counties were prominent, that would suggest regional or county specific buffer zones. However, such a proposal potentially would contain an overwhelming administrative burden, both for the Department and Agricultural Commissioners. Devising buffer zones customized to each county would require greater resources to develop, implement, train, and administer. Analogous to a spatial separation, theoretical buffer zones are dependent on season, as evidenced by the comparative t-tests of temperature, stability, season between middle versus extreme meteorological days (Table 5.6.3). One could contemplate, examining the buffer zone requirement as a function of season. The same discussion of administrative burden, as in the case of customized county buffer zones, would be relevant.

Separating distributions by county, or by season, and then recombining them by weighting with spatial and temporal use would result in distributions, which were different to a degree than those presented in this paper. For example, Monterey County at 7.6 million lbs of methyl bromide used in 1995-1997 would receive a larger weight the individual counties of Merced, Fresno, or Ventura whose combined use was 9.43 million pounds. The Salinas Valley in Monterey County is known to have a diurnal wind shift, which would reduce overall air concentrations for an isolated field, such as in this current study. If lower concentrations were reflected in lower distributional values for the Monterey County meteorological data, then by weighting Monterey County distribution by its portion of the use, the overall distributions of the combined four counties would be reduced. Similarly, a temporal weighting, might change the overall distribution. Figure 5.6.1 shows the statewide pounds of methyl bromide applied to soil for the five year period from 1994 to 1995. The regularity of this time series is remarkable. The peak months are September and October. The distributions presented in this paper are equally weighted between seasons. Winter receives an equal weight compared to fall. However, based on Figure 5.6.1, one could contemplate weighting the fall distributions more because of the higher use. By weighting the late summer, early fall distributions more than the winter distributions, it is conceivable that the resulting combined distributions would show lower concentrations since the outlier analysis indicated that the highest concentrations probably occurred in winter. That exercise, however, is beyond the scope of this paper. In addition, methodology for weighting and combining frequency distributions would need to be determined.

Section 5.5 presented distributions of concentrations based on the concentrations in all directions around each application site at the buffer zone distance. The idea to develop this analysis stemmed from suggestions made by the National Academy of Sciences review of the proposed methyl bromide regulations. These distributions tend to make the buffer zones seem more protective because the concentrations, which correspond to specific percentiles, are much lower than in the case of using only the maximum daily concentration along the buffer zone. Which distribution to use to describe the exposure, is a matter of policy and is under discussion.

The outliers analysis presents another area for discussion. The criteria for defining outliers is described as ‘Data values that are far enough beyond the fourths are considered as potential outliers. We use the fourth-spread to make this vague concept precise and give technical meaning to the term “outlier”…Data values that are smaller…or larger…are called outliers and will receive special attention.’ (Emerson and Strenio p59-60). The statistical reference does not say to exclude these values, only to give them special attention. In this paper, I have given them special attention by performing an extended analysis on the meteorological characteristics, which correspond to those days classified as outliers, versus those days in the middle of the distribution. The result of this analysis is a better understanding of what kind of meteorology leads to high values, which is of potential use to Agriculture Commissioners and others. It is reasonable to ask, however, how many methyl bromide applications take place on days, which may lead, to high concentrations or in parallel, how often do these high concentration potential days occur. Another question, which is reasonable to ask, are there other meteorological conditions, which are not captured by the methodology in this paper, which could lead to high concentrations. For example, calm conditions are not simulated by ISCST3. However, calm conditions could conceivably lead to high concentrations due to stagnation and/or low capping inversions. These conditions are not possible to simulate using ISCST3. Moreover, the replacement model, AERMOD, has not improved upon the algorithm in order to simulate calm conditions for area sources (Roger Brode, personal communication). It is beyond the scope of this work to address these issues. Nevertheless, it is important to understand the limitations of this present analysis, and to discuss areas, which might constitute natural extensions of this work.

## 6 Summary

Meteorological data was obtained from the CIMIS weather station network for five counties, representing the highest five counties in terms of methyl bromide soil application use. The meteorological data was screened using USEPA methodology to produce four data sets, each consisting of 5 years of daily meteorological data for Fresno, Merced, Monterey and Ventura. A scheme of simulation using the USEPA ISCST3 model and post-processing of the simulation results provided cumulative distribution functions for 25 combinations of acreage and flux which covered the proposed buffer zone table consisting of 1 to 40 acres in combination with fluxes from 30 lbs/a-d to 225 lbs/a-d. Information extracted from the simulation results included daily maximum distance from the field to the 815 ug/m$^3$ concentration (required buffer zone), daily maximum air concentration along the buffer zone perimeter, distance to 815 ug/m$^3$ in all directions and concentrations along the buffer zone distance in all directions. For each combination of flux and acreage, cumulative distributions of these two parameters were determined. When the table of suggested permit buffer zones was compared to the frequency distributions of maximum daily required buffer zone for each of the 25 acre x flux combinations, the resulting percentiles ranged from 89% to 100%. When all directions were taken into account for each day, the lowest percentile was 98.6%. Similarly, for the concentrations along the buffer zone perimeter the 25 flux x acreage combinations ranged in percentile from 89% to 100%. For the all directions analysis, 98.6% was the lowest percentile for 815 ug/m$^3$. An analysis of the outliers amongst the maximum daily concentration along the buffer zone for the 20 acre, 130 lbs/a-d scenario, indicated that compared to the middle value meteorological days, high concentration outliers generally consisted of days with higher stability, cooler temperatures, and lower wind speeds during the winter. Some limitations of this analysis include uncertainty in the flux, which creates uncertainty in the distributions, applicability to counties, which were not simulated, the degree to which these distributions can be considered statewide, and the inability of ISCST3 to simulate calm hours.

## 7 References

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Table 4.1. Pesticide use report for methyl bromide applications where units treated are acres during 1995-1997. Ranking based on total pounds used during this three year period. Bolded counties are the highest five counties. Counties not shown or blank entries indicate no reported methyl bromide soil use.

| County | Lbs AI Used 1995 | #Apps | Acres Treated | Lbs AI Used 1996 | #Apps | Acres Treated | Lbs AI Used 1997 | #Apps | Acres Treated | Total Lbs Used 95-97 | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALAMEDA | 75910 | 18 | 192 | 30011 | 8 | 101 | 19185 | 6 | 49 | 125,107 | 32 |
| AMADOR | 31163 | 1 | 157 | | | | | | | 31,163 | 41 |
| BUTTE | 151131 | 98 | 1485 | 169463 | 68 | 962 | 145455 | 85 | 1617 | 466,048 | 20 |
| COLUSA | 12535 | 17 | 439 | 626 | 2 | 4 | | | | 13,161 | 44 |
| CONTRA COSTA | 1509 | 5 | 32 | 4165 | 6 | 29 | 2401 | 4 | 22 | 8,074 | 45 |
| DEL NORTE | 33104 | 15 | 148 | 38495 | 21 | 119 | 58025 | 29 | 220 | 129,625 | 30 |
| EL DORADO | 5 | 5 | 5 | 728 | 2 | 13 | 1 | 1 | 1 | 734 | 46 |
| **FRESNO** | **1209120** | **485** | **4357** | **689959** | **400** | **2959** | **910425** | **491** | **3581** | **2,809,504** | **5** |
| GLENN | 25730 | 21 | 1140 | 27897 | 24 | 708 | 22396 | 13 | 320 | 76,023 | 35 |
| HUMBOLDT | 12872 | 4 | 53 | 7022 | 3 | 28 | 2086 | 2 | 8 | 21,981 | 42 |
| IMPERIAL | 268962 | 79 | 1763 | 165911 | 46 | 847 | 189462 | 28 | 988 | 624,335 | 18 |
| **KERN** | **1647506** | **173** | **7079** | **1480943** | **179** | **5719** | **1324968** | **148** | **4684** | **4,453,417** | **2** |
| KINGS | 55640 | 35 | 556 | 104502 | 36 | 625 | 79782 | 33 | 297 | 239,924 | 26 |
| LAKE | | | | 5399 | 4 | 13 | 38754 | 5 | 98 | 44,153 | 40 |
| LASSEN | 90960 | 14 | 365 | 149734 | 27 | 731 | 7625 | 2 | 32 | 248,318 | 25 |
| LOS ANGELES | 28379 | 37 | 140 | 18155 | 41 | 9059 | 15956 | 46 | 8269 | 62,489 | 36 |
| MADERA | 447817 | 67 | 1620 | 76041 | 12 | 267 | 142609 | 29 | 409 | 666,467 | 16 |
| MARIPOSA | 12 | 8 | 8 | | | | | | | 12 | 47 |
| MENDOCINO | 48287 | 10 | 131 | 71077 | 12 | 179 | 44808 | 8 | 122 | 164,173 | 29 |
| **MERCED** | **656079** | **499** | **9401** | **1267021** | **527** | **10842** | **1133651** | **618** | **11227** | **3,056,751** | **4** |
| MODOC | | | | | | | 15688 | 2 | 194 | 15,688 | 43 |
| **MONTEREY** | **3007192** | **811** | **12530** | **2266327** | **595** | **10308** | **2327815** | **697** | **10571** | **7,601,334** | **1** |
| NAPA | 312354 | 85 | 831 | 146335 | 48 | 455 | 169939 | 42 | 524 | 628,629 | 17 |
| ORANGE | 363939 | 142 | 1890 | 350431 | 141 | 2043 | 336799 | 139 | 1949 | 1,051,168 | 14 |
| PLACER | 16058 | 10 | 73 | 17803 | 9 | 70 | 18158 | 14 | 80 | 52,018 | 38 |
| RIVERSIDE | 653432 | 152 | 3264 | 726166 | 178 | 3846 | 572414 | 129 | 2597 | 1,952,012 | 11 |
| SACRAMENTO | 30219 | 13 | 95 | 41619 | 11 | 111 | 33603 | 9 | 110 | 105,441 | 33 |
| SAN BENITO | 143621 | 43 | 625 | 47357 | 22 | 307 | 107808 | 35 | 430 | 298,786 | 24 |
| SAN BERNARDINO | 29118 | 38 | 167 | 40676 | 43 | 224 | 14380 | 26 | 85 | 84,175 | 34 |
| SAN DIEGO | 324363 | 234 | 2212 | 411043 | 249 | 2856 | 399744 | 322 | 2521 | 1,135,150 | 13 |
| SAN JOAQUIN | 779459 | 325 | 10526 | 643479 | 265 | 6103 | 558051 | 368 | 10048 | 1,980,989 | 10 |
| SAN LUIS OBISPO | 173819 | 256 | 725 | 157240 | 272 | 693 | 198151 | 288 | 852 | 529,211 | 19 |
| SAN MATEO | 17734 | 19 | 68 | 14091 | 13 | 51 | 16160 | 19 | 63 | 47,985 | 39 |
| SANTA BARBARA | 581933 | 280 | 2680 | 675426 | 269 | 3085 | 773162 | 352 | 3358 | 2,030,520 | 9 |
| SANTA CLARA | 58384 | 25 | 218 | 31212 | 20 | 131 | 36833 | 22 | 246 | 126,429 | 31 |
| SANTA CRUZ | 764164 | 325 | 3374 | 681593 | 285 | 3086 | 714055 | 372 | 3231 | 2,159,813 | 7 |
| SHASTA | 160213 | 32 | 640 | 93300 | 26 | 375 | 136792 | 35 | 551 | 390,306 | 23 |
| SISKIYOU | 176665 | 32 | 775 | 158833 | 22 | 671 | 95473 | 12 | 375 | 430,971 | 21 |
| SOLANO | 73791 | 14 | 576 | 70605 | 19 | 200 | 93407 | 23 | 396 | 237,803 | 27 |
| SONOMA | 467267 | 106 | 1243 | 432394 | 104 | 1153 | 463145 | 97 | 1175 | 1,362,806 | 12 |
| STANISLAUS | 684815 | 523 | 16942 | 751941 | 425 | 12235 | 647814 | 470 | 12490 | 2,084,570 | 8 |
| SUTTER | 290188 | 244 | 2513 | 316984 | 162 | 2616 | 298087 | 188 | 2362 | 905,259 | 15 |
| TEHAMA | 66335 | 78 | 3124 | 71092 | 64 | 2273 | 37817 | 46 | 1905 | 175,244 | 28 |
| TULARE | 720026 | 316 | 3290 | 674466 | 285 | 2429 | 892623 | 272 | 2826 | 2,287,115 | 6 |
| **VENTURA** | **1000804** | **514** | **8281** | **1318783** | **501** | **6161** | **1240990** | **614** | **6599** | **3,560,577** | **3** |
| YOLO | 7971 | 6 | 82 | 16717 | 14 | 117 | 28088 | 8 | 75 | 52,776 | 37 |
| YUBA | 154775 | 33 | 563 | 146024 | 40 | 1042 | 116646 | 40 | 636 | 417,446 | 22 |

| | |
|---|---|
| Subtotal top 5 counties | 21,481,583 |
| Total | 44,945,681 |
| Percentage top 5 of total | 48% |

Table 4.2. Monthly analysis of missing days for 120 years of CIMIS meteorological data in higher use methyl bromide counties. FRE=Fresno, KER and KEX=Kern, MON and MOX=Monterey, MER=Mer
VEN=Ventura. MOX11 is Monterey station 111. VEN11 is Ventura station 101. KEX25 is Kern station 125. Bolded rows were those years selected for simulation.

| FILE | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | BAD | GOOD | TTOT | %GOOD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 83fre01.SUM | 2 | 2 | 0 | 0 | 0 | 18 | 18 | 0 | 0 | 3 | 3 | 4 | 50 | 315 | 365 | 86 |
| 84fre01.SUM | 4 | 3 | 1 | 0 | 3 | 0 | 0 | 1 | 1 | 3 | 7 | 6 | 29 | 337 | 366 | 92 |
| 85fre01.SUM | 5 | 17 | 8 | 2 | 4 | 5 | 1 | 6 | 3 | 20 | 11 | 6 | 88 | 277 | 365 | 76 |
| 86fre01.SUM | 7 | 2 | 3 | 0 | 0 | 0 | 4 | 5 | 4 | 5 | 2 | 0 | 32 | 333 | 365 | 91 |
| 87fre01.SUM | 4 | 5 | 6 | 2 | 2 | 12 | 12 | 2 | 8 | 2 | 3 | 4 | 62 | 303 | 365 | 83 |
| 83fre02.SUM | 3 | 0 | 2 | 5 | 0 | 18 | 18 | 1 | 0 | 5 | 4 | 4 | 60 | 305 | 365 | 84 |
| **84fre02.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **2** | **0** | **0** | **0** | **4** | **4** | **10** | **356** | **366** | **97** |
| **85fre02.SUM** | **0** | **2** | **0** | **0** | **2** | **0** | **0** | **1** | **4** | **0** | **0** | **2** | **11** | **354** | **365** | **97** |
| **86fre02.SUM** | **1** | **1** | **3** | **2** | **1** | **0** | **1** | **1** | **0** | **4** | **1** | **0** | **15** | **350** | **365** | **96** |
| **87fre02.SUM** | **0** | **16** | **16** | **0** | **2** | **1** | **3** | **2** | **0** | **0** | **1** | **4** | **45** | **320** | **365** | **88** |
| **88fre02.SUM** | **1** | **0** | **4** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **2** | **8** | **358** | **366** | **98** |
| 89fre02.SUM | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 16 | 349 | 365 | 96 |
| 90fre02.SUM | 0 | 5 | 1 | 0 | 10 | 4 | 7 | 2 | 8 | 0 | 0 | 12 | 49 | 316 | 365 | 87 |
| 91fre02.SUM | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 362 | 365 | 99 |
| 92fre02.SUM | 20 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 345 | 366 | 94 |
| 93fre02.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 364 | 365 | 100 |
| 94fre02.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 363 | 365 | 99 |
| 95fre02.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 16 | 0 | 43 | 322 | 365 | 88 |
| 96fre02.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 2 | 0 | 0 | 0 | 8 | 358 | 366 | 98 |
| 97fre02.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 31 | 57 | 308 | 365 | 84 |
| 98fre02.SUM | 23 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 341 | 365 | 93 |
| 99fre02.SUM | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 363 | 365 | 99 |
| 83KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 84KER05.SUM | 31 | 29 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 366 | 0 | 366 | 0 |
| 85KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 86KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 87KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 88KER05.SUM | 31 | 29 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 366 | 0 | 366 | 0 |
| 89KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 90KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 91KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 99KER05.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 84KER31.SUM | 10 | 4 | 17 | 17 | 7 | 0 | 0 | 0 | 14 | 0 | 4 | 8 | 81 | 285 | 366 | 78 |
| 85KER31.SUM | 9 | 0 | 0 | 0 | 5 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 17 | 348 | 365 | 95 |
| 86KER31.SUM | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 3 | 11 | 354 | 365 | 97 |
| 87KER31.SUM | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 7 | 358 | 365 | 98 |
| 88KER31.SUM | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 9 | 1 | 3 | 4 | 19 | 347 | 366 | 95 |
| 89KER31.SUM | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 4 | 9 | 21 | 344 | 365 | 94 |
| 90KER31.SUM | 9 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 1 | 4 | 12 | 31 | 334 | 365 | 92 |
| 91KER31.SUM | 16 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 28 | 337 | 365 | 92 |
| 92KER31.SUM | 0 | 0 | 5 | 0 | 0 | 0 | 4 | 0 | 1 | 1 | 0 | 0 | 11 | 355 | 366 | 97 |
| 87KER54.SUM | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 0 | 2 | 0 | 1 | 1 | 10 | 355 | 365 | 97 |
| 88KER54.SUM | 3 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 1 | 2 | 1 | 0 | 11 | 355 | 366 | 97 |
| 89KER54.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 2 | 7 | 358 | 365 | 98 |
| 90KER54.SUM | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 360 | 365 | 99 |

| FILE | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | BAD | GOOD | TTOT | %GOOD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91KER54.SUM | 0 | 0 | 14 | 0 | 8 | 0 | 3 | 4 | 10 | 14 | 12 | 11 | 76 | 289 | 365 | 79 |
| 92KER54.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 12 | 1 | 0 | 0 | 14 | 352 | 366 | 96 |
| 93KER54.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 6 | 0 | 10 | 355 | 365 | 97 |
| 94KER54.SUM | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 6 | 17 | 347 | 364 | 95 |
| 95KER54.SUM | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 364 | 365 | 100 |
| 96KER54.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 366 | 366 | 100 |
| 97KER54.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 364 | 365 | 100 |
| 98KER54.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 365 | 100 |
| 99KER54.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 365 | 100 |
| 92KER93.SUM | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 12 | 1 | 0 | 0 | 17 | 349 | 366 | 95 |
| 93KER93.SUM | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 363 | 365 | 99 |
| 97KEX25.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 365 | 100 |
| 98KEX25.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 365 | 100 |
| 99KEX25.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 7 | 358 | 365 | 98 |
| 96KEX25.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 366 | 366 | 100 |
| 89MER56.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 14 | 17 | 39 | 326 | 365 | 89 |
| 90MER56.SUM | 9 | 5 | 3 | 5 | 7 | 5 | 4 | 1 | 0 | 0 | 2 | 8 | 49 | 316 | 365 | 87 |
| 91MER56.SUM | 19 | 11 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 32 | 333 | 365 | 91 |
| 92MER56.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 4 | 14 | 1 | 1 | 27 | 339 | 366 | 93 |
| **93MER56.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **365** | **365** | **100** |
| **94MER56.SUM** | **2** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **0** | **0** | **3** | **362** | **365** | **99** |
| **95MER56.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **365** | **365** | **100** |
| **96MER56.SUM** | **0** | **0** | **12** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **12** | **354** | **366** | **97** |
| **97MER56.SUM** | **0** | **0** | **4** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **5** | **360** | **365** | **99** |
| 98MER56.SUM | 0 | 0 | 0 | 0 | 24 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 337 | 365 | 92 |
| 99MER56.SUM | 0 | 11 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 349 | 365 | 96 |
| 83mon16.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 84mon16.SUM | 31 | 29 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 366 | 0 | 366 | 0 |
| 85mon16.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 86mon16.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 87mon16.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 | 365 | 0 | 365 | 0 |
| 88mon16.SUM | 31 | 29 | 31 | 30 | 19 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 141 | 225 | 366 | 61 |
| 89mon16.SUM | 0 | 0 | 0 | 1 | 3 | 0 | 4 | 4 | 16 | 15 | 5 | 0 | 48 | 317 | 365 | 87 |
| 90mon16.SUM | 3 | 2 | 0 | 15 | 7 | 4 | 0 | 0 | 0 | 2 | 0 | 1 | 34 | 331 | 365 | 91 |
| 91mon16.SUM | 4 | 8 | 8 | 3 | 1 | 0 | 0 | 0 | 0 | 7 | 3 | 1 | 35 | 330 | 365 | 90 |
| 92mon16.SUM | 7 | 19 | 9 | 17 | 6 | 12 | 31 | 31 | 30 | 0 | 0 | 2 | 164 | 202 | 366 | 55 |
| 93mon16.SUM | 0 | 5 | 0 | 8 | 9 | 10 | 1 | 5 | 12 | 18 | 4 | 0 | 72 | 293 | 365 | 80 |
| 94mon16.SUM | 0 | 0 | 0 | 8 | 17 | 6 | 2 | 13 | 6 | 5 | 1 | 0 | 58 | 307 | 365 | 84 |
| 95mon16.SUM | 4 | 1 | 0 | 0 | 4 | 1 | 12 | 7 | 0 | 0 | 0 | 0 | 29 | 207 | 236 | 88 |
| 83mon19.SUM | 9 | 0 | 0 | 1 | 2 | 3 | 4 | 8 | 5 | 6 | 18 | 18 | 74 | 291 | 365 | 80 |
| 84mon19.SUM | 13 | 10 | 10 | 9 | 10 | 2 | 7 | 14 | 18 | 23 | 17 | 15 | 148 | 218 | 366 | 60 |
| 85mon19.SUM | 21 | 9 | 1 | 7 | 9 | 17 | 31 | 31 | 30 | 31 | 30 | 31 | 248 | 117 | 365 | 32 |
| 86mon19.SUM | 31 | 28 | 31 | 30 | 31 | 30 | 25 | 6 | 13 | 2 | 1 | 0 | 228 | 137 | 365 | 38 |
| 87mon19.SUM | 0 | 1 | 0 | 4 | 0 | 3 | 1 | 0 | 0 | 0 | 1 | 5 | 15 | 350 | 365 | 96 |
| 88mon19.SUM | 0 | 13 | 1 | 12 | 2 | 0 | 8 | 0 | 0 | 0 | 0 | 6 | 42 | 324 | 366 | 89 |
| 89mon19.SUM | 0 | 0 | 0 | 0 | 0 | 2 | 15 | 17 | 22 | 13 | 9 | 3 | 81 | 284 | 365 | 78 |
| 90mon19.SUM | 3 | 8 | 1 | 7 | 21 | 27 | 0 | 0 | 3 | 0 | 29 | 26 | 125 | 240 | 365 | 66 |
| 91mon19.SUM | 11 | 6 | 28 | 7 | 3 | 2 | 0 | 0 | 2 | 0 | 4 | 3 | 66 | 299 | 365 | 82 |
| 92mon19.SUM | 0 | 1 | 0 | 1 | 0 | 5 | 22 | 1 | 0 | 0 | 0 | 0 | 30 | 336 | 366 | 92 |

| FILE | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | BAD | GOOD | TTOT | %GOOD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 93mon19.SUM | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 14 | 10 | 10 | 0 | 5 | 42 | 323 | 365 | 88 |
| 94mon19.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 364 | 365 | 100 |
| 95mon19.SUM | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 364 | 365 | 100 |
| 96mon19.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 366 | 366 | 100 |
| 97mon19.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 365 | 100 |
| 98mon19.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 15 | 350 | 365 | 96 |
| 99mon19.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 7 | 358 | 365 | 98 |
| 84MON37.SUM | 4 | 2 | 0 | 0 | 9 | 1 | 1 | 2 | 1 | 4 | 4 | 4 | 32 | 334 | 366 | 91 |
| 85MON37.SUM | 0 | 0 | 0 | 0 | 2 | 1 | 17 | 10 | 0 | 0 | 1 | 0 | 31 | 334 | 365 | 92 |
| 86MON37.SUM | 0 | 12 | 0 | 0 | 4 | 1 | 0 | 1 | 5 | 2 | 0 | 0 | 25 | 340 | 365 | 93 |
| 87MON37.SUM | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 7 | 2 | 0 | 19 | 346 | 365 | 95 |
| 88MON37.SUM | 0 | 3 | 7 | 0 | 1 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 19 | 347 | 366 | 95 |
| 89MON37.SUM | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 361 | 365 | 99 |
| 90MON37.SUM | 0 | 0 | 1 | 0 | 0 | 10 | 1 | 0 | 3 | 0 | 0 | 0 | 15 | 350 | 365 | 96 |
| 91MON37.SUM | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 12 | 353 | 365 | 97 |
| 95MON89.SUM | 6 | 6 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 350 | 365 | 96 |
| 96MON89.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 366 | 366 | 100 |
| 97MON89.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 3 | 9 | 356 | 365 | 98 |
| 98MON89.SUM | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 353 | 365 | 97 |
| 99MON89.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 365 | 100 |
| **95MOX16.SUM** | **0** | **0** | **0** | **9** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **9** | **356** | **365** | **98** |
| **96MOX16.SUM** | **0** | **0** | **0** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **365** | **366** | **100** |
| **97MOX16.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **365** | **365** | **100** |
| **98MOX16.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **365** | **365** | **100** |
| **99MOX16.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **365** | **365** | **100** |
| 92VEN11.SUM | 0 | 3 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 347 | 366 | 95 |
| 93VEN11.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 363 | 365 | 99 |
| 94VEN11.SUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 365 | 100 |
| **95VEN11.SUM** | **12** | **0** | **4** | **0** | **0** | **0** | **1** | **0** | **0** | **0** | **0** | **0** | **17** | **348** | **365** | **95** |
| **96VEN11.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **366** | **366** | **100** |
| **97VEN11.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **365** | **365** | **100** |
| **98VEN11.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **365** | **365** | **100** |
| **99VEN11.SUM** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **3** | **0** | **0** | **0** | **3** | **362** | **365** | **99** |

# Table 4.3. Station descriptions from CIMIS web site.

## Fresno County

| | | | |
|---|---|---|---|
| STATION NO. | = 1 | MAINT. BY | = M-DWR |
| STATION NAME | = Fresno/F.S.U. USDA | ELEVATION | = 340 ft. |
| COUNTY | = Fresno | LATITUDE | = 36D48'52"N |
| REGION | = San Joaquin Valley | LONGITUDE | = 119D43'54"W |
| NEARBY CITY | = Fresno | START DATE | = 6/ 7/82 |
| OWNER | = USDA | END DATE | = 9/25/88 |
| MAINT. PERSON | = San Joaquin District | | |

DESCRIPTION OF SITE =

The site is in the agricultural research area of the CSU Fresno Campus. The station is located on a large section of grass maintained by university personnel.

| | | | |
|---|---|---|---|
| STATION NO. | = 2 | MAINT. BY | = M-DWR |
| STATION NAME | = FivePoints/WSFS USDA | ELEVATION | = 285 ft. |
| COUNTY | = Fresno | LATITUDE | = 36D20'11"N |
| REGION | = San Joaquin Valley | LONGITUDE | = 120D06'47"W |
| NEARBY CITY | = Five Points | START DATE | = 6/ 7/82 |
| OWNER | = USDA | END DATE | = ACTIVE |
| MAINT. PERSON | = San Joaquin District | | |

DESCRIPTION OF SITE =

The site is at the UC Westside Field Station research facility. Located on a large grass plot, it has few constraints.

## Kern County

| | | | |
|---|---|---|---|
| STATION NO. | = 5 | MAINT. BY | = M-DWR |
| STATION NAME | = Shafter/USDA | ELEVATION | = 360 ft. |
| COUNTY | = Kern | LATITUDE | = 35D31'59"N |
| REGION | = San Joaquin Valley | LONGITUDE | = 119D16'52"W |
| NEARBY CITY | = Shafter | START DATE | = 6/ 1/82 |
| OWNER | = USDA Cotton Research Stati | END DATE | = ACTIVE |
| MAINT. PERSON | = USDA | | |

DESCRIPTION OF SITE =

The station is located at the USDA Cotton Research Station north of Shafter. The area is predominantly row crop land with scattered distant almond orchards in all directions.  A grass plot about 120'(w-e) x 60'(n-s) is located in the cotton stations experimental crop growing area.  The weather station is located about 65' east and 20' north of the southwest corner of the grass plot.  Most years cotton is grown around the grass plot, although small grains are used in rotation.  A dirt road borders western edge of the grass.

The grass is flood irrigated and the vigorously growing perenial rye grass is regularly cut.  There is no more than 70' of upwind grass fetch in the northwesterly prevailing wind direction.  A 4' high chain link fence

(Table 4.3 contd)

surrounds the station which also includes a USWB Class A evaporation pan. The USDA owned station uses a pyrenometer and net radiometer which are different from the CIMIS standard equipment.

| | | | |
|---|---|---|---|
| STATION NO. | = 31 | MAINT. BY | = M-DWR |
| STATION NAME | = McFarland/Kern Farms | ELEVATION | = 480 ft. |
| COUNTY | = Kern | LATITUDE | = 35D42'10"N |
| REGION | = San Joaquin Valley | LONGITUDE | = 119D09'06"W |
| NEARBY CITY | = McFarland | START DATE | = 1/11/83 |
| OWNER | = DWR | END DATE | = 3/ 8/93 |
| MAINT. PERSON | = San Joaquin District | | |

DESCRIPTION OF SITE =

No information is available at this time.

| | | | |
|---|---|---|---|
| STATION NO. | = 54 | MAINT. BY | = M-DWR |
| STATION NAME | = Blackwells Corner | ELEVATION | = 705 ft. |
| COUNTY | = Kern | LATITUDE | = 35D38'59"N |
| REGION | = San Joaquin Valley | LONGITUDE | = 119D57'30"W |
| NEARBY CITY | = Blackwells Corner | START DATE | = 10/19/86 |
| OWNER | = DWR | END DATE | = ACTIVE |
| MAINT. PERSON | = San Joaquin District | | |

DESCRIPTION OF SITE =

No information is available at this time.

| | | | |
|---|---|---|---|
| STATION NO. | = 93 | MAINT. BY | = M-DWR |
| STATION NAME | = Lamont | ELEVATION | = 382 ft. |
| COUNTY | = Kern | LATITUDE | = 35D17'12"N |
| REGION | = San Joaquin Valley | LONGITUDE | = 118D55'43"W |
| NEARBY CITY | = Lamont | START DATE | = 2/ 4/90 |
| OWNER | = DWR | END DATE | = 10/ 3/94 |
| MAINT. PERSON | = San Joaquin District | | |

DESCRIPTION OF SITE =

No information is available at this time.

| | | | |
|---|---|---|---|
| STATION NO. | = 125 | MAINT. BY | = AEHSD |
| STATION NAME | = Arvin-Edison | ELEVATION | = 500 ft. |
| COUNTY | = Kern | LATITUDE | = 35D12'22"N |
| REGION | = San Joaquin Valley | LONGITUDE | = 118D46'40"W |
| NEARBY CITY | = Arvin | START DATE | = 3/22/95 |
| OWNER | = DWR | END DATE | = ACTIVE |
| MAINT. PERSON | = Arvin-Edison H2o Storage District | | |

DESCRIPTION OF SITE =

No information is available at this time.

(Table 4.3 contd)

**Merced County**

```
STATION NO.   =  56                          MAINT. BY   = M-DWR
STATION NAME  = Los Banos                    ELEVATION   =      95 ft.
COUNTY        = Merced                       LATITUDE    = 37D05'30"N
REGION        = San Joaquin Valley           LONGITUDE   = 120D45'35"W
NEARBY CITY   = Los Banos                    START DATE  =  6/28/88
OWNER         = Richard Rodoni               END DATE    = ACTIVE
MAINT. PERSON = San Joaquin District

DESCRIPTION OF SITE =

 No information is available at this time.
```

**Monterey County**

```
STATION NO.   =  16                          MAINT. BY   = M-DWR
STATION NAME  = San Juan                     ELEVATION   =      44 ft.
COUNTY        = Monterey                     LATITUDE    = 36D54'17"N
REGION        = Monterey Bay                 LONGITUDE   = 121D42'11"W
NEARBY CITY   = Watsonville                  START DATE  = 10/23/82
OWNER         = DWR                          END DATE    =  8/24/95
MAINT. PERSON = San Joaquin District

DESCRIPTION OF SITE =

 No information is available at this time.

STATION NO.   =  19                          MAINT. BY   = M-DWR
STATION NAME  = Castroville                  ELEVATION   =       9 ft.
COUNTY        = Monterey                     LATITUDE    = 36D46'05"N
REGION        = Monterey Bay                 LONGITUDE   = 121D46'25"W
NEARBY CITY   = Castroville                  START DATE  = 11/18/82
OWNER         = DWR                          END DATE    = ACTIVE
MAINT. PERSON = San Joaquin District

DESCRIPTION OF SITE =

 No information is available at this time.


STATION NO.   =  37                          MAINT. BY   = M-DWR
STATION NAME  = USDA Salinas                 ELEVATION   =     120 ft.
COUNTY        = Monterey                     LATITUDE    = 36D37'14"N
REGION        = Monterey Bay                 LONGITUDE   = 121D32'43"W
NEARBY CITY   = Salinas                      START DATE  =  4/11/83
OWNER         = DWR                          END DATE    =  7/27/92
MAINT. PERSON = San Joaquin District

DESCRIPTION OF SITE =

 No information is available at this time.
```

(Table 4.3 contd)

| | | | |
|---|---|---|---|
| STATION NO. | = 89 | MAINT. BY | = M-DWR |
| STATION NAME | = Salinas South | ELEVATION | = 120 ft. |
| COUNTY | = Monterey | LATITUDE | = 36D31'35"N |
| REGION | = Monterey Bay | LONGITUDE | = 121D31'45"W |
| NEARBY CITY | = Salinas | START DATE | = 9/ 5/92 |
| OWNER | = DWR | END DATE | = ACTIVE |
| MAINT. PERSON | = San Joaquin District | | |

DESCRIPTION OF SITE =

No information is available at this time.

| | | | |
|---|---|---|---|
| STATION NO. | = 116 | MAINT. BY | = M-OWN |
| STATION NAME | = Salinas North | ELEVATION | = 61 ft. |
| COUNTY | = Monterey | LATITUDE | = 36D43'00"N |
| REGION | = Monterey Bay | LONGITUDE | = 121D41'27"W |
| NEARBY CITY | = Salinas | START DATE | = 6/18/93 |
| OWNER | = MCWRA | END DATE | = ACTIVE |
| MAINT. PERSON | = MCWRA | | |

DESCRIPTION OF SITE =

No information is available at this time.

## Ventura County

| | | | |
|---|---|---|---|
| STATION NO. | = 101 | MAINT. BY | = M-DWR |
| STATION NAME | = Piru | ELEVATION | = 640 ft. |
| COUNTY | = Ventura | LATITUDE | = 34D22'30"N |
| REGION | = Central Coast/Valley | LONGITUDE | = 118D47'20"W |
| NEARBY CITY | = Piru | START DATE | = 8/27/91 |
| OWNER | = United Water CD | END DATE | = ACTIVE |
| MAINT. PERSON | = United Water CD | | |

DESCRIPTION OF SITE =

No information is available at this time.

Table 4.4. Adjustment to wind direction standard deviation categories for roughness and 2 meter wind measurement height for CIMIS data (USEPA 1987, 2000). The adjustment is produced by multiplying the lower cutoff bound by the roughness factor and the wind measurement height factor.

| Stability Class | Lower Cutoff Bound (degrees) | **Roughness Factor** **Z0=3cm** $\left(\frac{z_0}{15}\right)^{0.2}$ | **Wind Measurement Height Factor** **Z=2m** $P_\theta$ | $\left(\frac{Z}{10}\right)^{P_\theta}$ | Adjusted Cutoff (degrees) |
|---|---|---|---|---|---|
| A | 22.50 | 0.72 | -0.06 | 1.10 | 18.0 |
| B | 17.50 | 0.72 | -0.15 | 1.27 | 16.2 |
| C | 12.50 | 0.72 | -0.17 | 1.31 | 11.9 |
| D | 7.50 | 0.72 | -0.23 | 1.45 | 7.9 |
| F | 3.80 | 0.72 | -0.38 | 1.84 | 5.1 |

Table 4.5. Selected acreage x flux combinations and corresponding proposed buffer zone (feet) from Segawa et al. (2000).

| **Acres** | **30 lbs/a-d** | **80 lbs/a-d** | **130 lbs/a-d** | **180 lbs/a-d** | **225 lbs/a-d** |
|---|---|---|---|---|---|
| **1** | 100 | 110 | 220 | 330 | 420 |
| **10** | 100 | 410 | 840 | 1200 | 1600 |
| **20** | 100 | 610 | 1200 | 1800 | 2300 |
| **30** | 100 | 770 | 1600 | 2300 | 2900 |
| **40** | 100 | 900 | 1800 | 2700 | 3400 |

Table 4.6. Transect characteristics for each acreage.

| Acres | Total # Transects | Transect Length(m) | Field Side (m) | #Transects Each Corner | #Transects Each Side |
|---|---|---|---|---|---|
| 1 | 96 | 400. | 63.6 | 17 | 7 |
| 10 | 148 | 1800. | 201.2 | 17 | 20 |
| 20 | 184 | 2600. | 284.5 | 17 | 29 |
| 30 | 208 | 4000. | 348.4 | 17 | 35 |
| 40 | 228 | 5000. | 402.3 | 17 | 40 |

**Table 5.2.1.** Selected key frequencies and corresponding required buffer zones from 25 cumulative distributions. In this table, column headers are flux (lbs/a-d) and values in the table are in feet. For example, for a 1 acre field the 99th percentile (frequency=0.99)for a flux of 180 lbs/a-d is 384 feet.

| | | **030** | **080** | **130** | **180** | **225** |
|---|---|---|---|---|---|---|
| **01 ACRES** | | | | | | |
| | 0.1000 | 0 | 0 | 0 | 35 | 76 |
| | 0.2000 | 0 | 0 | 0 | 61 | 102 |
| | 0.3000 | 0 | 0 | 0 | 80 | 122 |
| | 0.4000 | 0 | 0 | 28 | 97 | 143 |
| | 0.5000 | 0 | 0 | 47 | 113 | 161 |
| | 0.6000 | 0 | 0 | 63 | 131 | 183 |
| | 0.7000 | 0 | 0 | 81 | 154 | 210 |
| | 0.8000 | 0 | 0 | 102 | 179 | 241 |
| | 0.8500 | 0 | 0 | 115 | 198 | 263 |
| | 0.9000 | 0 | 0 | 135 | 221 | 292 |
| | 0.9250 | 0 | 0 | 148 | 238 | 313 |
| | 0.9500 | 0 | 36 | 166 | 263 | 343 |
| | 0.9600 | 0 | 44 | 177 | 277 | 357 |
| | 0.9700 | 0 | 59 | 194 | 295 | 384 |
| | 0.9800 | 0 | 78 | 215 | 327 | 418 |
| | 0.9900 | 0 | 112 | 263 | 384 | 485 |
| | 0.9990 | 0 | 218 | 430 | 618 | 759 |
| **10 ACRES** | | | | | | |
| | 0.1000 | 0 | 15 | 165 | 292 | 402 |
| | 0.2000 | 0 | 62 | 224 | 371 | 496 |
| | 0.3000 | 0 | 98 | 275 | 436 | 577 |
| | 0.4000 | 0 | 130 | 320 | 496 | 650 |
| | 0.5000 | 0 | 160 | 366 | 561 | 727 |
| | 0.6000 | 0 | 191 | 417 | 628 | 814 |
| | 0.7000 | 0 | 226 | 480 | 719 | 919 |
| | 0.8000 | 0 | 273 | 559 | 820 | 1046 |
| | 0.8500 | 0 | 306 | 611 | 892 | 1131 |
| | 0.9000 | 0 | 350 | 682 | 989 | 1251 |
| | 0.9250 | 0 | 380 | 734 | 1062 | 1343 |
| | 0.9500 | 0 | 424 | 805 | 1166 | 1459 |
| | 0.9600 | 0 | 457 | 844 | 1206 | 1522 |
| | 0.9700 | 0 | 492 | 907 | 1296 | 1615 |
| | 0.9800 | 5 | 547 | 993 | 1404 | 1757 |
| | 0.9900 | 63 | 665 | 1172 | 1631 | 2023 |
| | 0.9990 | 244 | 1026 | 1807 | 2559 | 3393 |
| **20 ACRES** | | | | | | |
| | 0.1000 | 0 | 79 | 262 | 456 | 613 |
| | 0.2000 | 0 | 135 | 356 | 575 | 766 |
| | 0.3000 | 0 | 177 | 435 | 676 | 891 |
| | 0.4000 | 0 | 221 | 502 | 766 | 999 |
| | 0.5000 | 0 | 265 | 575 | 866 | 1117 |
| | 0.6000 | 0 | 312 | 651 | 976 | 1251 |
| | 0.7000 | 0 | 369 | 750 | 1109 | 1412 |
| | 0.8000 | 0 | 443 | 872 | 1267 | 1605 |
| | 0.8500 | 0 | 494 | 952 | 1376 | 1740 |
| | 0.9000 | 0 | 564 | 1061 | 1526 | 1929 |
| | 0.9250 | 16 | 608 | 1142 | 1639 | 2065 |
| | 0.9500 | 40 | 670 | 1256 | 1791 | 2263 |
| | 0.9600 | 56 | 722 | 1308 | 1864 | 2375 |

(Table 5.2.1 contd)

| | | | | | | |
|---|---|---|---|---|---|---|
| | 0.9700 | 77 | 778 | 1401 | 1997 | 2513 |
| | 0.9800 | 114 | 865 | 1523 | 2162 | 2753 |
| | 0.9900 | 178 | 1051 | 1807 | 2550 | 3224 |
| | 0.9990 | 399 | 1609 | 2827 | 4167 | 5545 |
| **30 ACRES** | | | | | | |
| | 0.1000 | 0 | 134 | 333 | 594 | 792 |
| | 0.2000 | 0 | 198 | 448 | 748 | 981 |
| | 0.3000 | 0 | 245 | 568 | 869 | 1145 |
| | 0.4000 | 0 | 293 | 658 | 985 | 1286 |
| | 0.5000 | 0 | 343 | 749 | 1116 | 1437 |
| | 0.6000 | 0 | 402 | 844 | 1256 | 1612 |
| | 0.7000 | 0 | 481 | 972 | 1426 | 1824 |
| | 0.8000 | 0 | 587 | 1129 | 1632 | 2076 |
| | 0.8500 | 22 | 653 | 1232 | 1775 | 2257 |
| | 0.9000 | 56 | 741 | 1375 | 1980 | 2513 |
| | 0.9250 | 77 | 794 | 1473 | 2134 | 2702 |
| | 0.9500 | 104 | 877 | 1627 | 2339 | 2969 |
| | 0.9600 | 120 | 940 | 1697 | 2437 | 3129 |
| | 0.9700 | 146 | 1013 | 1817 | 2607 | 3318 |
| | 0.9800 | 182 | 1131 | 1999 | 2861 | 3646 |
| | 0.9900 | 252 | 1365 | 2364 | 3355 | 4251 |
| | 0.9990 | 515 | 2103 | 3739 | 5725 | 7315 |
| **40 ACRES** | | | | | | |
| | 0.1000 | 0 | 183 | 399 | 710 | 952 |
| | 0.2000 | 0 | 254 | 524 | 902 | 1171 |
| | 0.3000 | 0 | 305 | 679 | 1041 | 1371 |
| | 0.4000 | 0 | 358 | 798 | 1180 | 1541 |
| | 0.5000 | 0 | 412 | 906 | 1337 | 1727 |
| | 0.6000 | 0 | 479 | 1013 | 1509 | 1937 |
| | 0.7000 | 0 | 574 | 1166 | 1714 | 2201 |
| | 0.8000 | 40 | 713 | 1352 | 1969 | 2506 |
| | 0.8500 | 70 | 796 | 1482 | 2148 | 2744 |
| | 0.9000 | 107 | 901 | 1658 | 2396 | 3060 |
| | 0.9250 | 130 | 963 | 1775 | 2587 | 3302 |
| | 0.9500 | 160 | 1052 | 1964 | 2839 | 3625 |
| | 0.9600 | 181 | 1129 | 2042 | 2978 | 3824 |
| | 0.9700 | 206 | 1225 | 2198 | 3199 | 4080 |
| | 0.9800 | 243 | 1365 | 2431 | 3517 | 4458 |
| | 0.9900 | 320 | 1657 | 2884 | 4108 | 5182 |
| | 0.9990 | 613 | 2570 | 4655 | 7266 | 8866 |

**Table 5.2.2.** Interpolated individual cumulative frequencies for proposed buffer zones. Cumulative frequencies are shown, followed by the proposed buffer zone in feet in parentheses. The fluxes ranged from 30 to 225 lbs/a-d.

| Acres | 030 lbs/a-d | 080 lbs/a-d | 130 lbs/a-d | 180 lbs/a-d | 225 lbs/a-d |
|---|---|---|---|---|---|
| 01 | 1.000 ( 100) | 0.990 ( 110) | 0.981 ( 220) | 0.981 ( 330) | 0.981 ( 420) |
| 10 | 0.994 ( 100) | 0.943 ( 410) | 0.959 ( 840) | 0.958 (1200) | 0.969 (1600) |
| 20 | 0.977 ( 100) | 0.926 ( 610) | 0.940 (1200) | 0.951 (1800) | 0.955 (2300) |
| 30 | 0.947 ( 100) | 0.915 ( 770) | 0.946 (1600) | 0.947 (2300) | 0.945 (2900) |
| 40 | 0.892 ( 100) | 0.899 ( 900) | 0.929 (1800) | 0.938 (2700) | 0.936 (3400) |

Table 5.3.1. Selected frequencies and corresponding concentrations for maximum concentration distribution at buffer zone distance. Concentrations in ug/m3. Column headers are flux (lbs/a-d). For example, the 80th percentile (frequency=0.80) for 1 acre at 130 lbs/a-d flux is 507 ug/m3.

| | Percentile | 030 | 080 | 130 | 180 | 225 |
|---|---|---|---|---|---|---|
| 01 ACRES | | | | | | |
| | 0.1000 | 95 | 240 | 234 | 222 | 217 |
| | 0.2000 | 109 | 278 | 275 | 262 | 257 |
| | 0.3000 | 122 | 310 | 308 | 294 | 290 |
| | 0.4000 | 133 | 339 | 340 | 326 | 320 |
| | 0.5000 | 144 | 369 | 373 | 359 | 354 |
| | 0.6000 | 157 | 401 | 408 | 398 | 390 |
| | 0.7000 | 172 | 439 | 454 | 440 | 433 |
| | 0.8000 | 189 | 486 | 507 | 495 | 489 |
| | 0.8500 | 200 | 515 | 546 | 531 | 527 |
| | 0.9000 | 217 | 558 | 592 | 588 | 584 |
| | 0.9250 | 228 | 585 | 628 | 623 | 622 |
| | 0.9500 | 243 | 625 | 675 | 678 | 676 |
| | 0.9600 | 251 | 646 | 704 | 701 | 705 |
| | 0.9700 | 263 | 679 | 746 | 742 | 747 |
| | 0.9800 | 283 | 734 | 806 | 809 | 811 |
| | 0.9900 | 316 | 820 | 919 | 934 | 938 |
| | 0.9990 | 449 | 1166 | 1317 | 1401 | 1442 |
| 10 ACRES | | | | | | |
| | 0.1000 | 231 | 285 | 251 | 244 | 226 |
| | 0.2000 | 271 | 337 | 299 | 292 | 271 |
| | 0.3000 | 303 | 381 | 337 | 331 | 306 |
| | 0.4000 | 333 | 420 | 374 | 366 | 341 |
| | 0.5000 | 361 | 463 | 413 | 407 | 378 |
| | 0.6000 | 392 | 508 | 457 | 451 | 418 |
| | 0.7000 | 426 | 564 | 511 | 503 | 466 |
| | 0.8000 | 469 | 633 | 576 | 569 | 529 |
| | 0.8500 | 496 | 678 | 621 | 616 | 575 |
| | 0.9000 | 533 | 739 | 684 | 681 | 635 |
| | 0.9250 | 557 | 777 | 726 | 727 | 681 |
| | 0.9500 | 588 | 835 | 788 | 792 | 741 |
| | 0.9600 | 611 | 875 | 818 | 819 | 777 |
| | 0.9700 | 642 | 918 | 874 | 872 | 824 |
| | 0.9800 | 681 | 1003 | 955 | 954 | 890 |
| | 0.9900 | 760 | 1129 | 1107 | 1099 | 1041 |
| | 0.9990 | 1123 | 1538 | 1521 | 1623 | 1564 |
| 20 ACRES | | | | | | |
| | 0.1000 | 286 | 291 | 267 | 247 | 241 |
| | 0.2000 | 336 | 347 | 317 | 297 | 290 |
| | 0.3000 | 377 | 392 | 360 | 336 | 329 |
| | 0.4000 | 416 | 434 | 399 | 372 | 366 |
| | 0.5000 | 450 | 480 | 442 | 415 | 404 |
| | 0.6000 | 489 | 526 | 489 | 460 | 449 |
| | 0.7000 | 529 | 586 | 548 | 514 | 501 |
| | 0.8000 | 580 | 659 | 619 | 582 | 569 |
| | 0.8500 | 612 | 705 | 666 | 629 | 619 |
| | 0.9000 | 657 | 772 | 733 | 695 | 686 |
| | 0.9250 | 686 | 813 | 779 | 746 | 733 |
| | 0.9500 | 719 | 874 | 847 | 811 | 802 |
| | 0.9600 | 746 | 919 | 877 | 841 | 841 |
| | 0.9700 | 780 | 964 | 935 | 897 | 890 |

(Table 5.3.1 contd)

| | | | | | | |
|---|---|---|---|---|---|---|
| | 0.9800 | 835 | 1053 | 1025 | 980 | 963 |
| | 0.9900 | 927 | 1182 | 1191 | 1131 | 1125 |
| | 0.9990 | 1338 | 1629 | 1644 | 1674 | 1685 |
| 30 ACRES | | | | | | |
| | 0.1000 | 333 | 297 | 256 | 249 | 247 |
| | 0.2000 | 389 | 353 | 306 | 300 | 300 |
| | 0.3000 | 437 | 400 | 347 | 339 | 341 |
| | 0.4000 | 478 | 444 | 385 | 378 | 379 |
| | 0.5000 | 519 | 490 | 428 | 419 | 420 |
| | 0.6000 | 564 | 539 | 474 | 466 | 465 |
| | 0.7000 | 608 | 600 | 530 | 520 | 519 |
| | 0.8000 | 664 | 676 | 600 | 589 | 592 |
| | 0.8500 | 700 | 723 | 647 | 641 | 641 |
| | 0.9000 | 749 | 793 | 713 | 708 | 713 |
| | 0.9250 | 781 | 833 | 758 | 759 | 763 |
| | 0.9500 | 821 | 895 | 827 | 827 | 834 |
| | 0.9600 | 845 | 945 | 856 | 859 | 875 |
| | 0.9700 | 886 | 992 | 913 | 915 | 924 |
| | 0.9800 | 939 | 1079 | 994 | 995 | 1008 |
| | 0.9900 | 1044 | 1215 | 1166 | 1155 | 1170 |
| | 0.9990 | 1506 | 1679 | 1614 | 1707 | 1764 |
| 40 ACRES | | | | | | |
| | 0.1000 | 367 | 304 | 271 | 256 | 256 |
| | 0.2000 | 429 | 363 | 324 | 308 | 311 |
| | 0.3000 | 482 | 412 | 367 | 348 | 353 |
| | 0.4000 | 530 | 457 | 407 | 389 | 393 |
| | 0.5000 | 573 | 505 | 454 | 432 | 435 |
| | 0.6000 | 624 | 555 | 502 | 480 | 482 |
| | 0.7000 | 672 | 617 | 562 | 536 | 539 |
| | 0.8000 | 733 | 694 | 637 | 607 | 615 |
| | 0.8500 | 772 | 743 | 687 | 662 | 667 |
| | 0.9000 | 825 | 815 | 757 | 731 | 741 |
| | 0.9250 | 860 | 856 | 805 | 783 | 793 |
| | 0.9500 | 906 | 918 | 875 | 855 | 866 |
| | 0.9600 | 933 | 970 | 908 | 888 | 908 |
| | 0.9700 | 973 | 1022 | 970 | 946 | 961 |
| | 0.9800 | 1035 | 1107 | 1054 | 1029 | 1046 |
| | 0.9900 | 1148 | 1249 | 1241 | 1195 | 1216 |
| | 0.9990 | 1658 | 1724 | 1716 | 1762 | 1842 |

Table 5.3.2 Cumulative frequencies corresponding to 815 ug/m3 maximum concentration along the buffer zone. Column headers are flux (lbs/a-d). Table entries are cumulative frequencies.

| Acres | 030 | 080 | 130 | 180 | 225 |
|---|---|---|---|---|---|
| 01 | 1.000 | 0.990 | 0.981 | 0.980 | 0.981 |
| 10 | 0.994 | 0.943 | 0.959 | 0.958 | 0.969 |
| 20 | 0.977 | 0.926 | 0.940 | 0.951 | 0.955 |
| 30 | 0.947 | 0.915 | 0.946 | 0.947 | 0.945 |
| 40 | 0.892 | 0.899 | 0.929 | 0.938 | 0.936 |

Table 5.3.3. Matrix of possible concentration and distance outcomes for each day of simulation.

| | **Max distance to 815 ug/m3 < BZ** | **Max distance to 815 ug/m3 > BZ** |
|---|---|---|
| **Max conc At BZ distance Is less than 815ug/m3** | true | false |
| **Max conc At BZ distance Is greater than 815 ug/m3** | false | true |

Table 5.4.1. Interpolated individual cumulative frequencies for proposed buffer zones all direction cumulative distributions of distances to 815 ug/m3. Cumulative frequencies are shown followed by proposed buffer zone distance in feet in parentheses. The fluxes ranged from 30 to 225 lbs/a-d.

| **Acres** | **030 lbs/a-d** | **080 lbs/a-d** | **130 lbs/a-d** | **180 lbs/a-d** | **225 lbs/a-d** |
|---|---|---|---|---|---|
| **01** | 1.000 ( 100) | 0.999 ( 110) | 0.999 ( 220) | 0.999 ( 330) | 0.999 ( 420) |
| **10** | 0.999 ( 100) | 0.996 ( 410) | 0.998 ( 840) | 0.998 (1200) | 0.999 (1600) |
| **20** | 0.997 ( 100) | 0.995 ( 610) | 0.997 (1200) | 0.998 (1800) | 0.998 (2300) |
| **30** | 0.993 ( 100) | 0.994 ( 770) | 0.997 (1600) | 0.997 (2300) | 0.998 (2900) |
| **40** | 0.986 ( 100) | 0.993 ( 900) | 0.996 (1800) | 0.997 (2700) | 0.997 (3400) |

Table 5.5.1. Cumulative frequencies at 815 ug/m3 of concentrations along buffer zone distance in all directions. Column headers are flux (lbs/a-d). Table entries are cumulative frequencies. Percentiles would be derived by multiplying table values by 100.

| ACRES | 030 | 080 | 130 | 180 | 225 |
|---|---|---|---|---|---|
| 01 | 1.000 | 0.999 | 0.999 | 0.999 | 0.999 |
| 10 | 0.999 | 0.996 | 0.998 | 0.998 | 0.999 |
| 20 | 0.997 | 0.995 | 0.997 | 0.998 | 0.998 |
| 30 | 0.994 | 0.994 | 0.997 | 0.997 | 0.998 |
| 40 | 0.986 | 0.993 | 0.996 | 0.997 | 0.997 |

Table 5.6.1. Overlap measure in percent of meteorological x station days common to both simulation scenarios for cumulative distribution portion from 0.25 to 0.75 from the distributions of maximum concentrations along the buffer zone. Column headers are 1=30 lbs/a-d, 2=80 lbs/a-d...5=225 lbs/a-d.

| | | 01 ACRE | | | | | 10 ACRE | | | | | 20 ACRE | | | | | 30 ACRE | | | | | 40 ACRE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AC | FLX | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 01 | 030 | X | 98 | 83 | 76 | 73 | 82 | 87 | 77 | 73 | 69 | 78 | 85 | 77 | 72 | 69 | 74 | 84 | 75 | 71 | 68 | 73 | 84 | 75 | 70 | 68 |
| 01 | 080 | . | X | 85 | 78 | 74 | 81 | 88 | 79 | 74 | 71 | 77 | 86 | 78 | 73 | 70 | 73 | 86 | 77 | 72 | 69 | 72 | 86 | 77 | 72 | 69 |
| 01 | 130 | . | . | X | 90 | 84 | 73 | 87 | 91 | 85 | 79 | 70 | 88 | 91 | 83 | 78 | 67 | 88 | 89 | 82 | 78 | 66 | 88 | 88 | 81 | 77 |
| 01 | 180 | . | . | . | X | 93 | 69 | 82 | 93 | 93 | 87 | 67 | 82 | 93 | 91 | 86 | 66 | 83 | 93 | 90 | 85 | 65 | 82 | 93 | 89 | 85 |
| 01 | 225 | . | . | . | . | X | 68 | 78 | 88 | 96 | 92 | 66 | 79 | 88 | 95 | 91 | 65 | 79 | 90 | 94 | 90 | 64 | 79 | 89 | 93 | 90 |
| 10 | 030 | . | . | . | . | . | X | 80 | 71 | 68 | 67 | 95 | 79 | 71 | 68 | 66 | 90 | 79 | 70 | 68 | 66 | 88 | 79 | 70 | 68 | 67 |
| 10 | 080 | . | . | . | . | . | . | X | 86 | 80 | 76 | 77 | 98 | 86 | 79 | 76 | 73 | 97 | 84 | 78 | 75 | 72 | 97 | 84 | 78 | 75 |
| 10 | 130 | . | . | . | . | . | . | . | X | 91 | 84 | 69 | 87 | 99 | 89 | 83 | 67 | 87 | 97 | 88 | 83 | 66 | 87 | 97 | 87 | 82 |
| 10 | 180 | . | . | . | . | . | . | . | . | X | 92 | 67 | 81 | 91 | 98 | 91 | 65 | 81 | 93 | 96 | 90 | 64 | 81 | 92 | 95 | 90 |
| 10 | 225 | . | . | . | . | . | . | . | . | . | X | 65 | 77 | 84 | 93 | 99 | 64 | 77 | 86 | 95 | 98 | 64 | 77 | 85 | 95 | 97 |
| 20 | 030 | . | . | . | . | . | . | . | . | . | . | X | 76 | 69 | 67 | 65 | 95 | 76 | 68 | 66 | 65 | 94 | 76 | 68 | 66 | 66 |
| 20 | 080 | . | . | . | . | . | . | . | . | . | . | . | X | 87 | 80 | 76 | 73 | 99 | 85 | 79 | 76 | 72 | 99 | 85 | 79 | 76 |
| 20 | 130 | . | . | . | . | . | . | . | . | . | . | . | . | X | 89 | 84 | 67 | 87 | 97 | 88 | 83 | 66 | 87 | 98 | 87 | 83 |
| 20 | 180 | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 92 | 65 | 81 | 91 | 98 | 92 | 65 | 81 | 91 | 97 | 91 |
| 20 | 225 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 64 | 77 | 85 | 94 | 99 | 64 | 77 | 85 | 94 | 98 |
| 30 | 030 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 73 | 66 | 65 | 64 | 98 | 73 | 67 | 65 | 64 |
| 30 | 080 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 86 | 80 | 77 | 72 | 99 | 86 | 80 | 76 |
| 30 | 130 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 90 | 85 | 66 | 86 | 99 | 89 | 84 |
| 30 | 180 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 93 | 65 | 80 | 90 | 99 | 93 |
| 30 | 225 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 64 | 77 | 84 | 94 | 99 |
| 40 | 030 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 72 | 66 | 65 | 64 |
| 40 | 080 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 86 | 80 | 76 |
| 40 | 130 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 89 | 84 |
| 40 | 180 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 93 |

Table 5.6.2. Overlap measure in percent of meteorological x station days common to both simulation scenarios for cumulative distribution portion from 0.97 to 1.00 from the distributions of maximum concentrations along the buffer zone. Column headers are 1=30 lbs/a-d, 2=80 lbs/a-d...5=225 lbs/a-d.

| | | 01 ACRE | | | | | 10 ACRE | | | | | 20 ACRE | | | | | 30 ACRE | | | | | 40 ACRE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AC | FLX | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 01 | 030 | X | 98 | 79 | 72 | 67 | 80 | 86 | 74 | 69 | 65 | 77 | 84 | 74 | 67 | 64 | 74 | 84 | 73 | 67 | 64 | 71 | 84 | 73 | 67 | 63 |
| 01 | 080 | . | X | 81 | 73 | 69 | 80 | 88 | 76 | 70 | 66 | 77 | 87 | 76 | 69 | 66 | 74 | 87 | 75 | 68 | 65 | 71 | 86 | 75 | 68 | 64 |
| 01 | 130 | . | . | X | 90 | 85 | 67 | 85 | 94 | 86 | 80 | 64 | 85 | 93 | 84 | 79 | 61 | 85 | 93 | 83 | 78 | 60 | 85 | 93 | 83 | 77 |
| 01 | 180 | . | . | . | X | 93 | 61 | 78 | 93 | 94 | 87 | 59 | 78 | 93 | 93 | 86 | 56 | 78 | 95 | 91 | 85 | 55 | 78 | 94 | 90 | 84 |
| 01 | 225 | . | . | . | . | X | 58 | 73 | 87 | 96 | 94 | 55 | 73 | 87 | 98 | 93 | 53 | 73 | 89 | 96 | 92 | 53 | 73 | 88 | 96 | 91 |
| 10 | 030 | . | . | . | . | . | X | 75 | 63 | 60 | 56 | 97 | 75 | 64 | 58 | 56 | 92 | 74 | 63 | 58 | 56 | 88 | 75 | 63 | 58 | 55 |
| 10 | 080 | . | . | . | . | . | . | X | 83 | 76 | 71 | 73 | 99 | 83 | 74 | 70 | 69 | 99 | 82 | 73 | 70 | 67 | 98 | 82 | 73 | 69 |
| 10 | 130 | . | . | . | . | . | . | . | X | 90 | 84 | 60 | 83 | 99 | 89 | 82 | 58 | 83 | 98 | 87 | 82 | 57 | 83 | 98 | 87 | 81 |
| 10 | 180 | . | . | . | . | . | . | . | . | X | 92 | 57 | 76 | 90 | 98 | 90 | 54 | 76 | 92 | 96 | 90 | 54 | 76 | 91 | 95 | 89 |
| 10 | 225 | . | . | . | . | . | . | . | . | . | X | 54 | 71 | 83 | 94 | 98 | 53 | 72 | 86 | 95 | 98 | 52 | 72 | 85 | 95 | 97 |
| 20 | 030 | . | . | . | . | . | . | . | . | . | . | X | 72 | 61 | 55 | 54 | 95 | 72 | 60 | 56 | 53 | 91 | 73 | 60 | 55 | 53 |
| 20 | 080 | . | . | . | . | . | . | . | . | . | . | . | X | 83 | 74 | 70 | 68 | 99 | 82 | 74 | 70 | 67 | 99 | 82 | 73 | 69 |
| 20 | 130 | . | . | . | . | . | . | . | . | . | . | . | . | X | 88 | 81 | 58 | 84 | 98 | 87 | 81 | 57 | 83 | 98 | 87 | 80 |
| 20 | 180 | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 93 | 53 | 74 | 91 | 98 | 92 | 53 | 74 | 90 | 98 | 91 |
| 20 | 225 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 53 | 71 | 84 | 94 | 99 | 52 | 71 | 83 | 94 | 98 |
| 30 | 030 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 68 | 58 | 54 | 53 | 96 | 69 | 57 | 53 | 52 |
| 30 | 080 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 82 | 74 | 70 | 67 | 99 | 83 | 74 | 69 |
| 30 | 130 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 89 | 84 | 57 | 82 | 99 | 89 | 83 |
| 30 | 180 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 93 | 53 | 75 | 88 | 99 | 92 |
| 30 | 225 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 52 | 71 | 83 | 93 | 99 |
| 40 | 030 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 67 | 57 | 53 | 51 |
| 40 | 080 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 82 | 74 | 70 |
| 40 | 130 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 88 | 82 |
| 40 | 180 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | X | 93 |

Table 5.6.3. Statistical comparison of hourly meteorology for days from middle half of distribution of 20 acres, 130 lbs/a-d flux maximum concentration along buffer zone simulation compared to the upper 3 percentile from the same distribution with simple t-test. P values not changed by using pooled or separate standard deviations. There were 3574 and 215 days in the middle versus upper data sets.

| | Middle Half | | Upper 3% | | |
|---|---|---|---|---|---|
| **Variable** | **Mean** | **SD** | **Mean** | **SD** | **P** |
| **Season** | 1.06 | 0.70 | 0.52 | 0.63 | 0.00 |
| **Noncalm Hours** | 19.40 | 3.90 | 15.80 | 5.90 | 0.00 |
| **Average Speed (m/s)** | 2.86 | 0.78 | 2.09 | 0.49 | 0.00 |
| **Fraction F Stability** | 0.15 | 0.10 | 0.39 | 0.18 | 0.00 |
| **Average Temperature (K)** | 290.20 | 6.30 | 284.50 | 5.20 | 0.00 |
| **Mean Direction (Degrees)** | 158.20 | 86.10 | 232.70 | 95.60 | 0.00 |
| **Sigma Theta (Degrees)** | 51.10 | 26.80 | 50.90 | 28.40 | 0.91 |
| **Wind Range (Degrees)** | 163.50 | 71.90 | 150.90 | 70.90 | 0.01 |

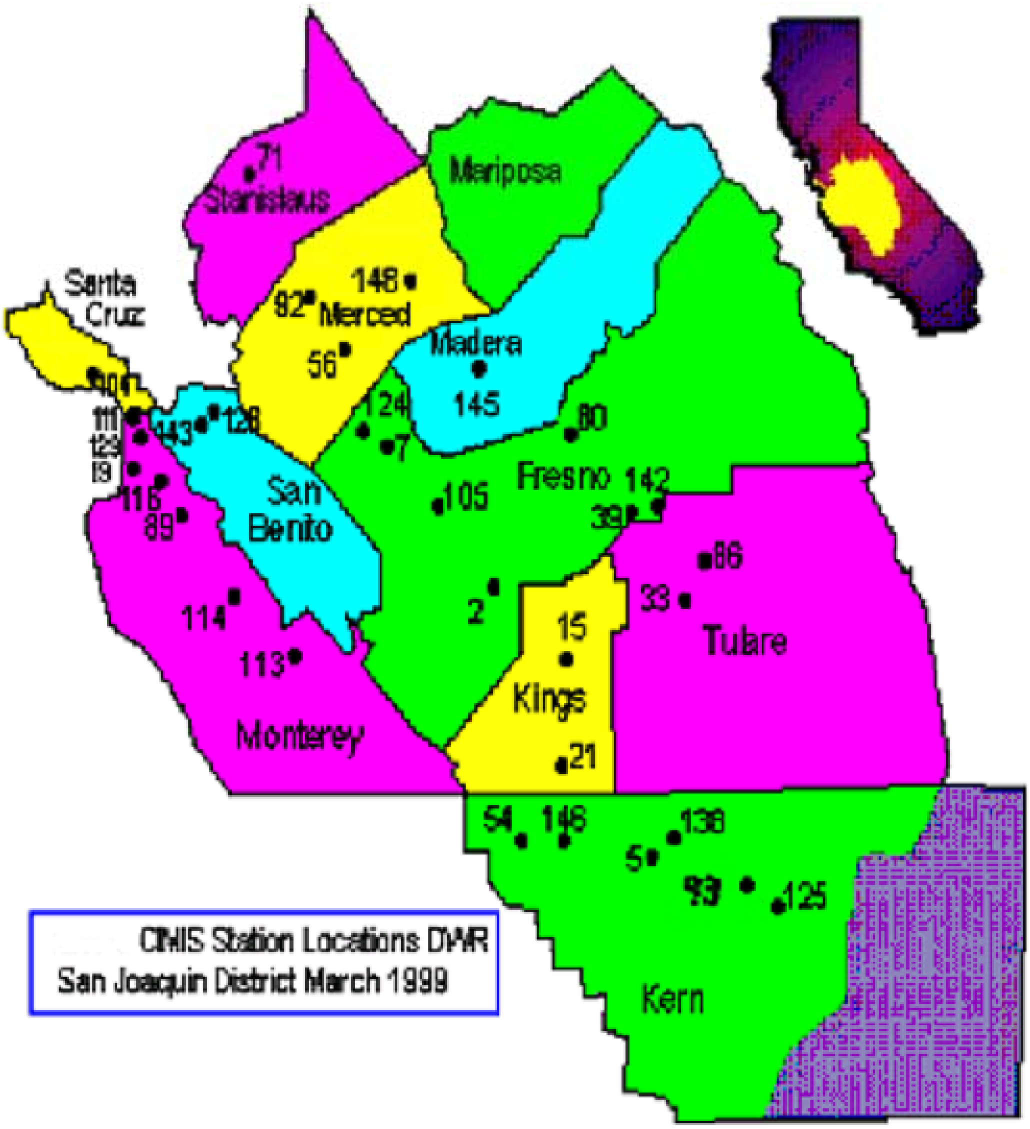



**Figure 4.1**. Graphic modified from CIMIS web site to show station 93 in Kern.

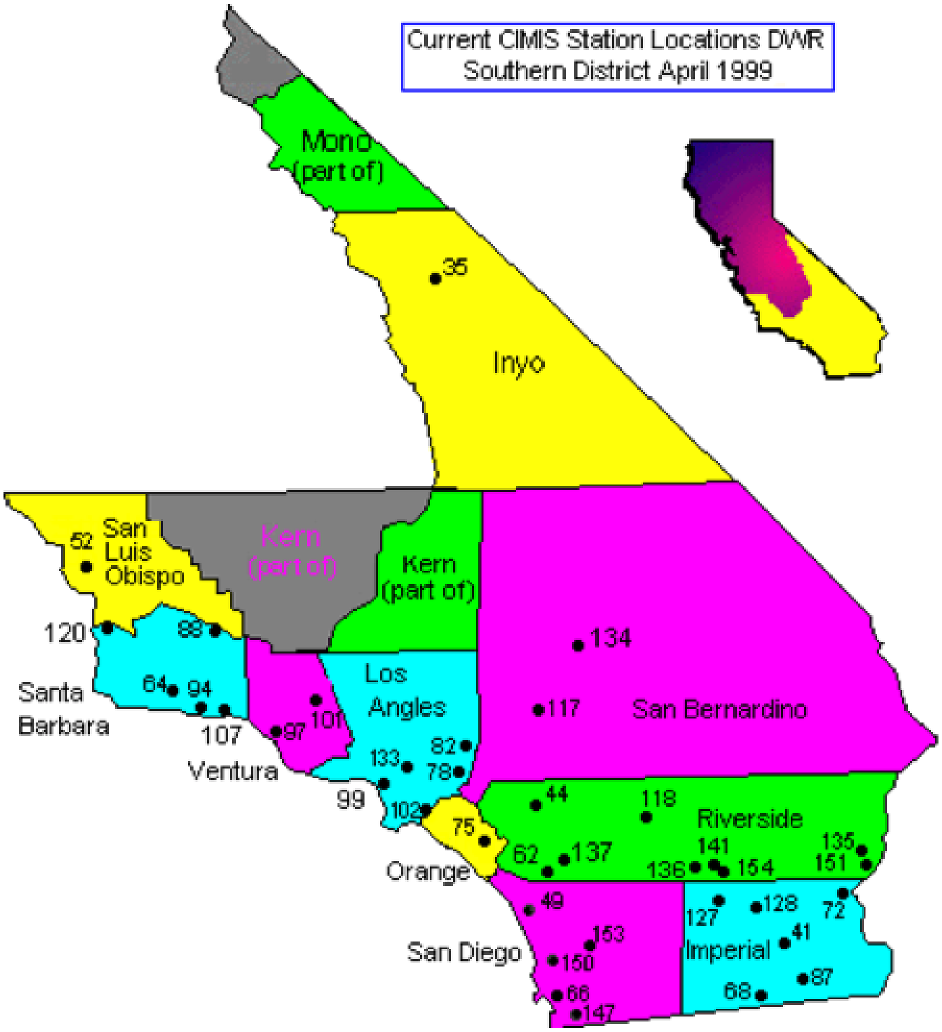



**Figure 4.2.**. Location of CIMIS stations in the southern district.

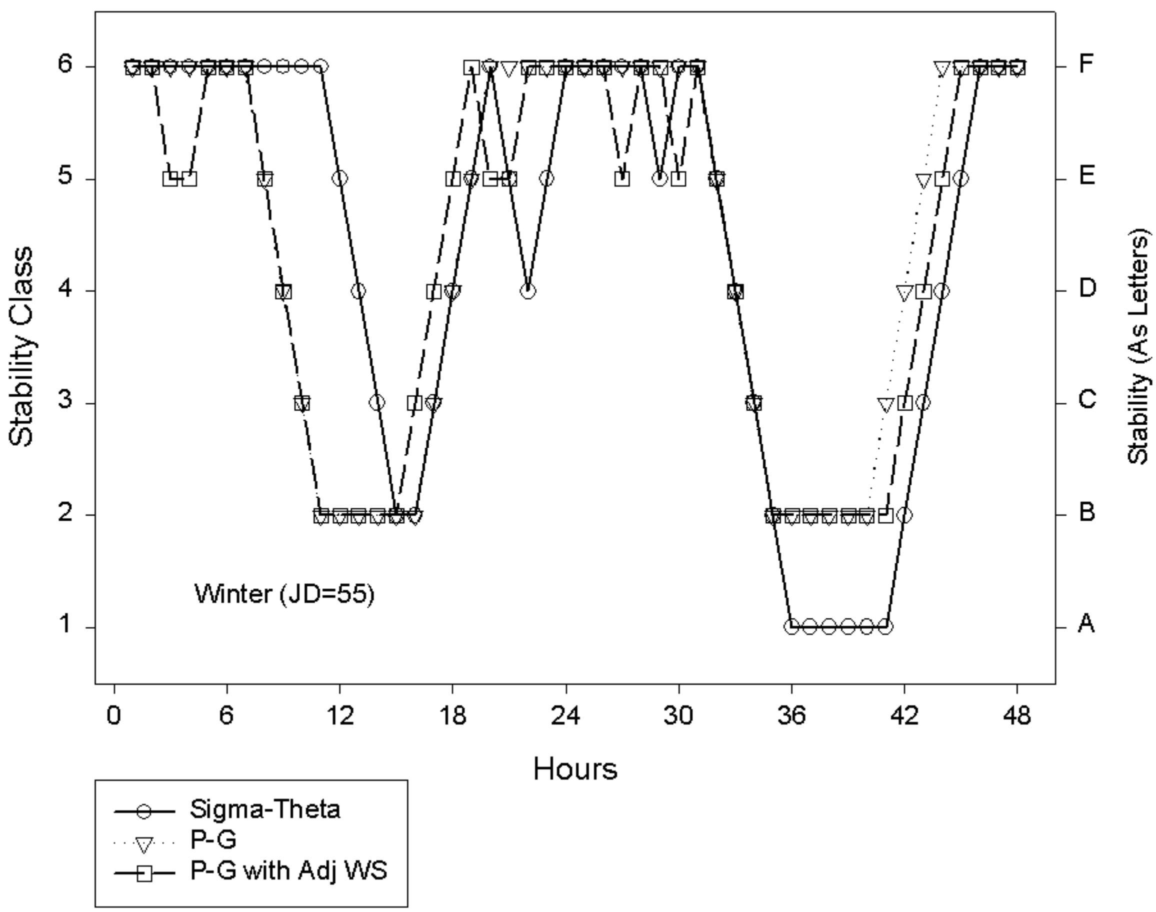



Figure 4.3A Winter stability class comparison.

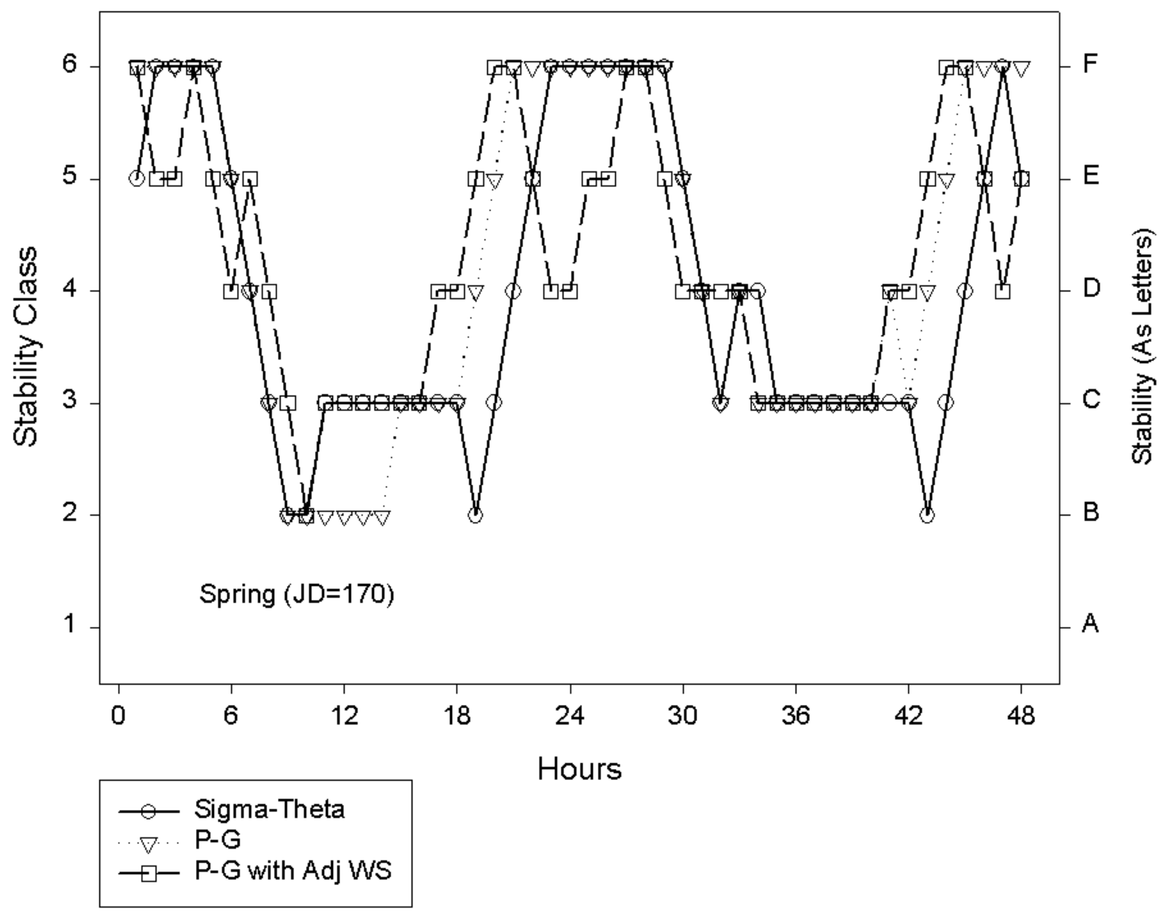



Figure 4.3B. Spring stability class comparison.

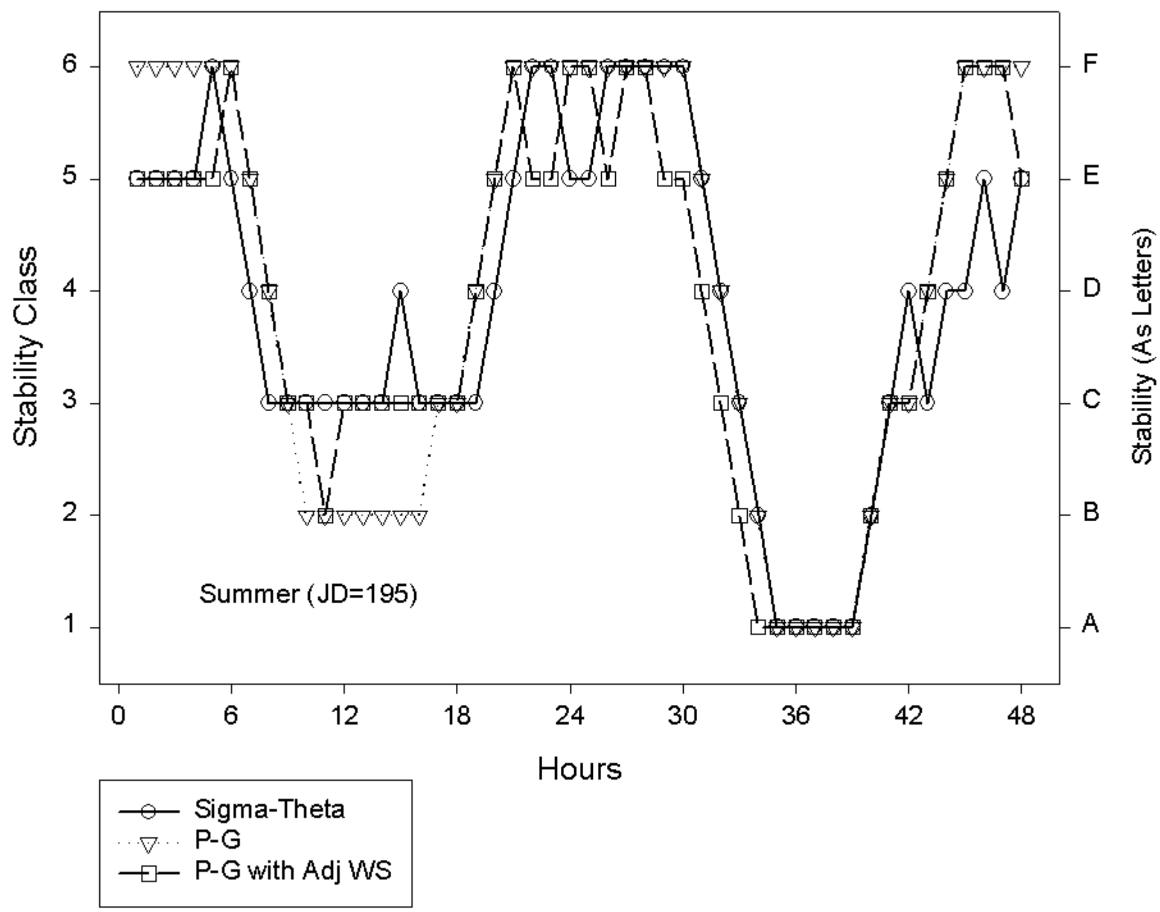



Figure 4.3C. Summer stability class comparison.

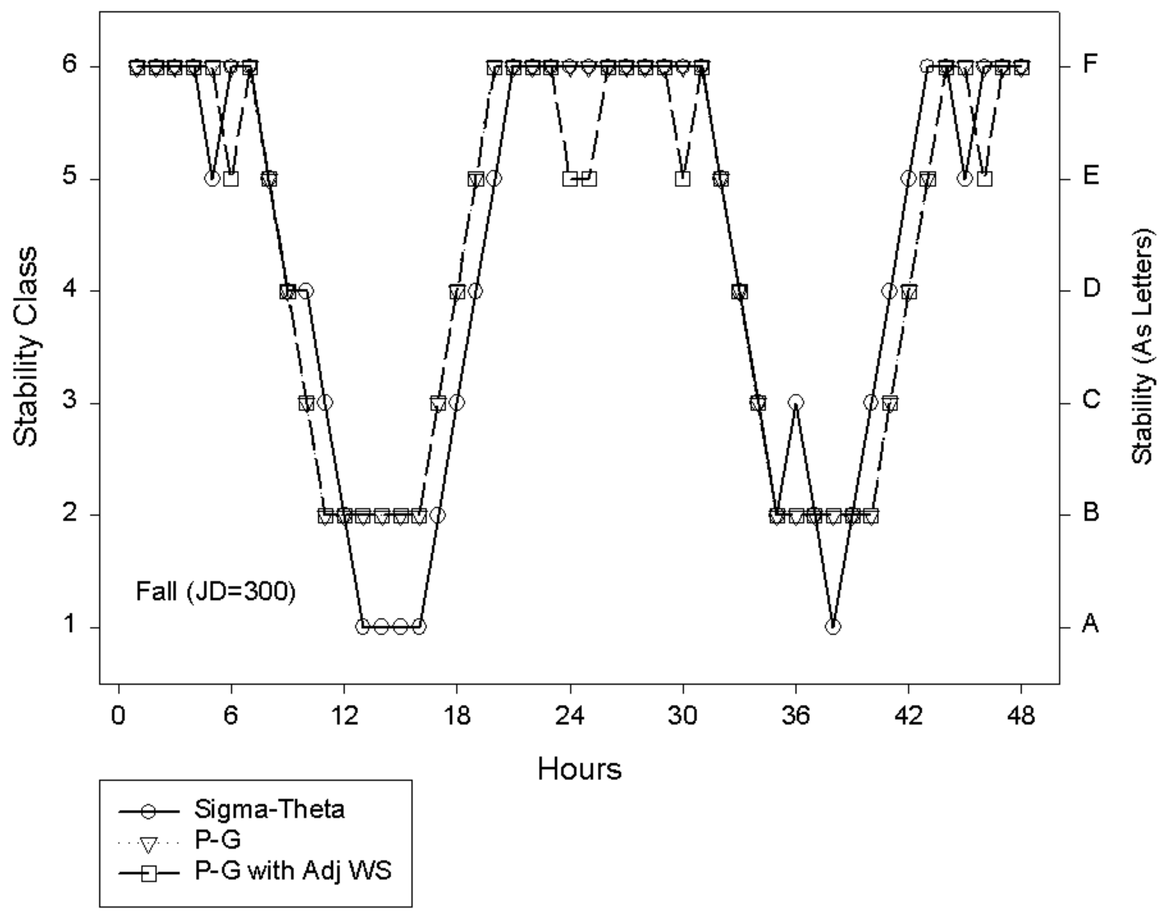



Figure 4.3D. Fall stability class comparison.

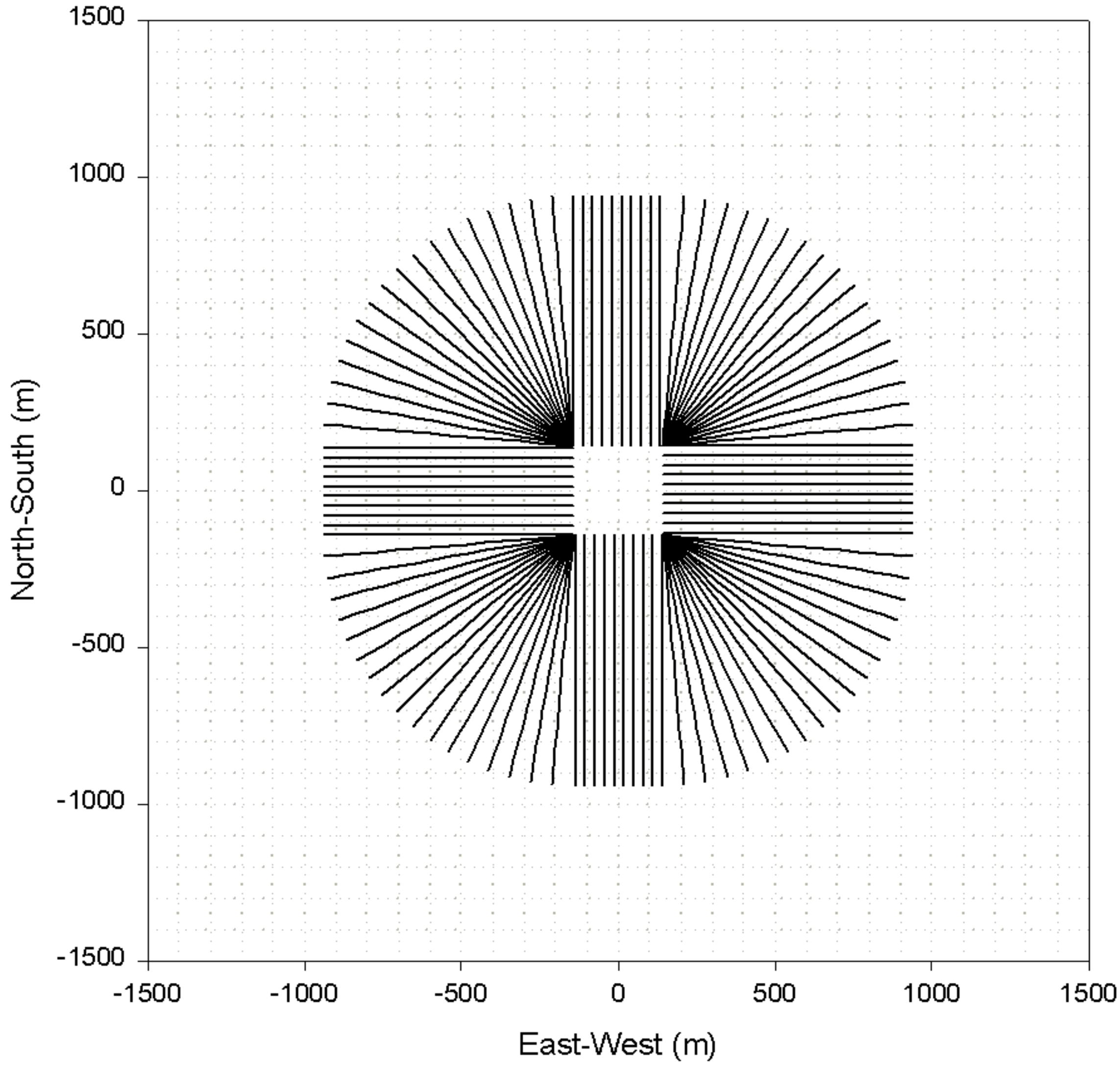



Figure 4.4. Transect construction plan. In this diagram, density of transects perpendicular to sides is one-half the density used in the simulation for illustration purposes.

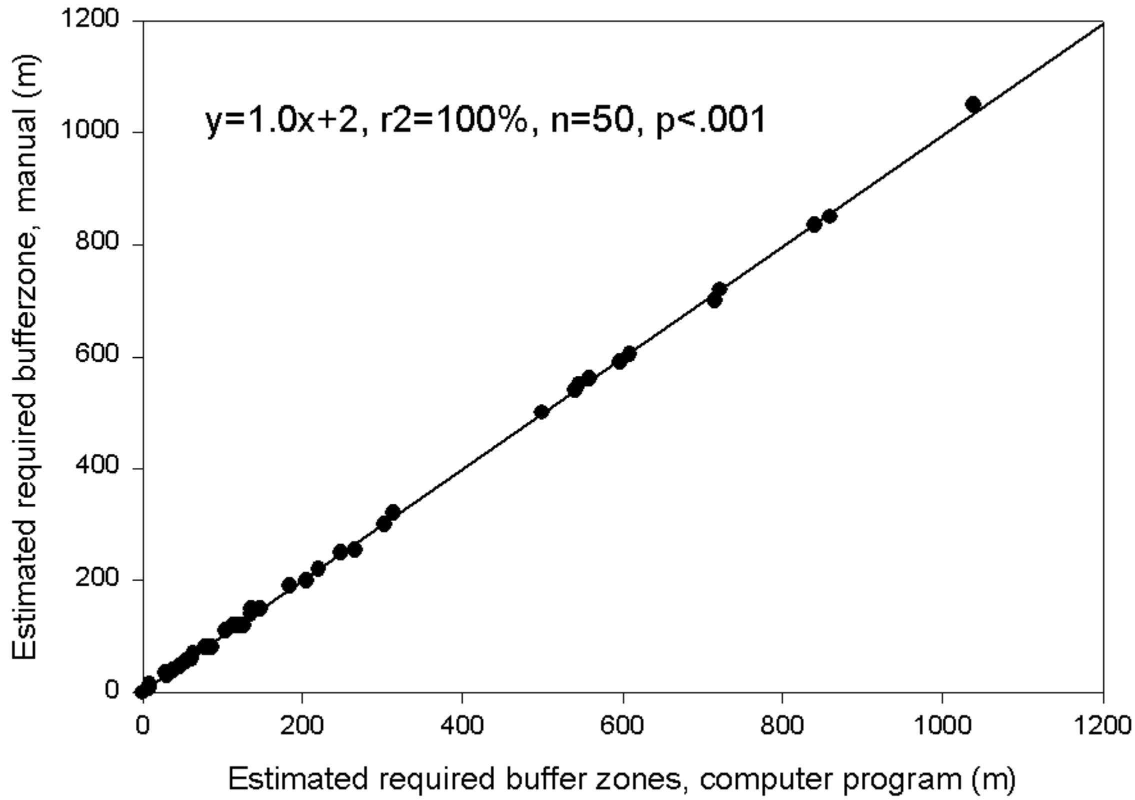



Figure 5.1.1. Comparison of manually derived daily required buffer zones to those derived automatically by computer programs. Line shown is regression line.

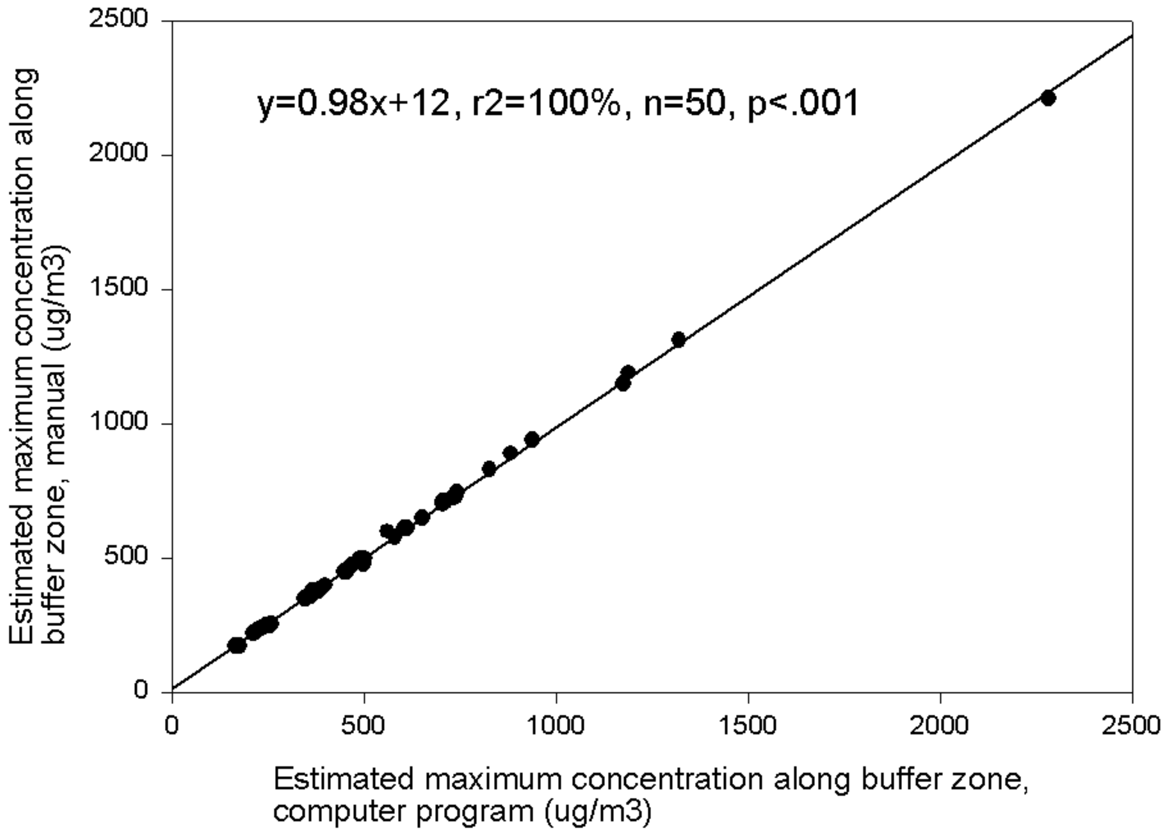



Figure 5.1.2. Comparison of manually derived maximum concentration along buffer zone to estimate derived by computer programs. Line shown is regression line.

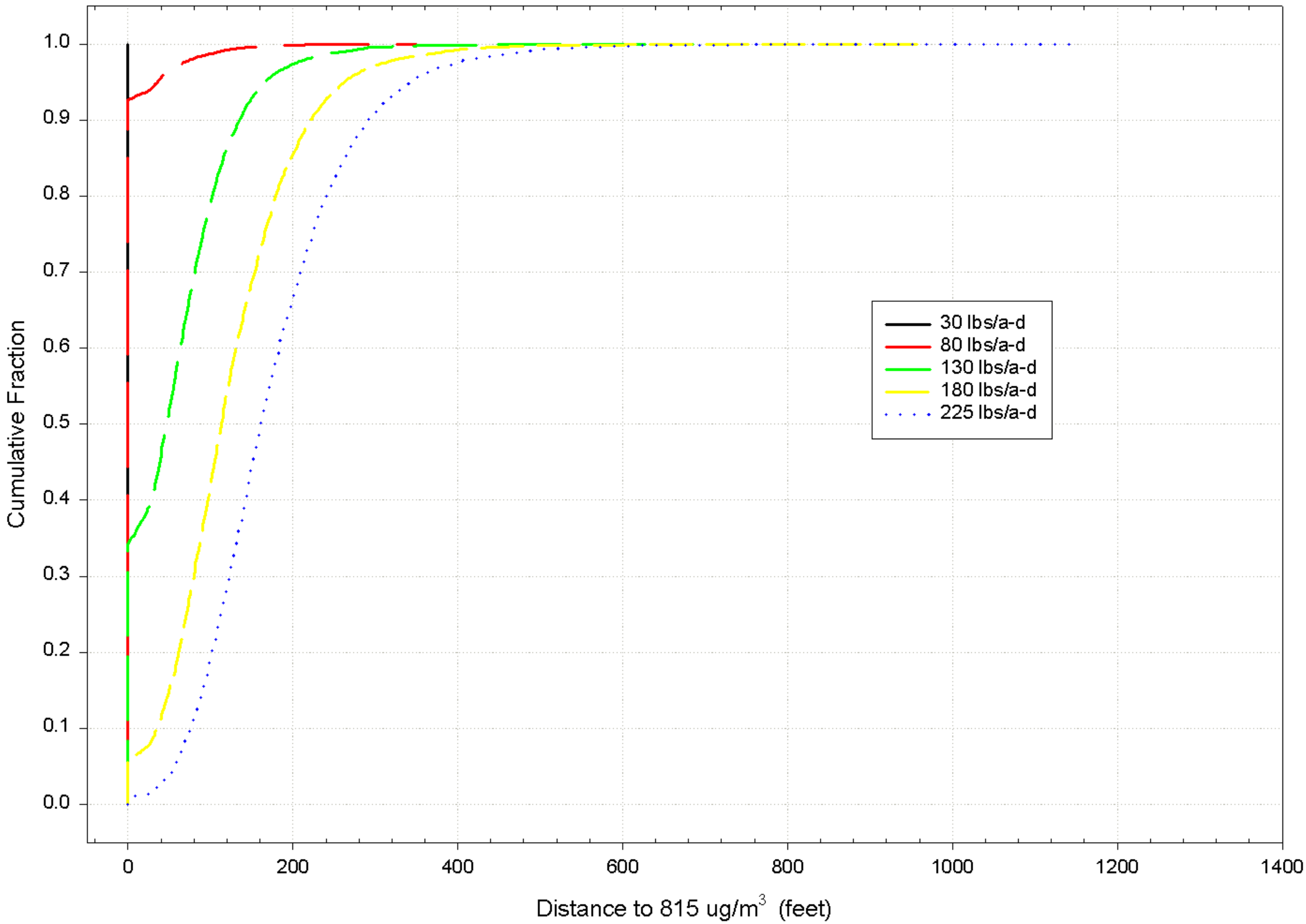



Figure 5.2.1. Cumulative distribution of daily maximum distance to 815 ug/m3 for 1 acre plot.

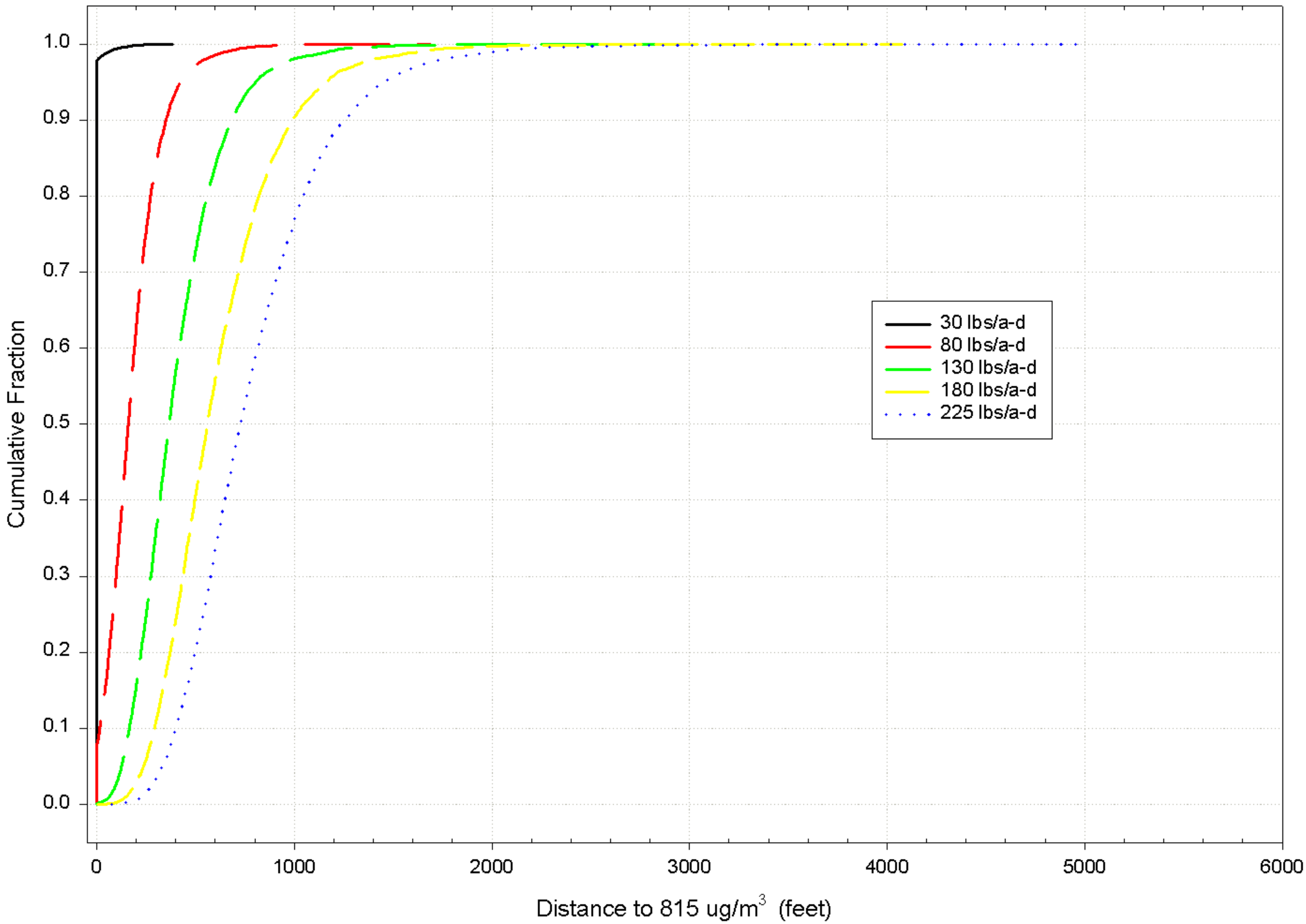



Figure 5.2.2. Cumulative distribution of daily maximum distance to 815 ug/m3 for 10 acre plot.

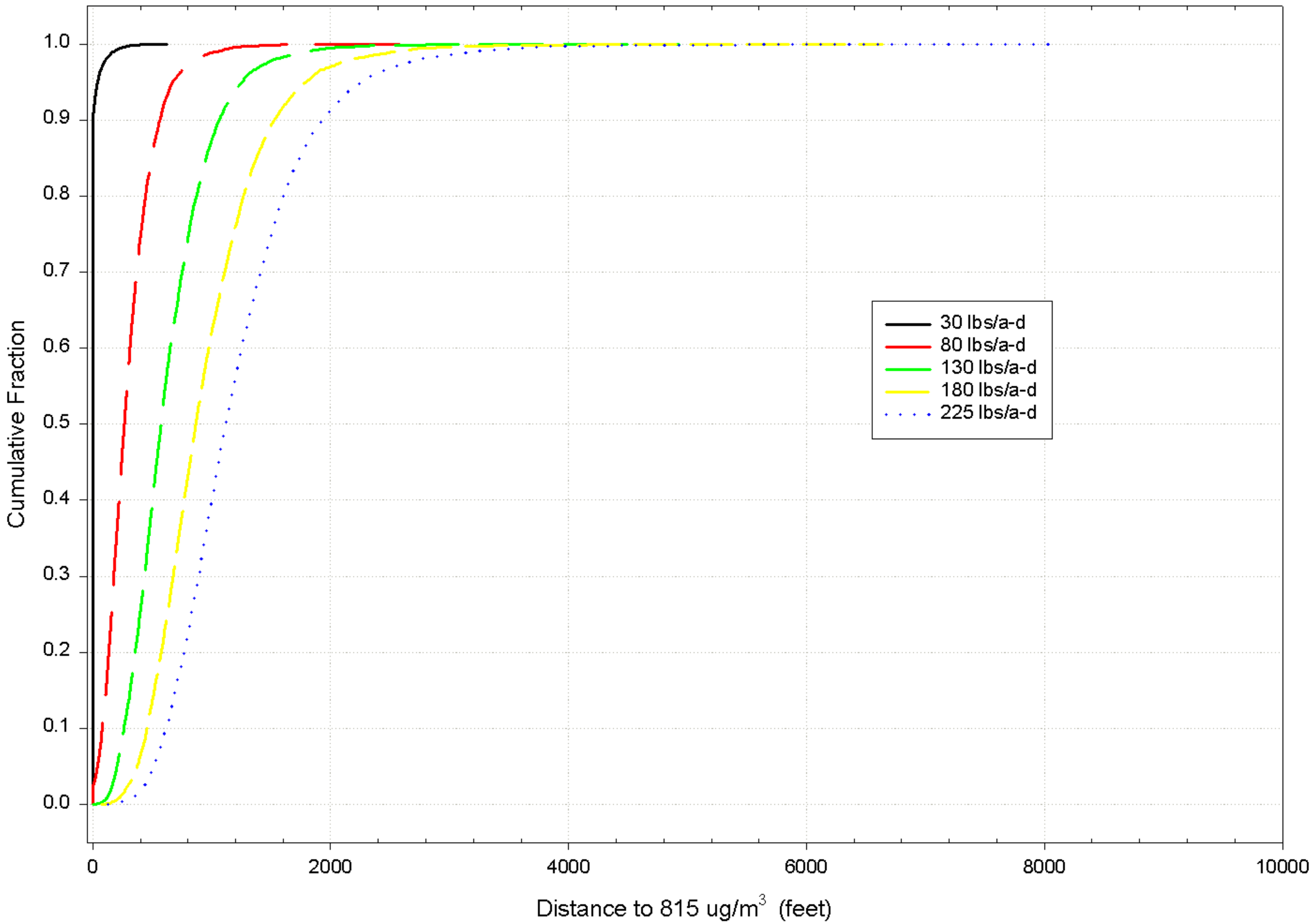



Figure 5.2.3. Cumulative distribution of daily maximum distance to 815 ug/m3 for 20 acre plot.

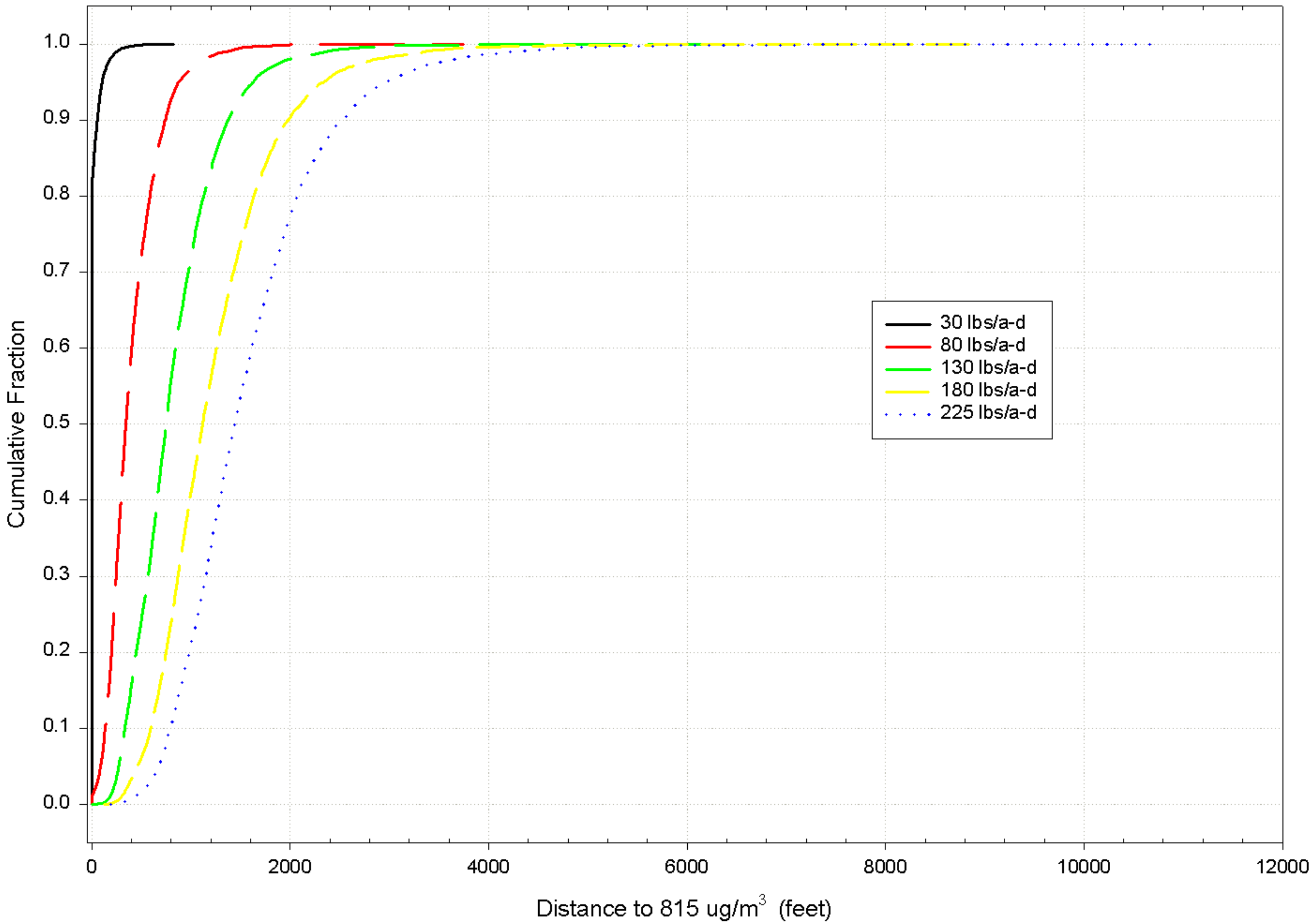



Figure 5.2.4. Cumulative distribution of daily maximum distance to 815 ug/m3 for 30 acre plot.

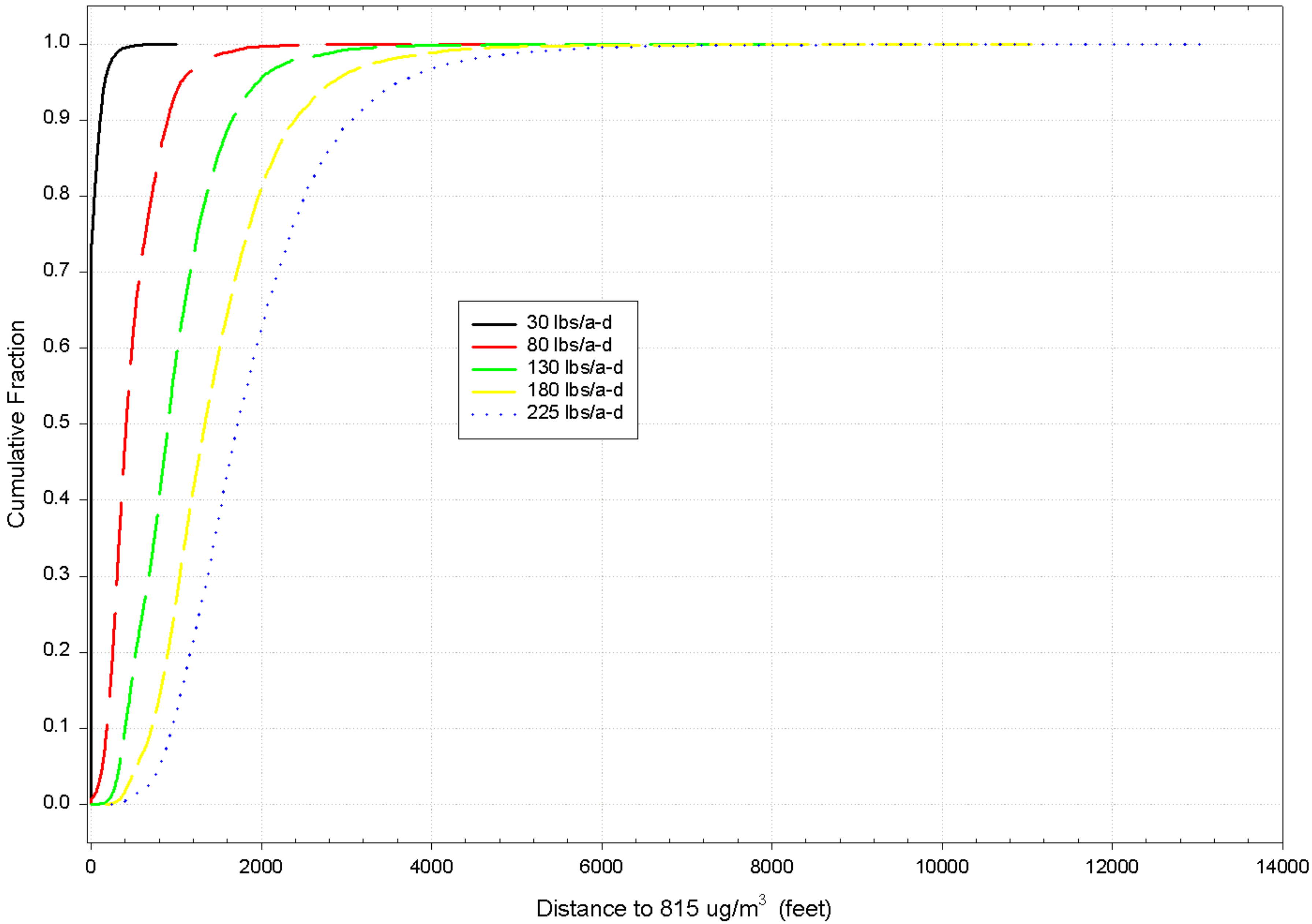



Figure 5.2.5. Cumulative distribution of daily maximum distance to 815 ug/m3 for 40 acre plot.

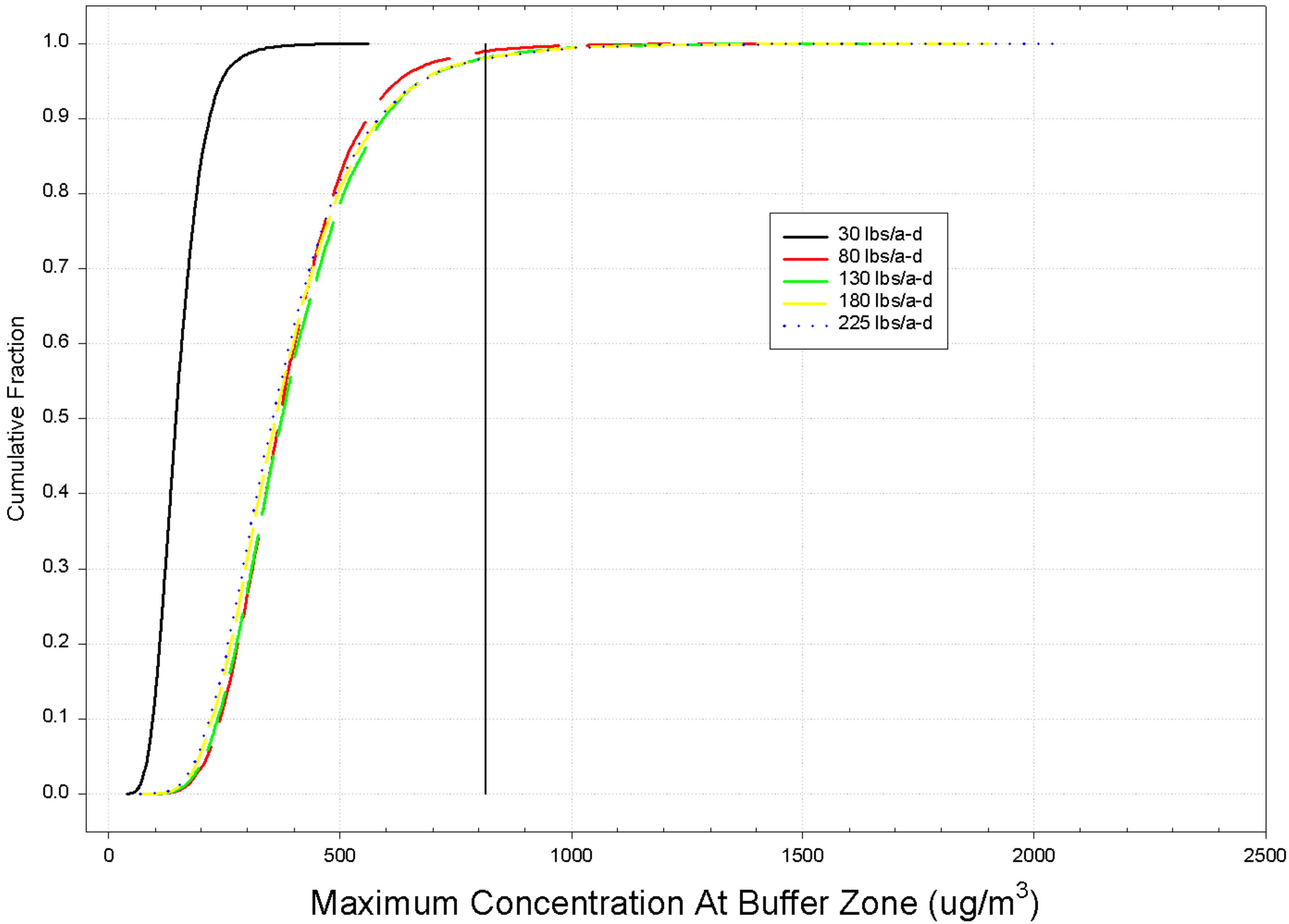



Figure 5.3.1. Cumulative distribution of maximum daily concentration along buffer zone perimeter for 1 acre plot. Vertical bar is 815 ug/m3.

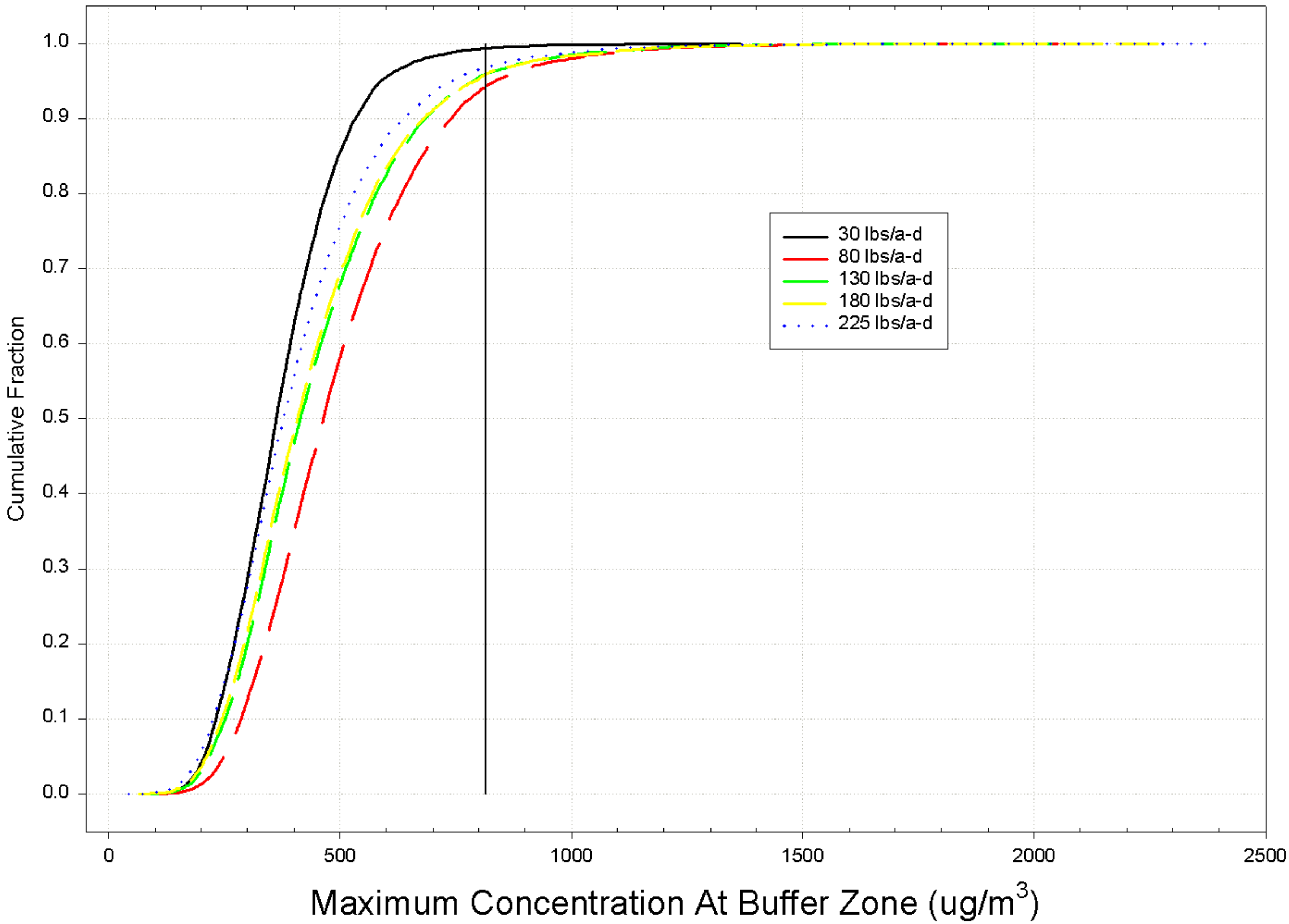



Figure 5.3.2. Cumulative distribution of maximum daily concentration along buffer zone perimeter for 10 acre plot. Vertical bar is 815 ug/m3.

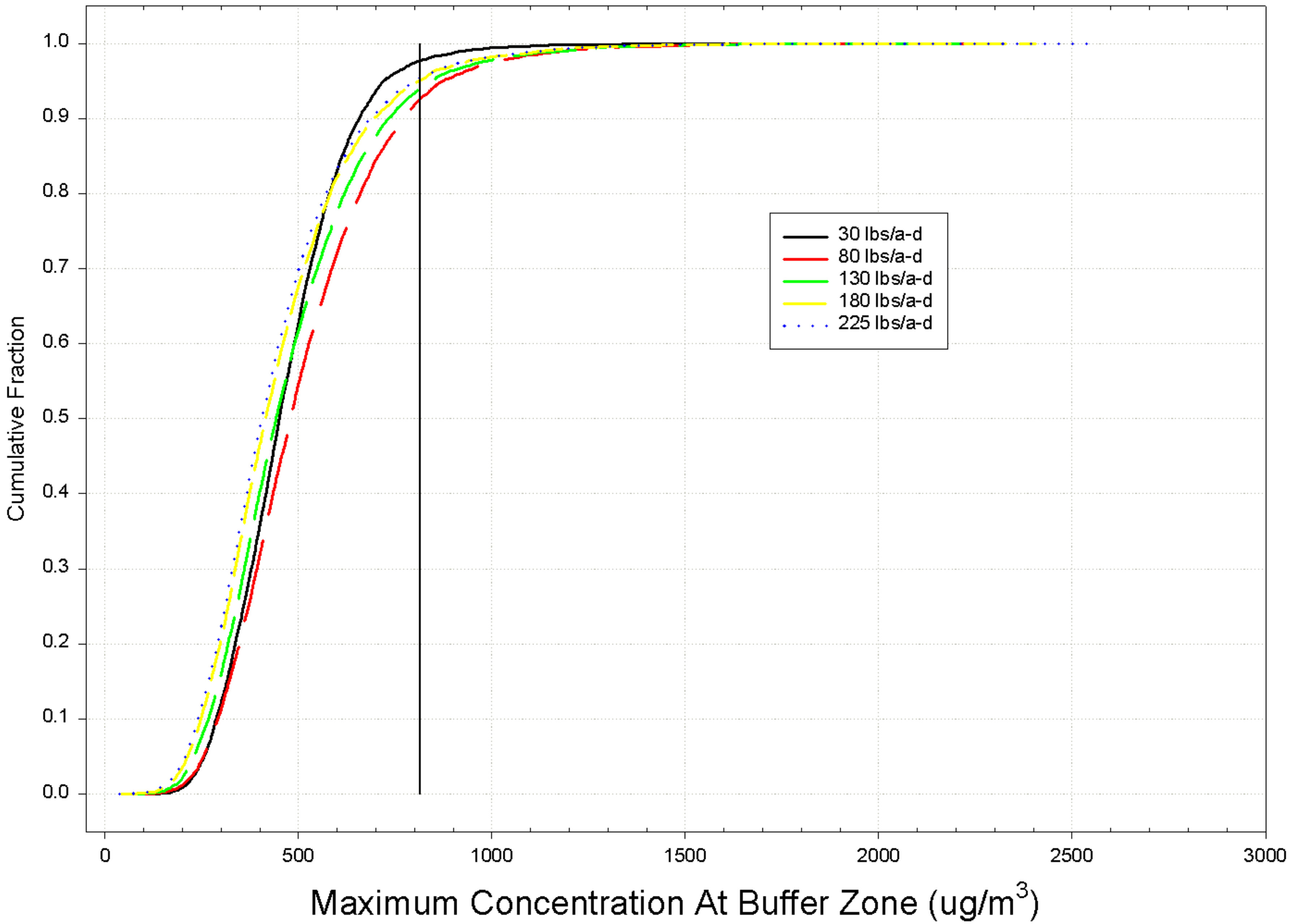



Figure 5.3.3. Cumulative distribution of maximum daily concentration along buffer zone perimeter for 20 acre plot. Vertical bar is 815 ug/m3.

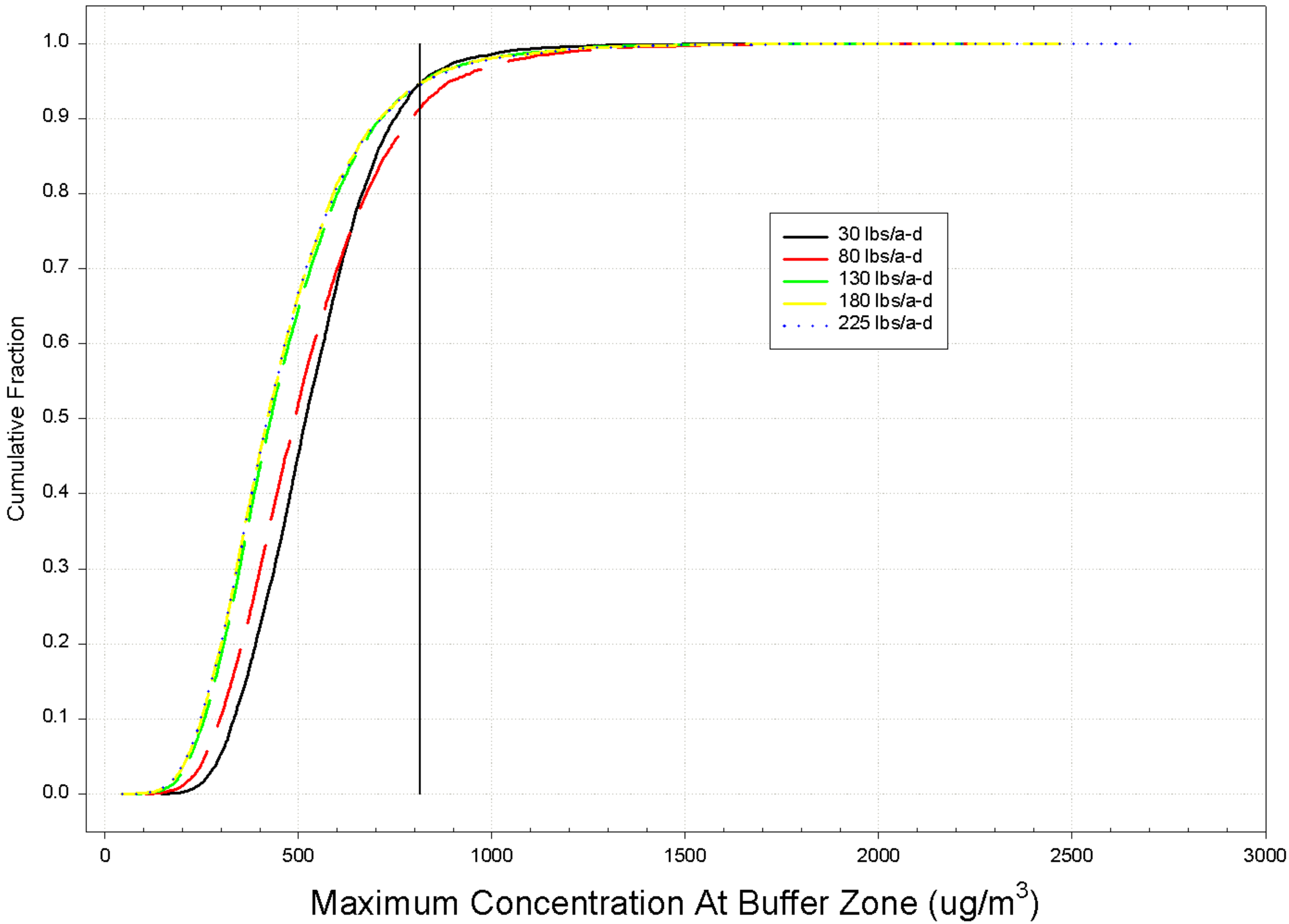



Figure 5.3.4. Cumulative distribution of maximum daily concentration along buffer zone perimeter for 30 acre plot. Vertical bar is 815 ug/m3.

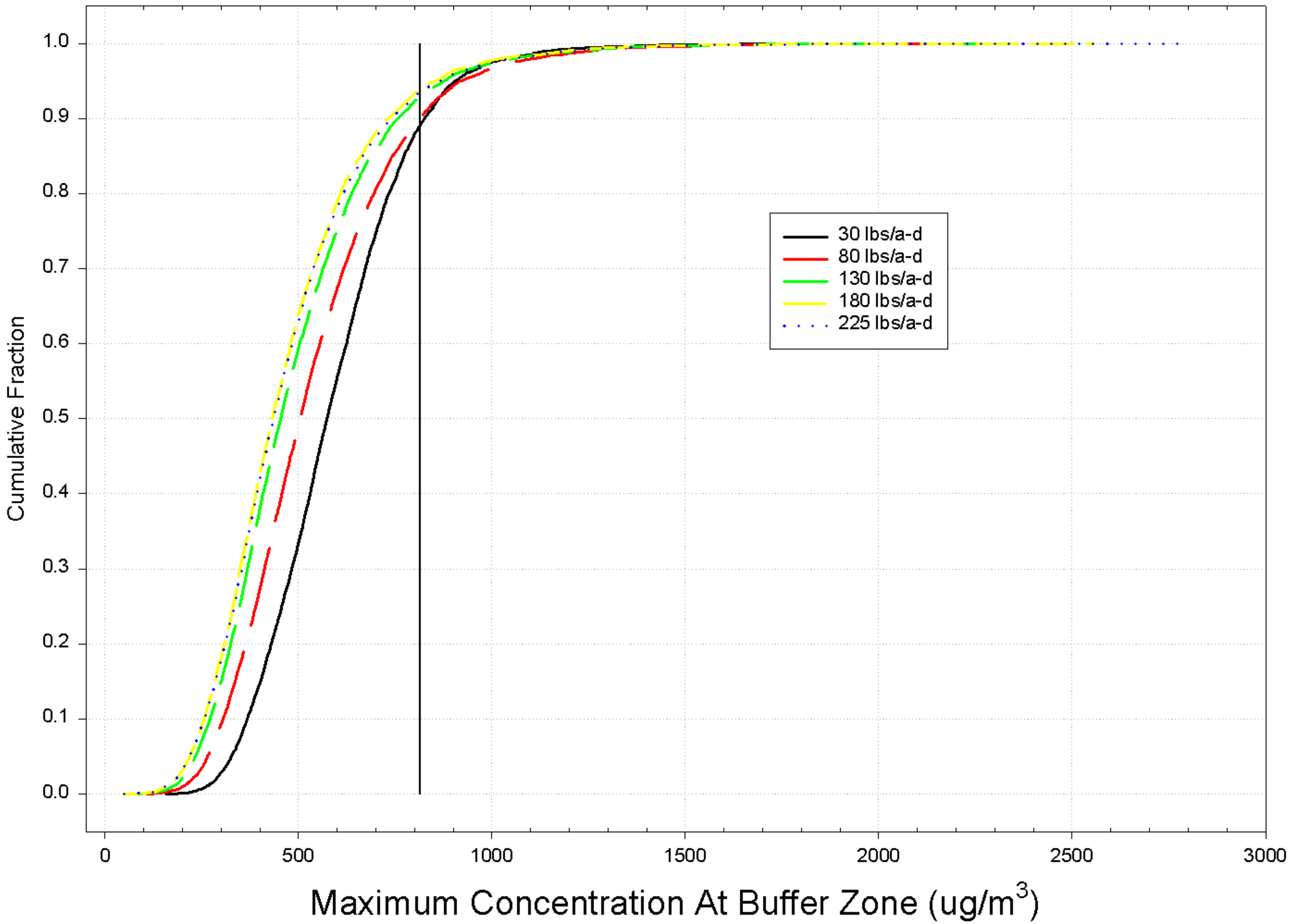



Figure 5.3.5. Cumulative distribution of maximum daily concentration along buffer zone perimeter for 40 acre plot. Vertical bar is 815 ug/m3.

Figure 5.3.6. Box and whisker plot for 1 acre maximum concentrations at buffer zone distance See text for explanation.

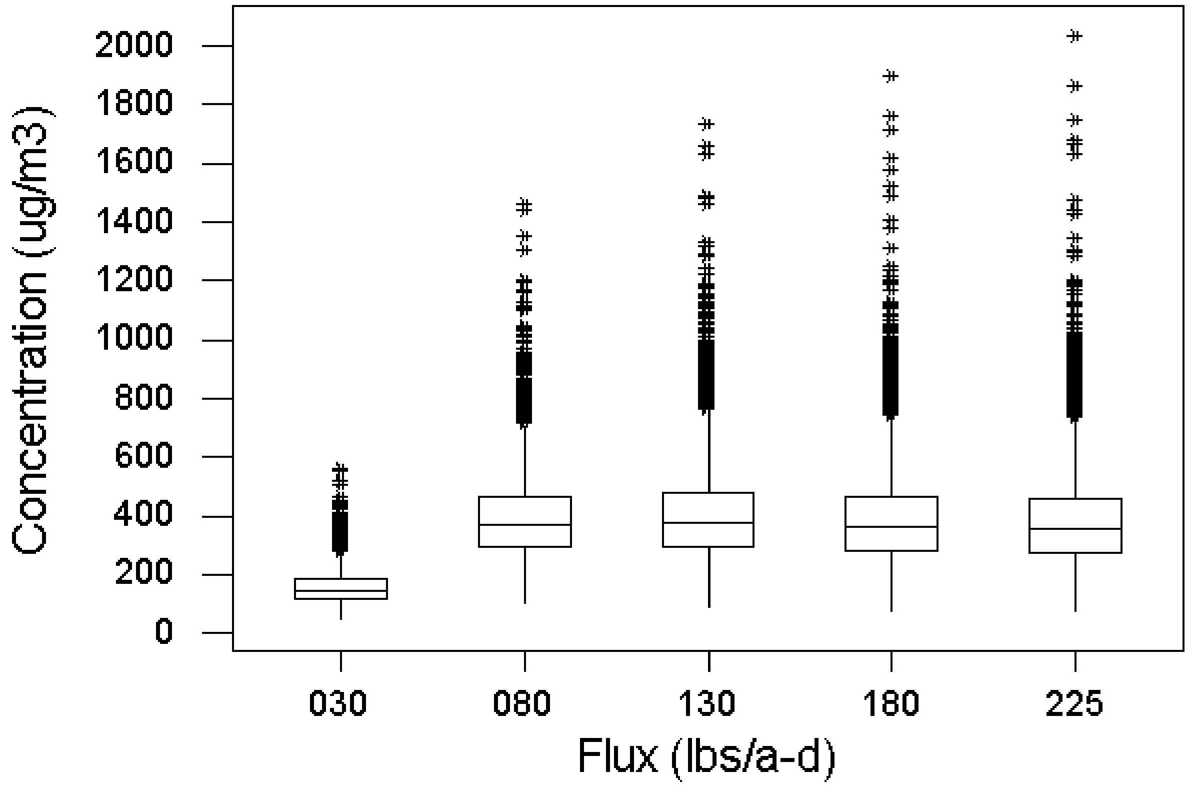


Figure 5.3.7. Box and whisker plot for 10 acre maximum concentrations at buffer zone distance. See text for explanation.

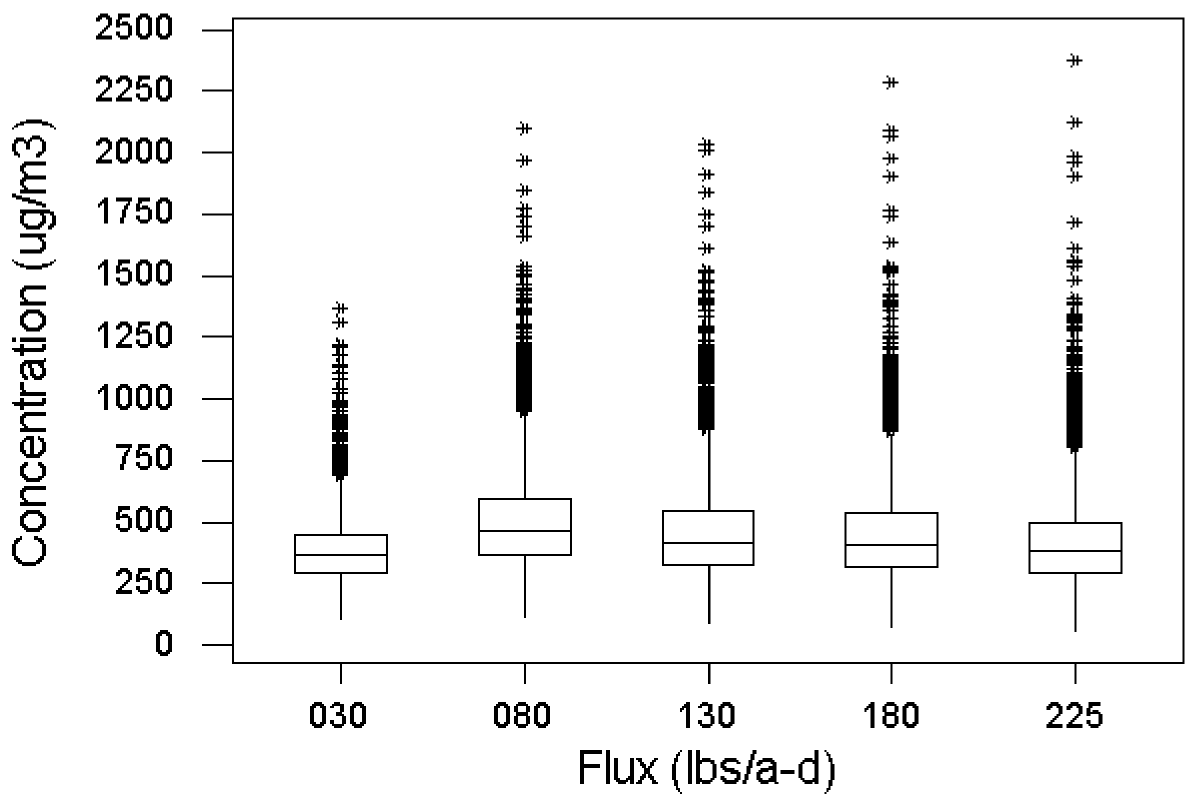


Figure 5.3.8. Box and whisker plot for 20 acre maximum concentration at buffer zone distance. See text for explanation.

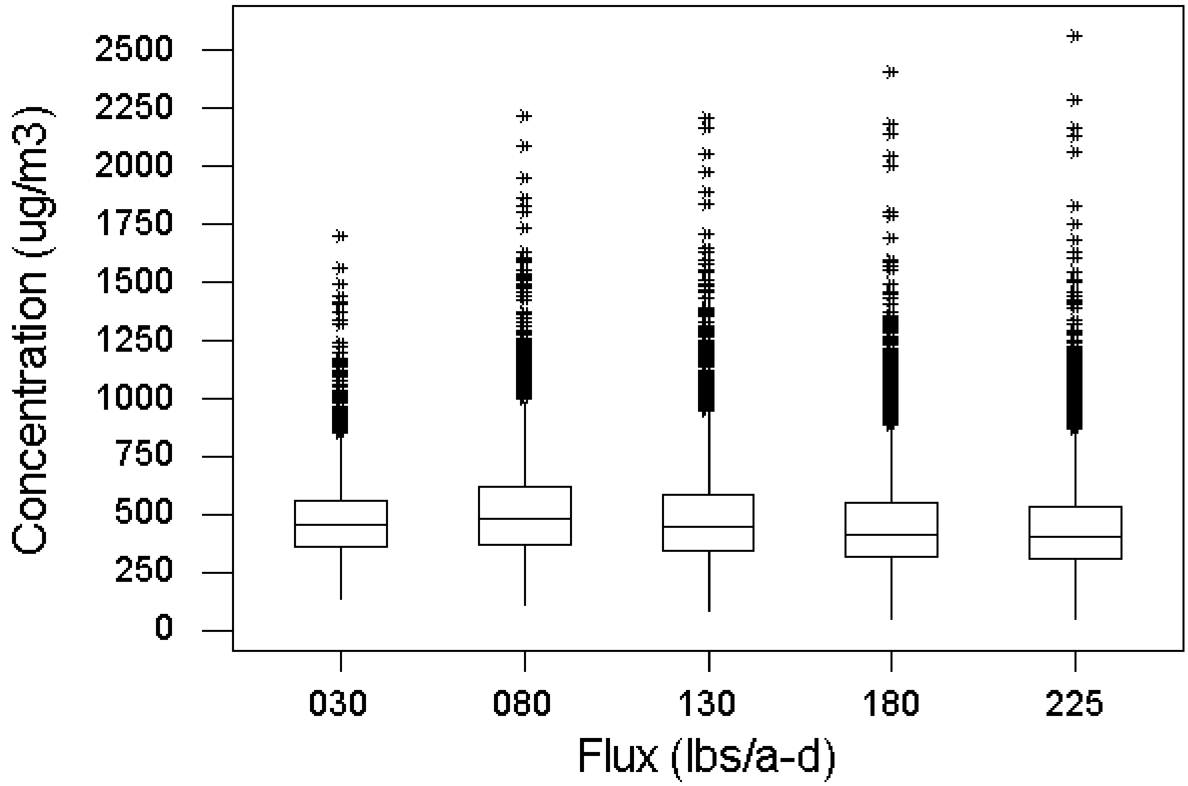


Figure 5.3.9. Box and whisker plot for 30 acre maximum concentration at buffer zone distance. See text for explanation.

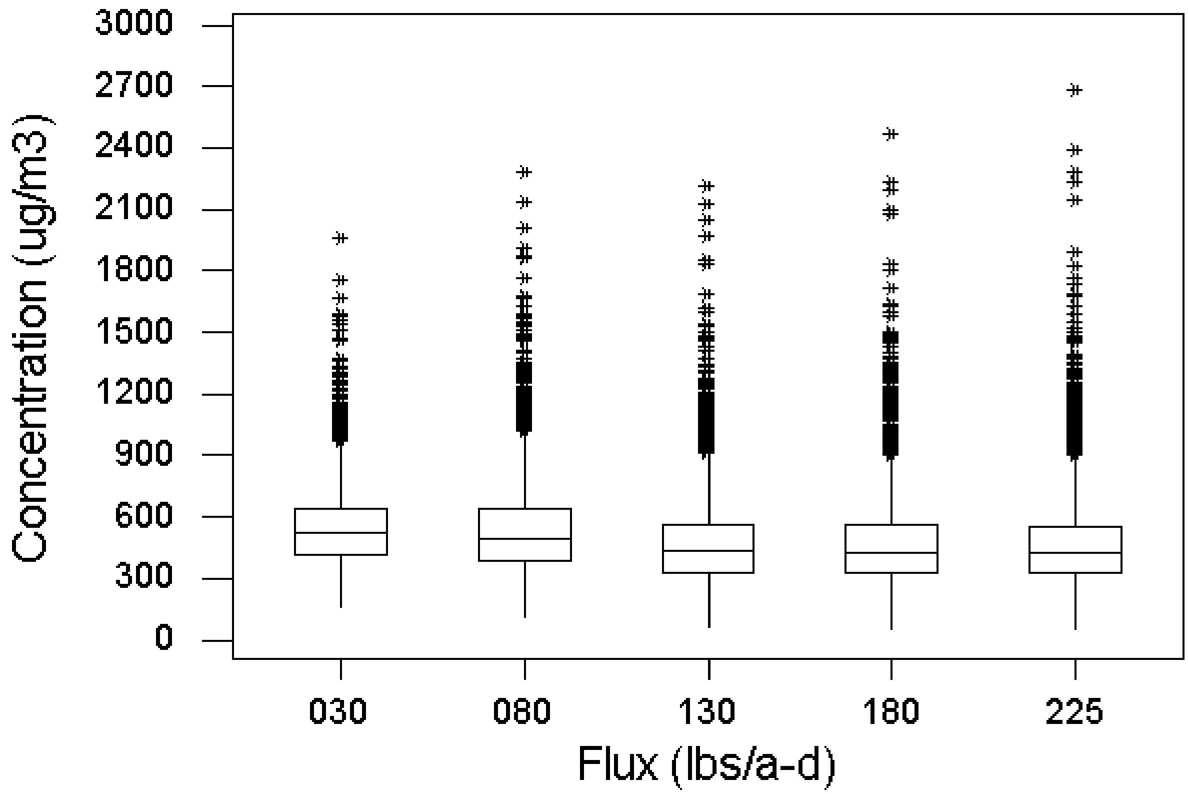
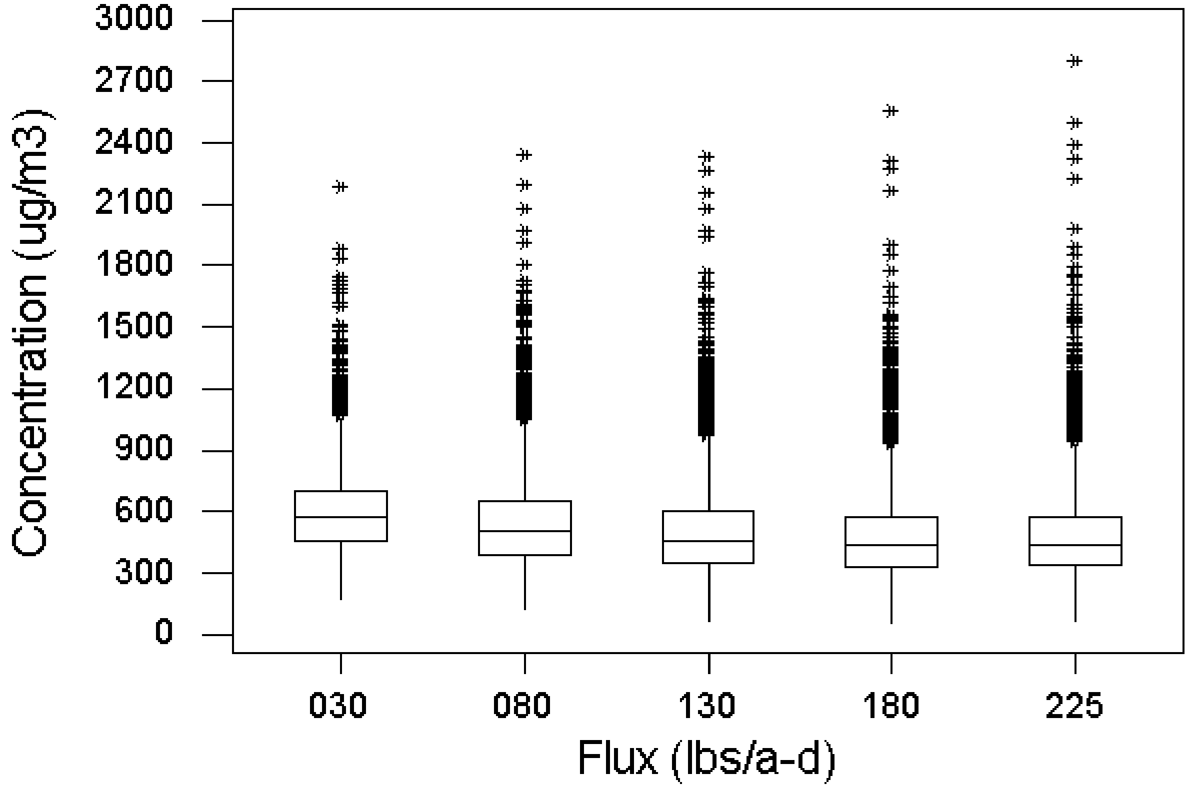


Figure 5.3.10. Box and whisker plot for 40 acre maximum concentration at buffer zone distance. See text for explanation.



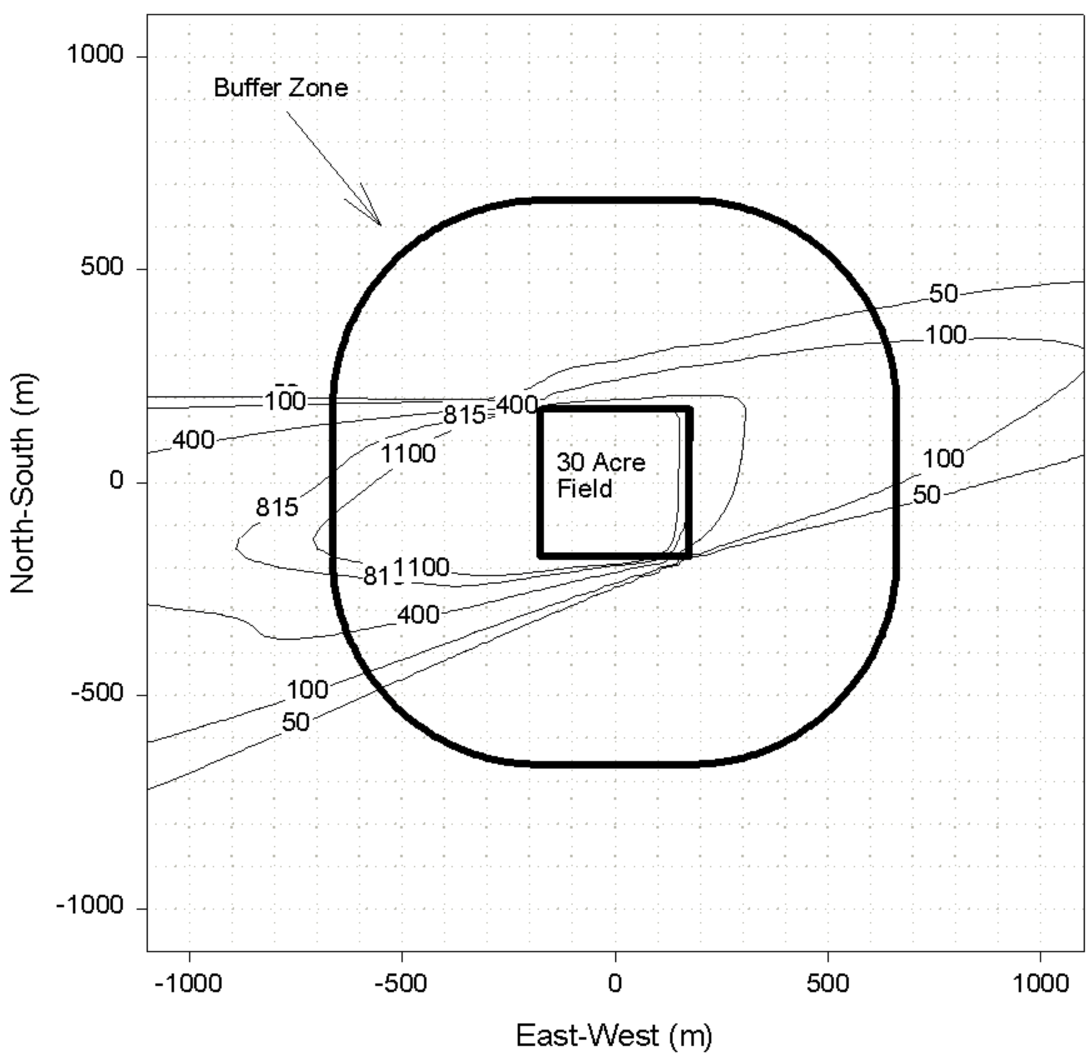



Figure 5.3.11. Example run from validation test. 30 acre field with 130 lbs/a-d flux. Meteorological data from Station 101 (Ventura), Julian Day 316, 1997. Length of field side is 348.4m. Buffer zone distance is 488m. Concentration isopleths in ug/m3. Interior square is field. Exterior shape is buffer zone. Portion of buffer zone along western edge in plume where concentration is greater than 815 ug/m3 is 242m in length.

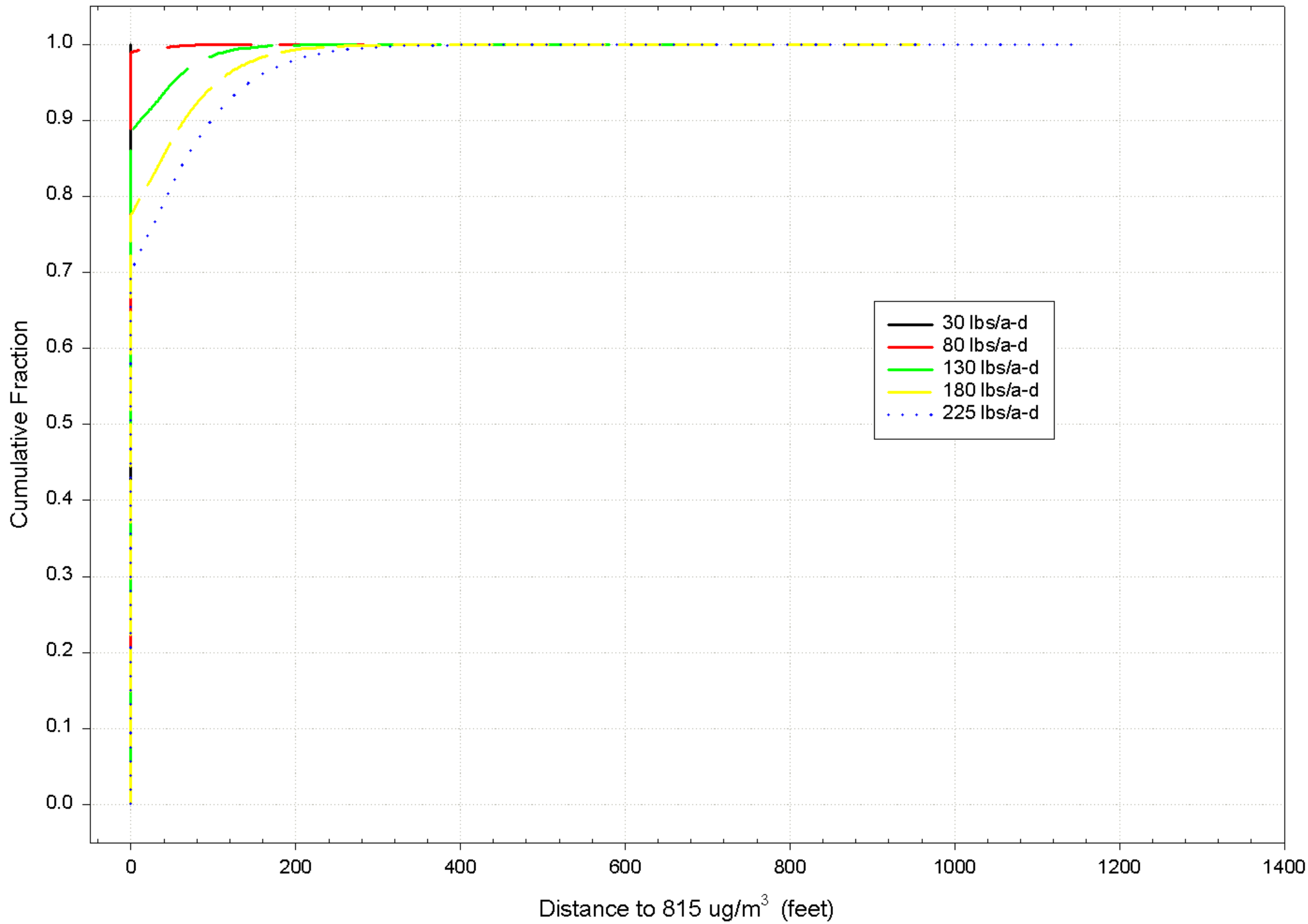



Figure 5.4.1. Cumulative distribution of daily distance over all directions to 815 ug/m3 for 1 acre plot.

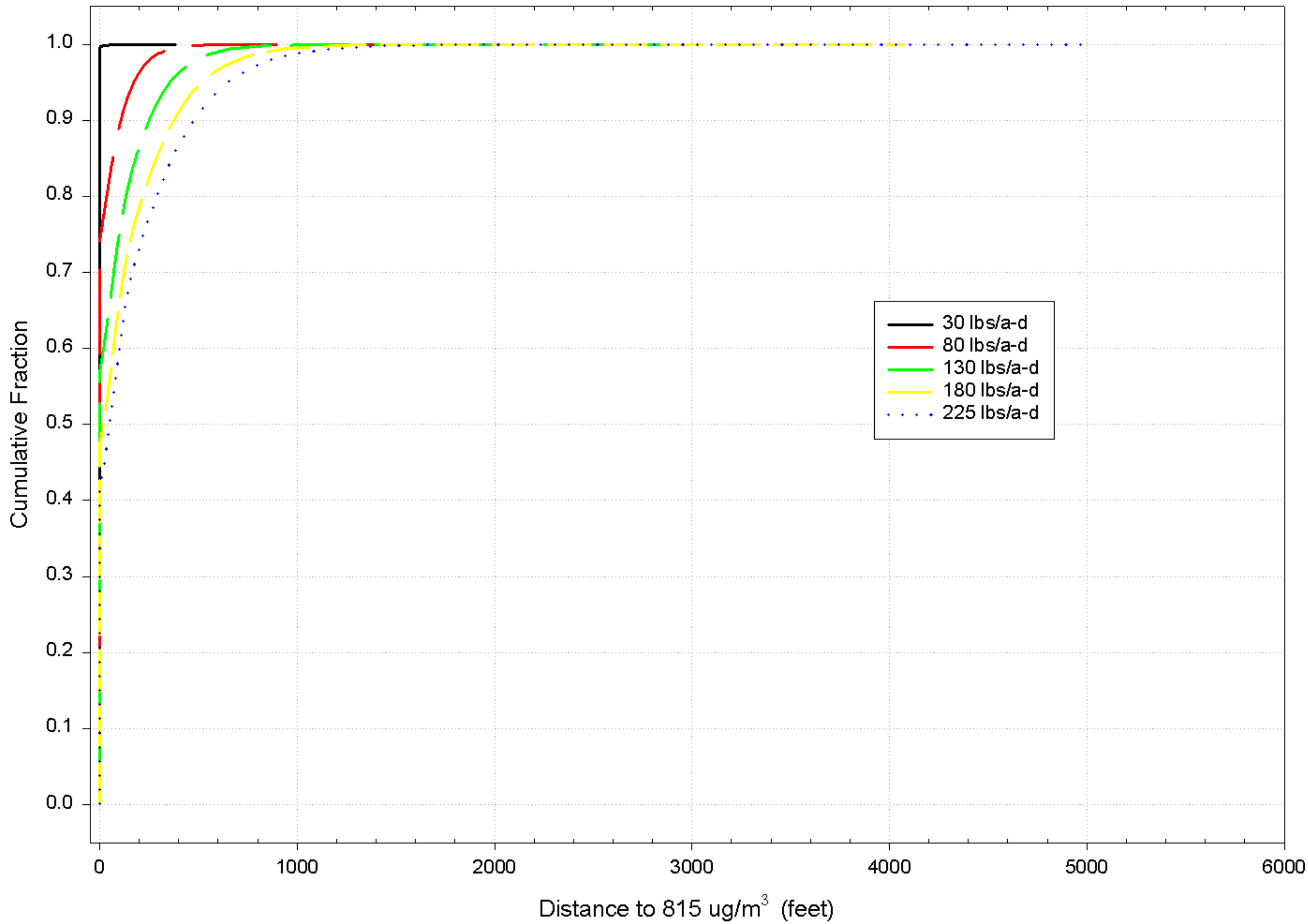



Figure 5.4.2. Cumulative distribution of daily distance over all directions to 815 ug/m3 for 10 acre plot.

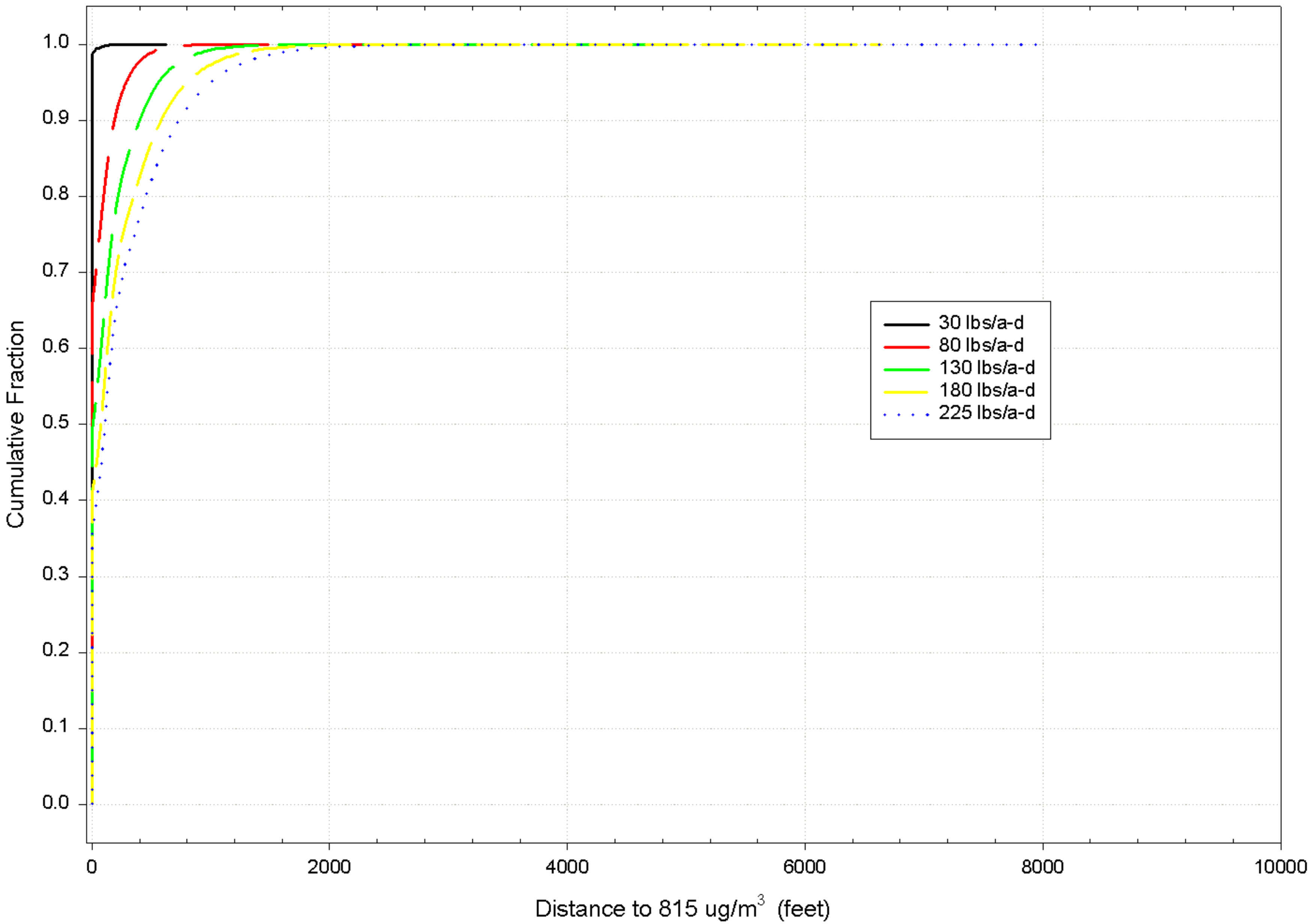



Figure 5.4.3. Cumulative distribution of daily distance over all directions to 815 ug/m3 for 20 acre plot.

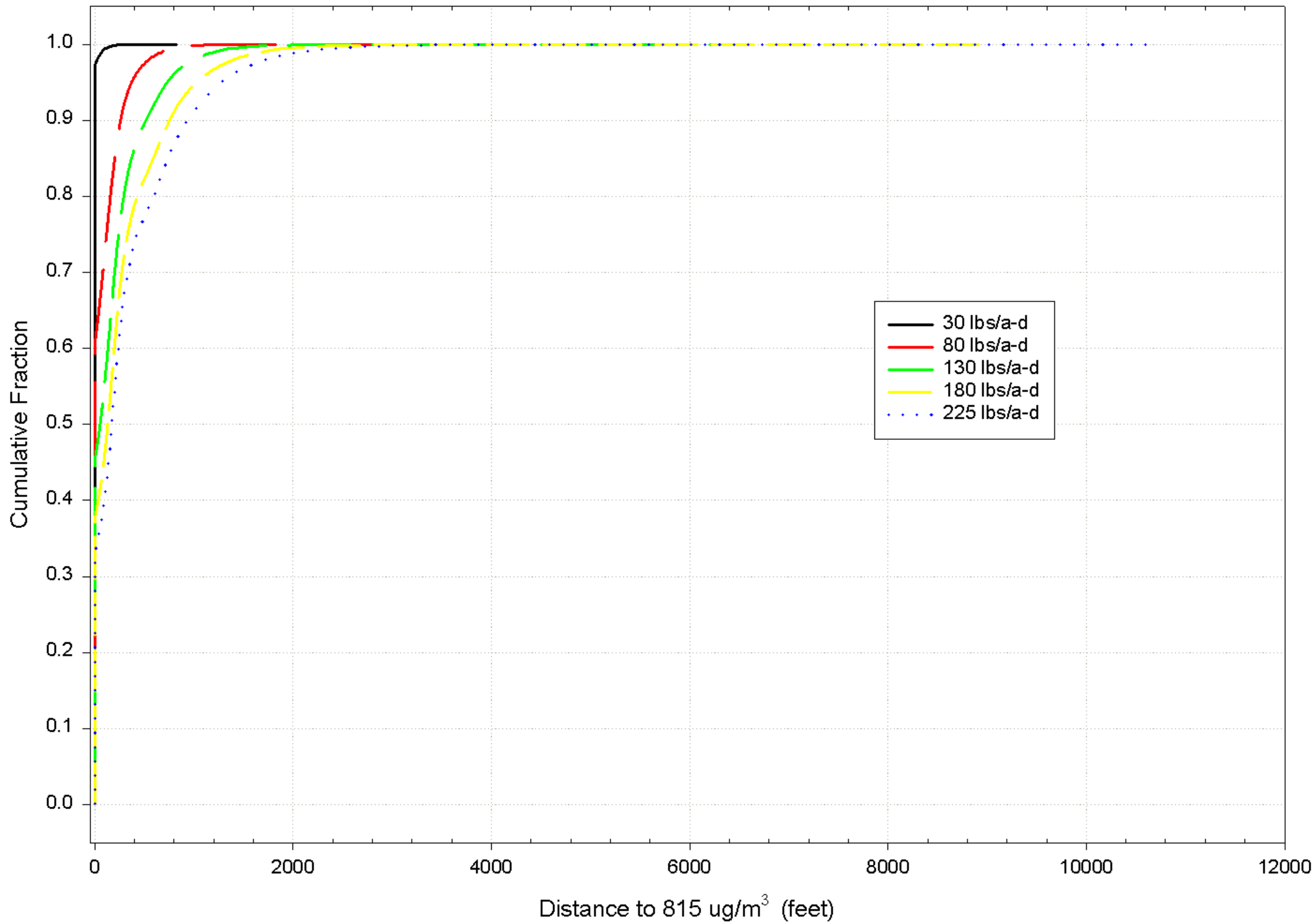



Figure 5.4.4. Cumulative distribution of daily distance over all directions to 815 ug/m3 for 30 acre plot.

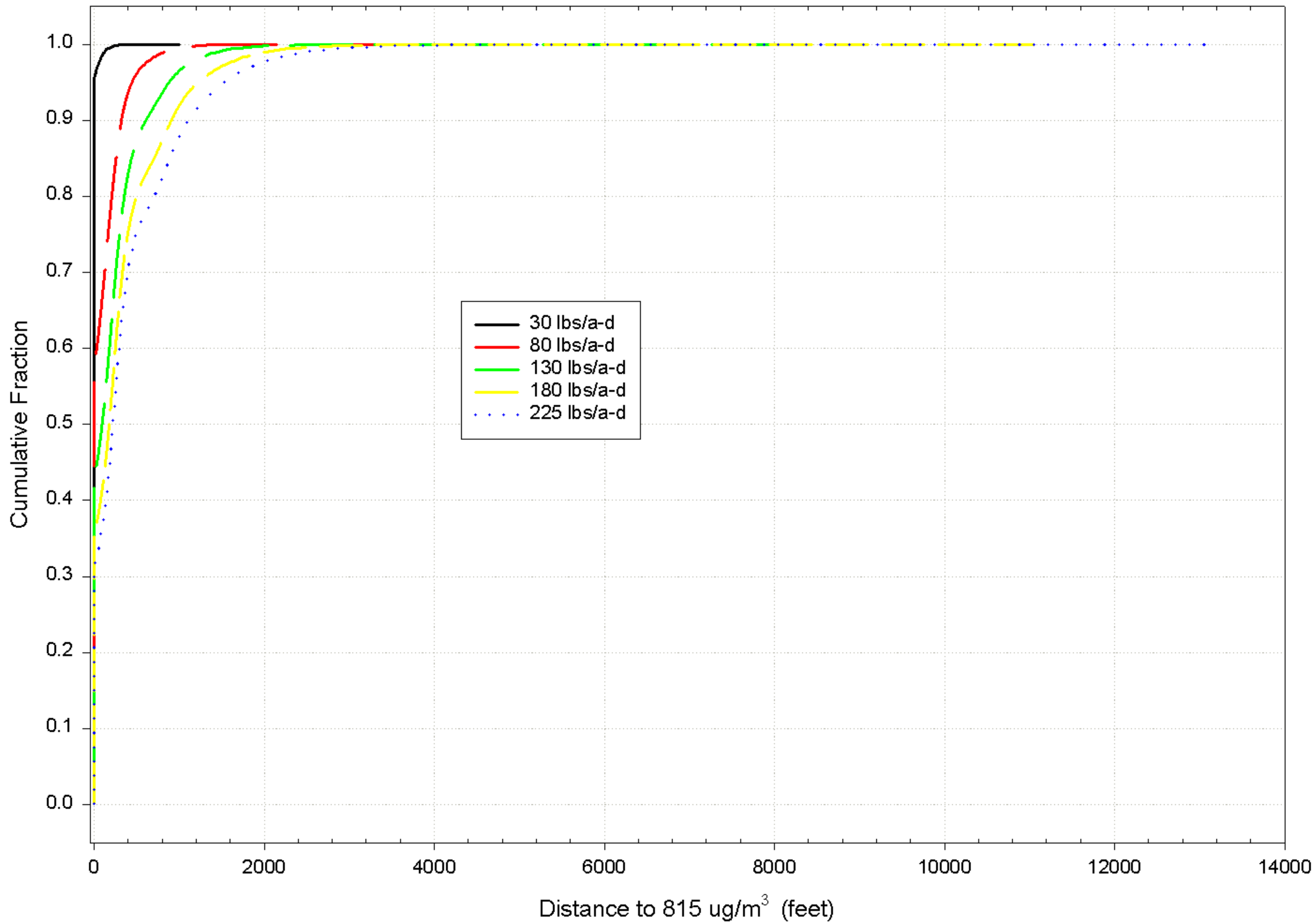



Figure 5.4.5. Cumulative distribution of daily distance over all directions to 815 ug/m3 for 40 acre plot.

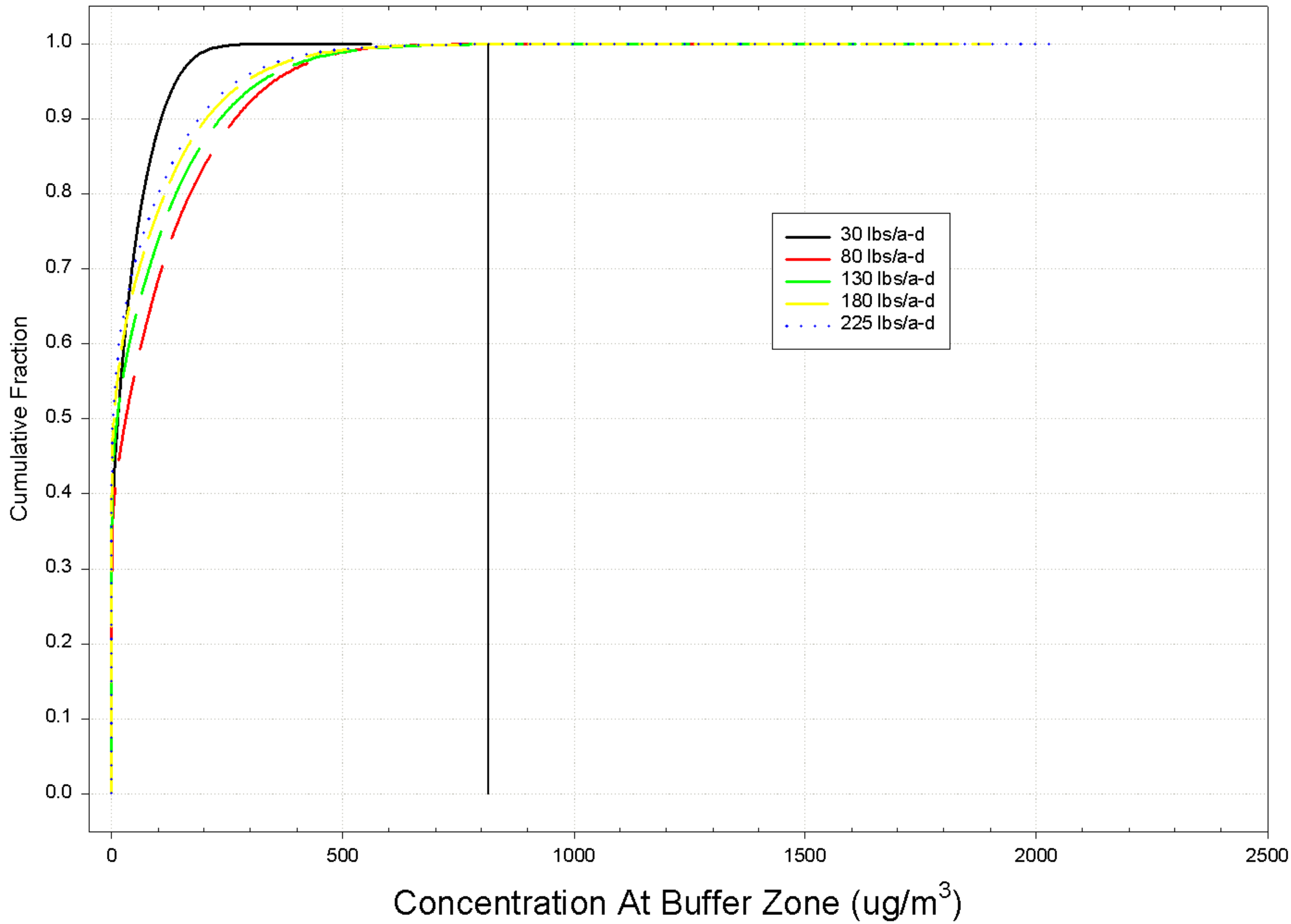



Figure 5.5.1. Cumulative distribution of daily concentration along buffer zone perimeter for 1 acre plot. Vertical bar is 815 ug/m3.

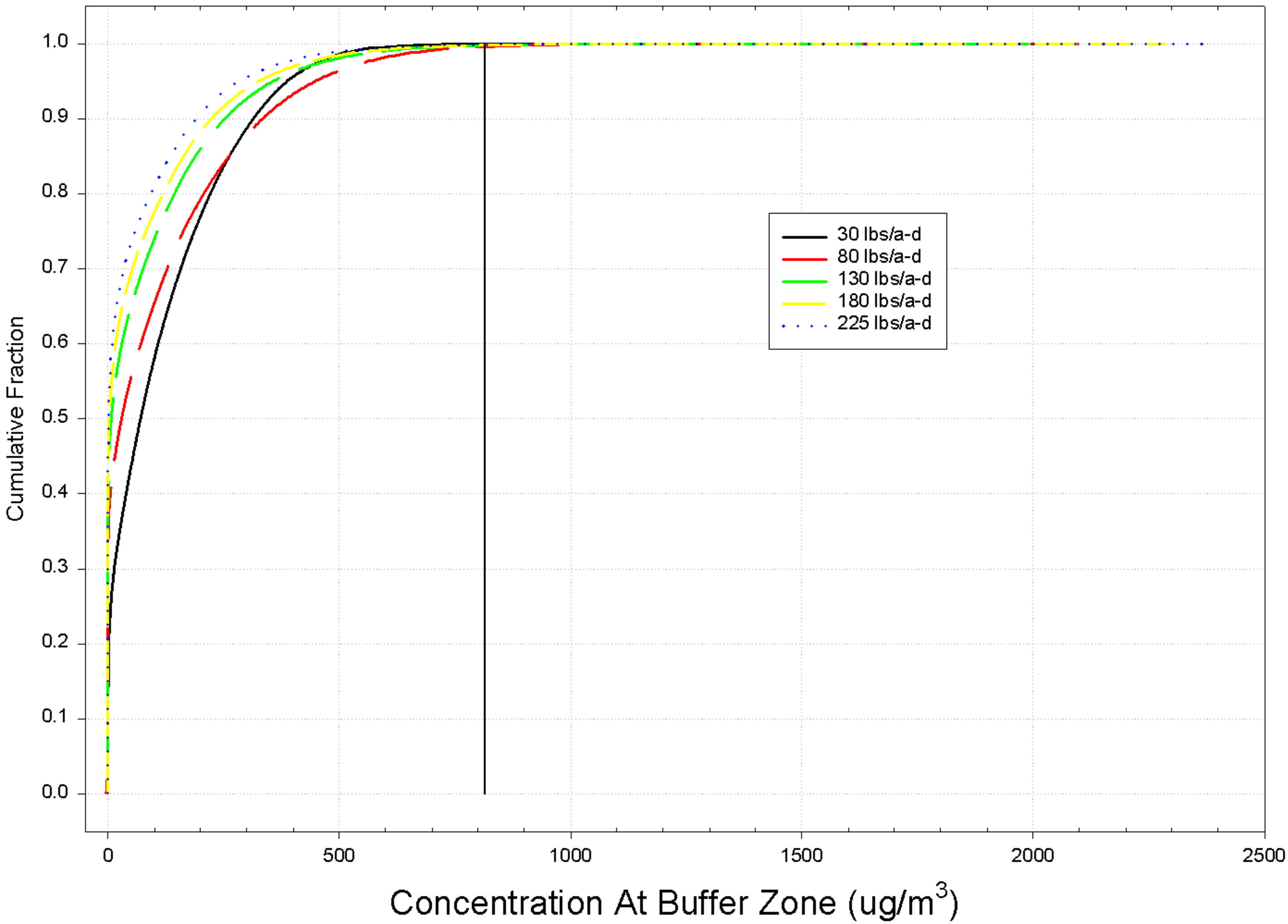



Figure 5.5.2. Cumulative distribution of daily concentration along buffer zone perimeter for 10 acre plot. Vertical bar is 815 ug/m3.

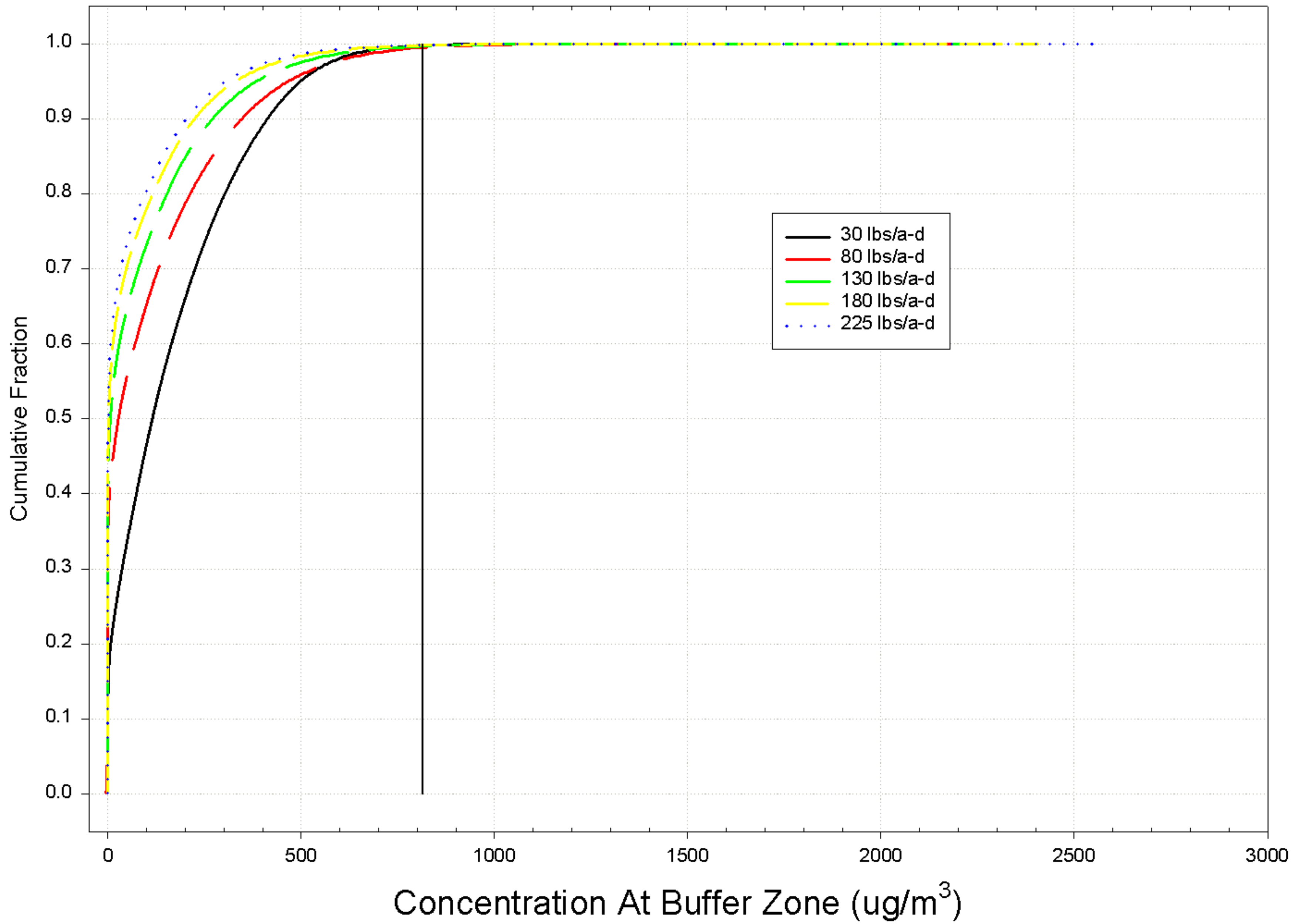



Figure 5.5.3. Cumulative distribution of daily concentration along buffer zone perimeter for 20 acre plot. Vertical bar is 815 ug/m3.

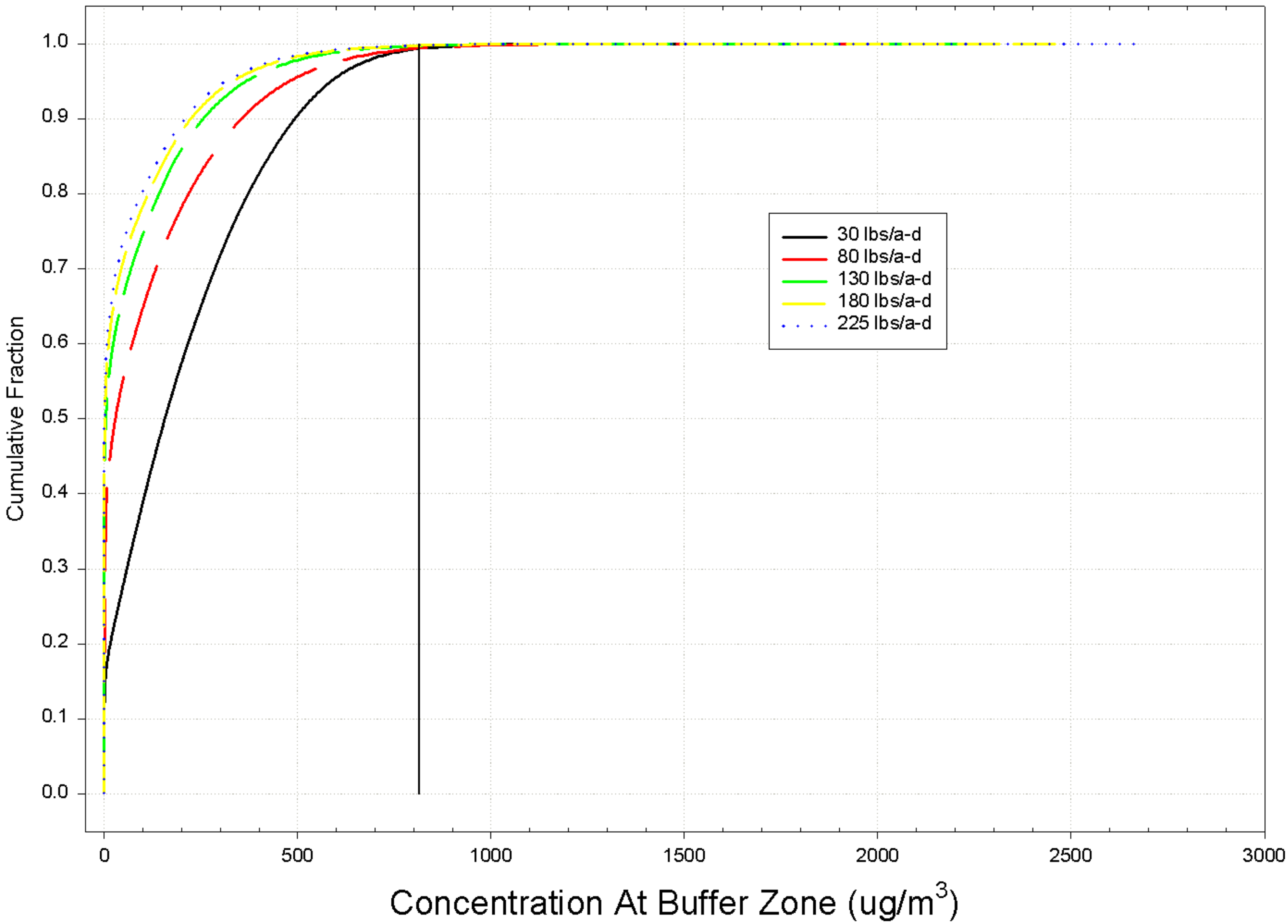



Figure 5.5.4. Cumulative distribution of daily concentration along buffer zone perimeter for 30 acre plot. Vertical bar is 815 ug/m3.

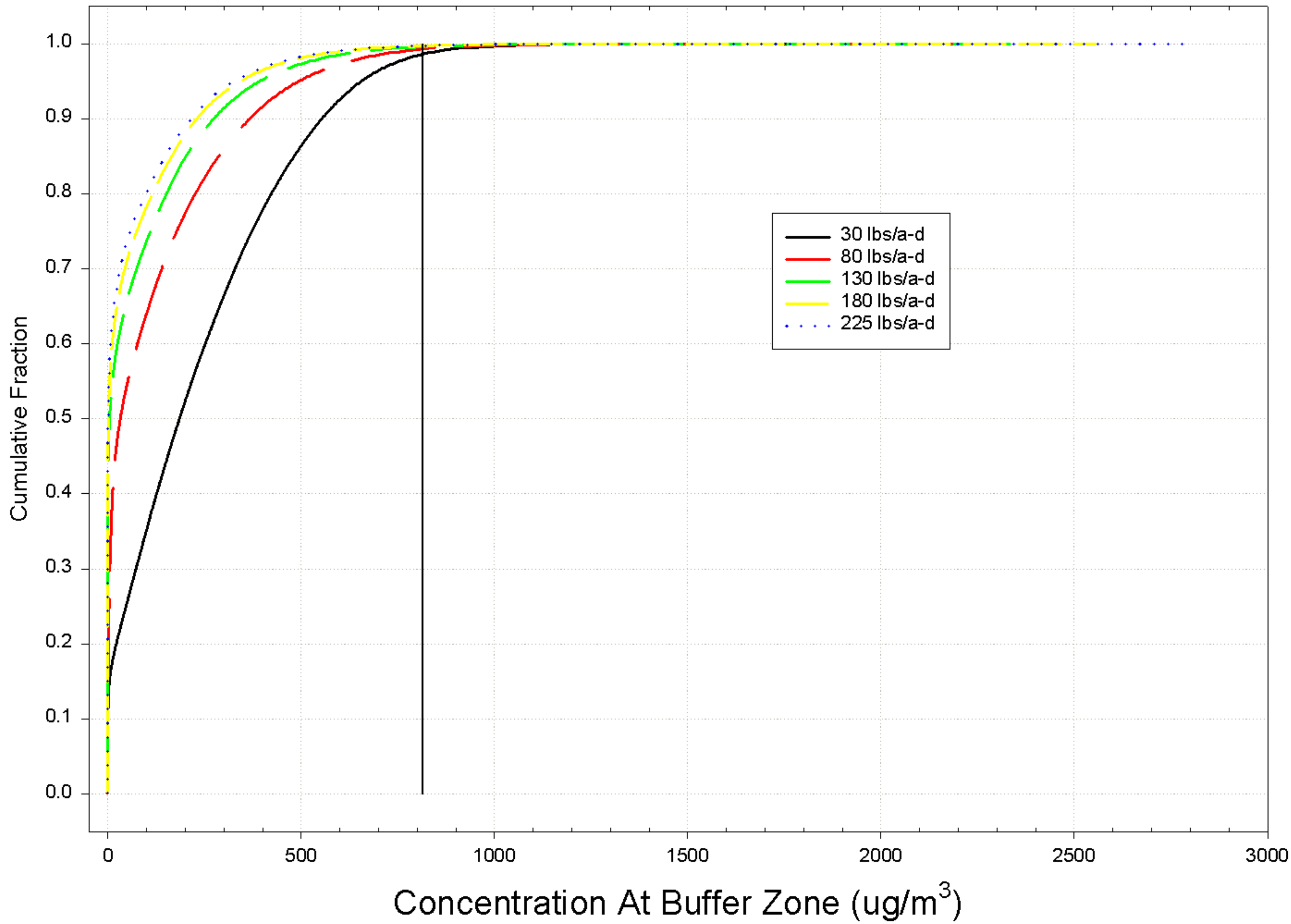



Figure 5.5.5. Cumulative distribution of daily concentration along buffer zone perimeter for 40 acre plot. Vertical bar is 815 ug/m3.

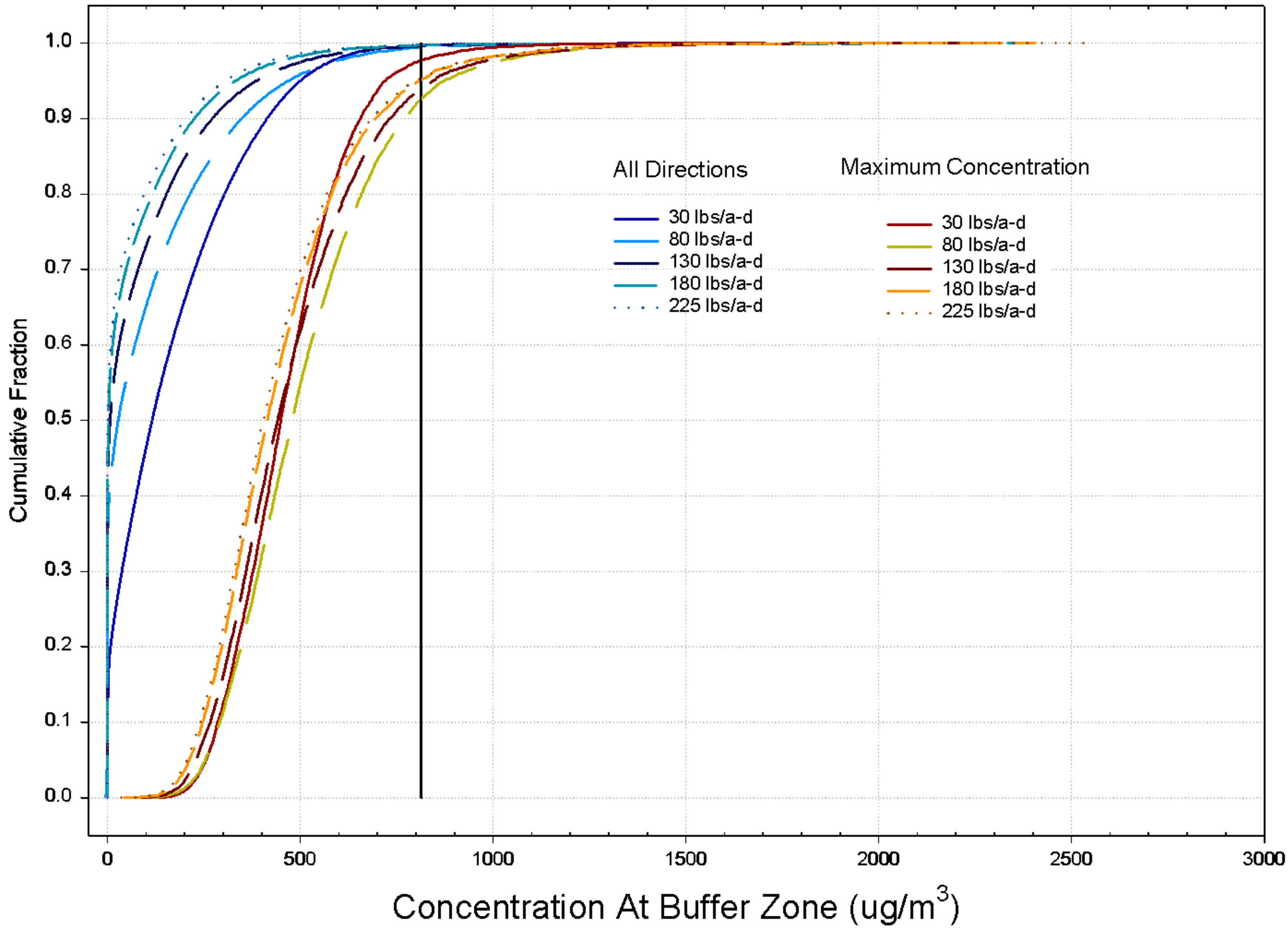



Figure 5.5.6. Cumulative distribution of daily concentrations for 20 acre plot along buffer zone perimeter comparing distributions based on all directions versus distributions based on maximum value at buffer zone. Vertical bar is 815 ug/m3.

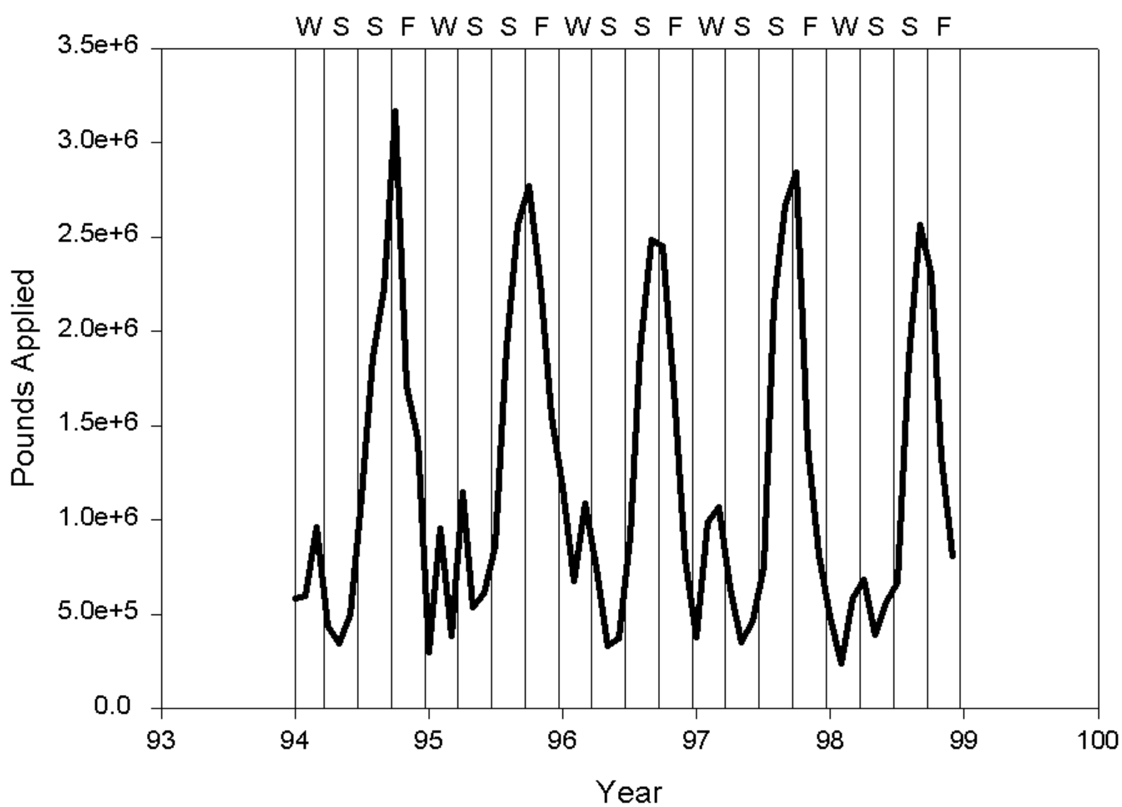



Figure 5.6.1. Monthly pounds of methyl bromide applied where units are acreage and outliers excluded.

# Appendix 1: General CIMIS Siting Criteria

B. Weather Station Siting Information

The placement of a weather station and the local environment of a weather station site can affect the utility and accuracy of ETo (calculated using the stations' weather data) for the area in which it is located. Buildings or trees close enough to a weather station can affect wind speed data, which in turn affects the resultant calculated ETo. The absence of a healthy green grass under a weather station can affect net radiation severely and humidity to some degree, which will adversely affect ETo. Bare soil instead of cropped land around the weather station can increase advected energy, increasing temperatures and decreasing humidities, which would increase the ETo value.

A CIMIS weather station should be located within the area that the station is meant to represent. The overriding factor in locating any CIMIS weather station is that the station location should be representative of the largest possible surrounding area. This will insure the most efficient use of weather stations for supplying accurate and applicable ETo information. The ideal site for a CIMIS weather station would be located in a 20-acre or larger pasture that is well maintained. The actual weather station would be located in the center of the pasture, inside a 10-yard to by 10-yard fenced enclosure. Inside the enclosure, the grass would also be well maintained (properly irrigated and fertilized) and mowed frequently to maintain a height between three to six inches.

It is often very difficult to find such a site for a new weather station. In some areas, there are few pastures. Also, if a pasture is found, the landowner must agree on allowing a weather station to be sited there. DWR has prepared, with the help of UC, the following criteria or guidelines to be used to find and judge sites for CIMIS weather stations when an ideal pasture cannot be found.

Regional and Local Criteria

1. A station should be sited within the region it is meant to represent.

2. Avoid locating a station in a transition area between two regions of distinct climates unless you are attempting to characterize that transitional area.

3. Topographic depressions should be avoided, as the temperature is frequently higher during the day and lower at night. High points should also be avoided in most cases.

4. There should be a long-term commitment to maintain the same land use in and around the site, to avoid moving the station in the future.

CIMIS WEATHER STATION SITING INFORMATION DATE:05-19-00
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## Surrounding Environment Criteria

1. Avoid wind obstructions within 100 yards of the site. Avoid linear obstructions (windbreaks, buildings) within 150 yards perpendicular to the direction of the prevailing wind.

2. Avoid placing a station in a field where there are frequent rotations of crops, because between crops the field will have bare soils.

3. Avoid abrupt crop/vegetation changes (i.e. pasture to row crops) within 50 yards of site, or 100 yards upwind of site.

4. Avoid roads within 45 m (50 yards) of the site. Unpaved roads should be no closer than 90 m (100 yards) upwind of the site.

5. Small rivers should be no closer than 100 yards of the site and larger rivers should be no closer than 200 yards of the site. Lakes should be no closer than 1,000 yards of the site if the

6. Avoid areas where extensive or frequent use of agricultural chemicals are used (can cause increasing degradation of sensors).

## Other General/Desireable Criteria

1. Site should have nearby dwellings (no closer than 100 yards) to reduce risk of vandalism.

2. The station enclosure should be a 10-yard by 10-yard by five-foot high fence, livestock-tight where necessary. The posts, boards and fencing material should not affect wind nor shade any instruments.

3. Site should have unrestricted access, seven days a week. There should be

vehicle access to the site enclosure (except when wet).

4. Site should be close to existing telephone lines (within 150 yards) for economical connections.

5. There should be local personnel (private or public) to help maintain the site to meet DWR's requirements.

Many of the weather stations sites in the CIMIS network are not the ideal large pasture situation. Some of these stations do not meet all of the above siting criteria. These sites will be upgraded if possible or relocated to a better quality site in the future. Specific information on each CIMIS site can be found in '4. Detailed Weather Station Information' under main menu item "Weather Station Information".

# Appendix 2. Determining a threshold calms value.

## 1 Introduction

The gaussian plume equation utilizes the wind speed in the denominator of the concentration equation. Consequently, as an absolute limit, wind speed cannot be zero. More practically, as the wind speed approaches zero, the theoretical concentration approaches infinity. On the basis of these theoretical reasons, there must be a threshold wind speed, below which the model should not be utilized.

Other reasons for determining a threshold stem from the practical aspects of measuring wind speed and direction. In the case of the CIMIS stations, the wind speed is measured utilizing a MET014A and the wind direction is measured using a MET024A anemometer. The minimum threshold for both devices is 1 mile per hour. During periods of time when the wind speed is below the threshold, the measured wind direction does not change. Consequently, utilization of these periods in simulation modeling would erroneously predict higher concentrations downwind due to unchanging wind directions.

For MET014A, the minimum possible reported average wind speed during a one hour period is 1 mph. When the wind speed is actually below 1 mph, the MET014A reports 1 mph. The CIMIS station data loggers record 1 measurement every minute, taking the average of the 60 measurements to determine an hourly average value. Therefore, when the average is 1 mph, all wind speeds during that hour were less than the threshold, for both the wind speed and wind direction sensors.

The objective of the threshold study is to examine hourly average wind speeds to determine the relationship between the average speed and the fraction of measurements used in the hourly average which are below the 1 mph threshold. The goal is to select a threshold wind speed which will minimize the percentage of measurements within the hour which are below the 1 mph threshold.

## 2 Methods

The study plan requires a simulation of the data collection and averaging process, in order to determine the fraction of measurements which lie below the threshold for a given hourly average wind speed. In order to accomplish this, a random wind speed generator is needed. The first step in constructing the generator was to summarize five years of wind speed data from the Merced station. A frequency distribution (Table Appendix2.1) of these hourly average wind speeds was created using BMDP 5D (BMDP 1993). Utilizing Table Curve (SPSS 2000) the cumulative distribution was fit with the cumulative Weibull distribution (Figure Appendix2.1) for speeds of at least 3.875 mph . This speed was choosen to insure that the hourly averages which comprise the distribution would be based on very few measurements at or below the 1 mph threshold. The Weibull function is frequently used to approximate wind speed distributions (Deaves and Lines 1998, Seguro and Lambert 2000). The cumulative Weibull function is given below.

$$y = a\left[1 - \exp\left(-\left(\frac{x + c(\ln 2)^{\frac{1}{d}} - b}{c}\right)^{d}\right)\right]$$

The fitted values are shown in Figure Appendix2.1. To complete the fitted distribution, a straight line was drawn connecting the value at 3.875 to 0 (Figure Appendix 2.2). Studies with highly sensitive sonic anemometers with a threshold of 0.01m/s show a monotonically increasing function of cumulative wind speeds starting at a speed of 0 (Deaves and Lines 1998). In addition, Deaves and Lines (1997) verified the accuracy of extrapolation to (0,0) through low wind speeds from the fitted Weibull distributions.

A FORTRAN program was written which sampled from the cumulative frequency distribution. The program took 60 random samples from the cumulative Weibull, then found the average wind speed. The program mimicked the operation of the MET014A, by assigning a value of 1 to any speed less than 1 mph and basing the average on this assigned value. In this way, the percentage of values less than 1 mph could be computed along with the average wind speed.

Initial runs from the program indicated that the average wind speed was 4.7 mph, identical to the actual average wind speed of the Merced data of 4.7 mph. However, sampling from the whole distribution always produced average wind speeds close to 4.7 mph and never produced average values close to the low average wind speeds needed for the study. In order to produce lower wind values, a scale factor was introduced. The scale factor was applied to the whole distribution in order to scale down the range of wind speed values during the simulation and produce lower average values. For example, a scale factor of 2 caused the random sample to be divided by 2. In this way , lower average values could be achieved.

A simulation produced 1001 pairs of values. Each pair consisted of an average wind speed based on 60 samples and determined following the MET014A procedure, and a fraction of wind speed samples which were less than or equal to 1 mph. Figure Appendix2.3 shows an example of one simulation with a scale factor of 1.82. For a fixed scale factor, the simulation produced a range of hourly outcomes, though the average wind speed of the hourly outcomes was 2.8 mph (sd=0.24) and the average fraction of measurements which were less than or equal to 1.0 mph was 0.21 (sd=0.05).

After establishing these basic procedures, six scale values were utilized to produce six clusters of simulated values. Each cluster consisted of 1001 pairs of average speed and fraction of values less than or equal to 1 mph. The cluster speed averages ranged from 1.6 to 4.7 mph.

## 3 Results

Figure Appendix 2.4 shows the six clusters with individual hourly averages plotted. The fraction of values averaged from 13% in the cluster with an average speed of 4.7 mph to 40% in the cluster with the lowest average speed of 1.6 mph. Figure Appendix 2.5 summarizes the 6 simulation clusters, showing the mean and standard deviations of the simulated group speeds and fraction of values less than or equal to 1.0 mph. The general shape of this pattern shows a break point at approximate fractional values of 20%. At this point, the curve is steep to the left, and flattens out to the right. For this reason, 20% was chosen as the acceptable maximum level of average fraction of 'calms' during an hourly measurement period. This level translates into an average speed of 2.8 mph, which is equivalent to 1.25 meters per second

## 4 References.


BMDP. 1993. BMDP5D – Histograms and Univariate Plots. Release 7. BMDP Statistical Software, Inc. Los Angeles, CA 90025 USA

Deaves, D.M. and I.G. Lines. 1998. The nature and frequency of low wind speed conditions. Journal of Wind Engineering and Industrial Aerodynamics 73:1-29.

Deaves, D.M. and I.G. Lines. 1997. On the fitting of low mean windpseed data to the Weibull distribution. Journal of Wind Engineering and Industrial Aerodynamics 66:169-178.

Seguro, J.V. and T.W. Lambert. 2000. Modern estimation of the parameters of the Weibull wind speed distribution for wind energy analysis. Journal of Wind Engineering and Industrial Aerodynamics 85:75-84.

SPSS. 2000. TableCurve 2D 5.0 Automated Curve Fitting and Equation Discovery. SPSS Inc, Chicago, IL.

Table Appendix2.1. Cumulative distribution of Merced Station (CIMIS 056) wind speeds 1993-1997.

| Speed (mph) | Cumulative Fraction | Weight Used in Fitting | Speed (mph) | Cumulative Fraction | Weight Used in Fitting |
|---|---|---|---|---|---|
| 1.875 | 0.067 | 0 | 14.125 | 0.975 | 1 |
| 2.125 | 0.101 | 0 | 14.375 | 0.978 | 1 |
| 2.375 | 0.144 | 0 | 14.625 | 0.980 | 1 |
| 2.625 | 0.189 | 0 | 14.875 | 0.981 | 1 |
| 2.875 | 0.243 | 0 | 15.125 | 0.983 | 1 |
| 3.125 | 0.298 | 0 | 15.375 | 0.984 | 1 |
| 3.375 | 0.352 | 0 | 15.625 | 0.986 | 1 |
| 3.625 | 0.401 | 0 | 15.875 | 0.988 | 1 |
| 3.875 | 0.445 | 1 | 16.125 | 0.989 | 1 |
| 4.125 | 0.482 | 1 | 16.375 | 0.990 | 1 |
| 4.375 | 0.517 | 1 | 16.625 | 0.991 | 1 |
| 4.625 | 0.549 | 1 | 16.875 | 0.992 | 1 |
| 4.875 | 0.579 | 1 | 17.125 | 0.992 | 1 |
| 5.125 | 0.607 | 1 | 17.375 | 0.993 | 1 |
| 5.375 | 0.633 | 1 | 17.625 | 0.994 | 1 |
| 5.625 | 0.657 | 1 | 17.875 | 0.995 | 1 |
| 5.875 | 0.680 | 1 | 18.125 | 0.995 | 1 |
| 6.125 | 0.700 | 1 | 18.375 | 0.996 | 1 |
| 6.375 | 0.722 | 1 | 18.625 | 0.996 | 1 |
| 6.625 | 0.740 | 1 | 18.875 | 0.997 | 1 |
| 6.875 | 0.757 | 1 | 19.125 | 0.997 | 1 |
| 7.125 | 0.774 | 1 | 19.375 | 0.997 | 1 |
| 7.375 | 0.790 | 1 | 19.625 | 0.998 | 1 |
| 7.625 | 0.804 | 1 | 19.875 | 0.998 | 1 |
| 7.875 | 0.818 | 1 | 20.125 | 0.998 | 1 |
| 8.125 | 0.829 | 1 | 20.375 | 0.998 | 1 |
| 8.375 | 0.841 | 1 | 20.625 | 0.998 | 1 |
| 8.625 | 0.852 | 1 | 20.875 | 0.999 | 1 |
| 8.875 | 0.862 | 1 | 21.125 | 0.999 | 1 |
| 9.125 | 0.871 | 1 | 21.375 | 0.999 | 1 |
| 9.375 | 0.880 | 1 | 21.625 | 0.999 | 1 |
| 9.625 | 0.890 | 1 | 21.875 | 0.999 | 1 |
| 9.875 | 0.898 | 1 | 22.125 | 0.999 | 1 |
| 10.125 | 0.906 | 1 | 22.375 | 0.999 | 1 |
| 10.375 | 0.913 | 1 | 22.625 | 0.999 | 1 |
| 10.625 | 0.919 | 1 | 22.875 | 1.000 | 1 |
| 10.875 | 0.926 | 1 | 23.125 | 1.000 | 1 |
| 11.125 | 0.931 | 1 | 23.375 | 1.000 | 1 |
| 11.375 | 0.936 | 1 | 23.625 | 1.000 | 1 |
| 11.625 | 0.941 | 1 | 23.875 | 1.000 | 1 |
| 11.875 | 0.946 | 1 | 24.125 | 1.000 | 1 |
| 12.125 | 0.950 | 1 | 24.375 | 1.000 | 1 |
| 12.375 | 0.954 | 1 | 24.625 | 1.000 | 1 |
| 12.625 | 0.957 | 1 | 24.875 | 1.000 | 1 |
| 12.875 | 0.961 | 1 | 25.125 | 1.000 | 1 |
| 13.125 | 0.964 | 1 | 25.375 | 1.000 | 1 |
| 13.375 | 0.967 | 1 | 25.625 | 1.000 | 1 |
| 13.625 | 0.970 | 1 | 25.875 | 1.000 | 1 |
| 13.875 | 0.973 | 1 | 26.125 | 1.000 | 1 |
| | | | 26.375 | 1.000 | 1 |

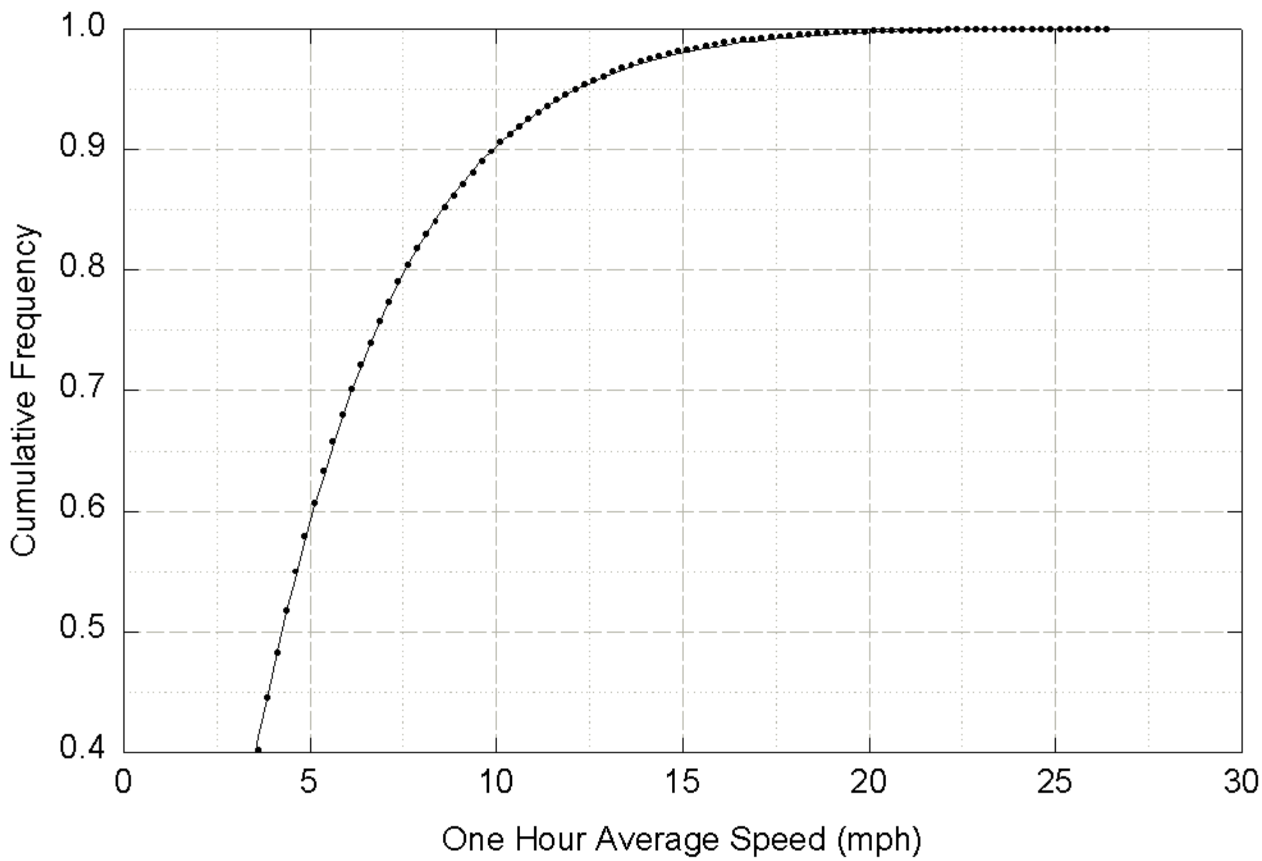



Figure Appendix2.1. Weibull function fit to cumulative wind speed data from Merced CIMIS Station (056). TableCurve Equation 8087 WeibullCum_(a,b,c,d) r2=0.9999, a=1.0020777, b=4.2543636, c=4.0892545, d=1.1139557. Extra parameter accuracy for purposes of identification. Speeds less than 3.875 mph given a weight of zero.

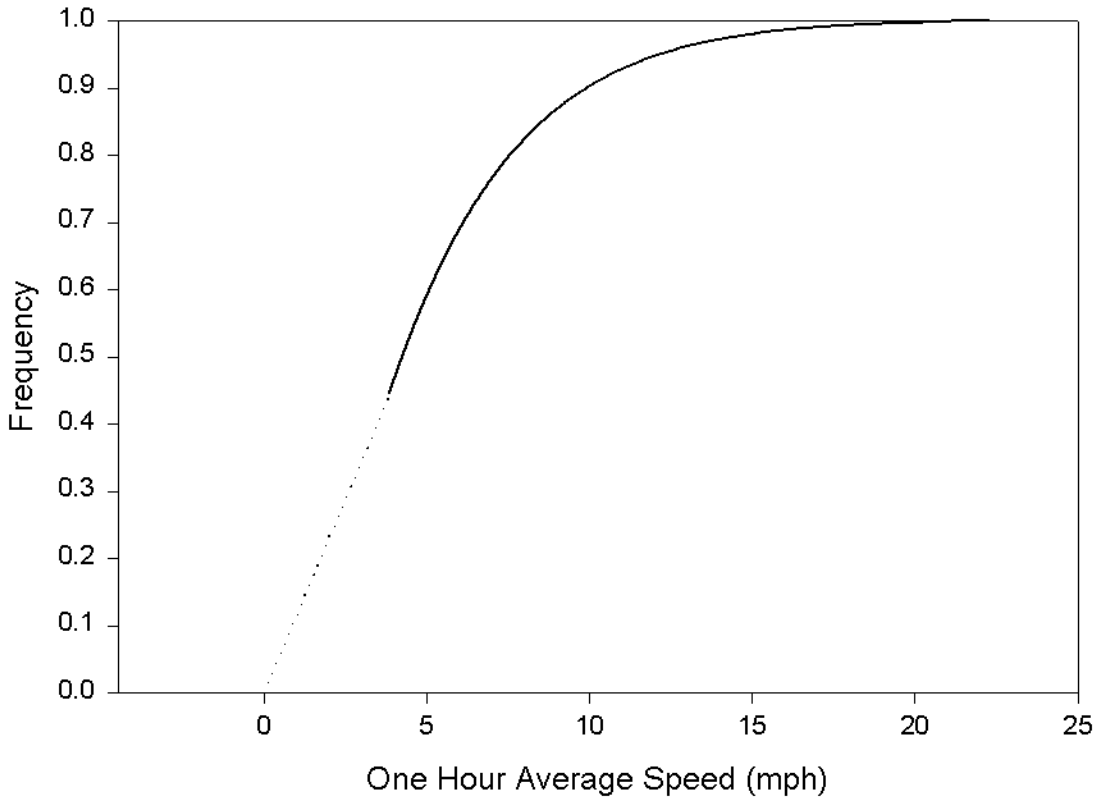



Figure Appendix2.2. Completed cumulative distribution function combining linear interpolation from 0.0 to 3.875 (dotted line) and fitted cumulative Weibull function thereafter (solid line).

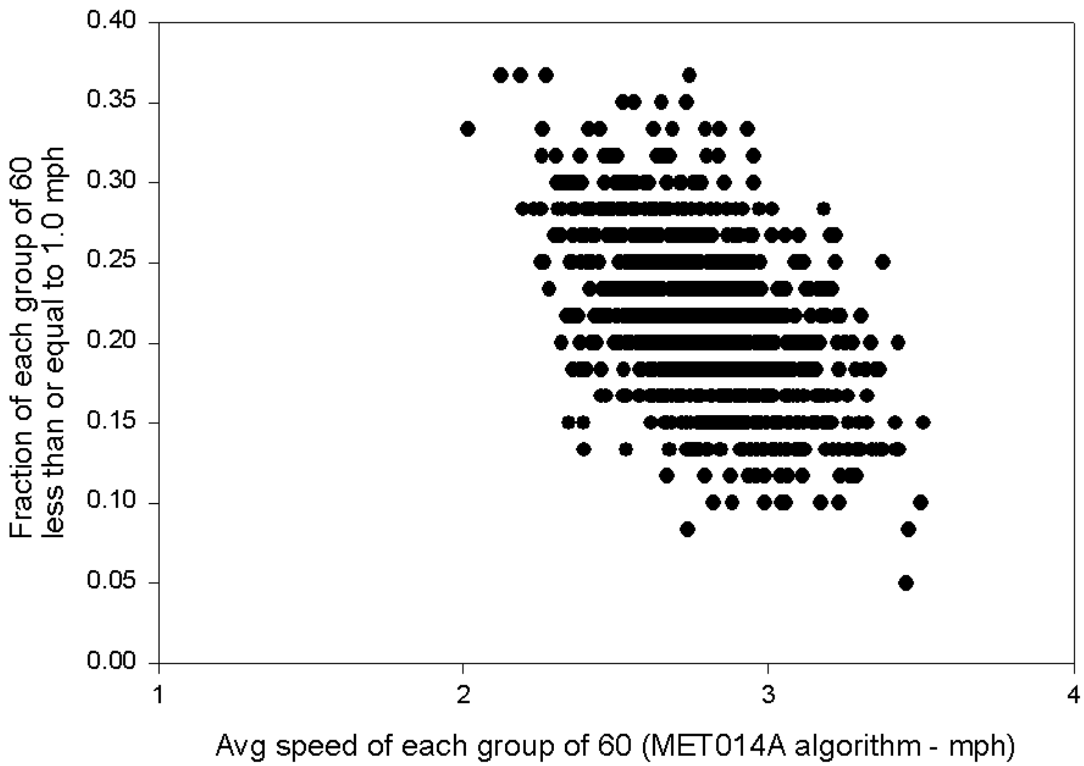
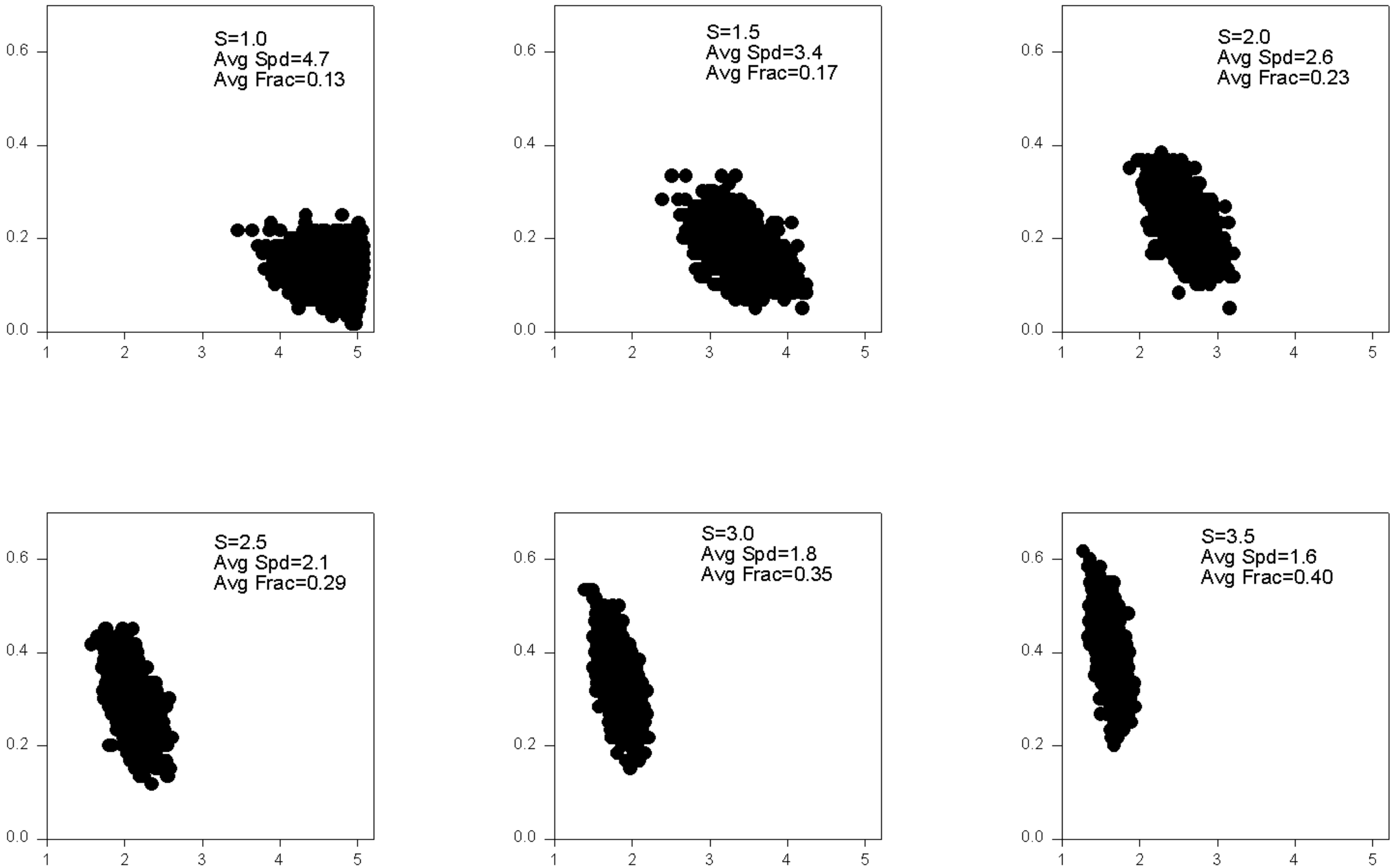



Figure Appendix2.3. Distribution of group averages for scale factor of 1.82626, which gave average speed amongst all 1001 groups of 2.8 mph and an average fraction of values less than or equal to 1 mph of 0.21.

Figure Appendix2.4. Distribution of fraction of values less than 1 mph in each simulated one hour average using cumulative weibull fit to CIMIS station 056 5 years of wind speed data and simulating the output of a Met014A with a minimum wind speed of 1 mph. Y axis is fraction of values in one hour average where wind speed was less than or equal to 1 mph and X axis is average reported MET01A speed (mph). S is the scale factor applied to the speed. The average wind speeds and average fraction of speeds less than or equal to 1.0 mph are reported on the graphs.



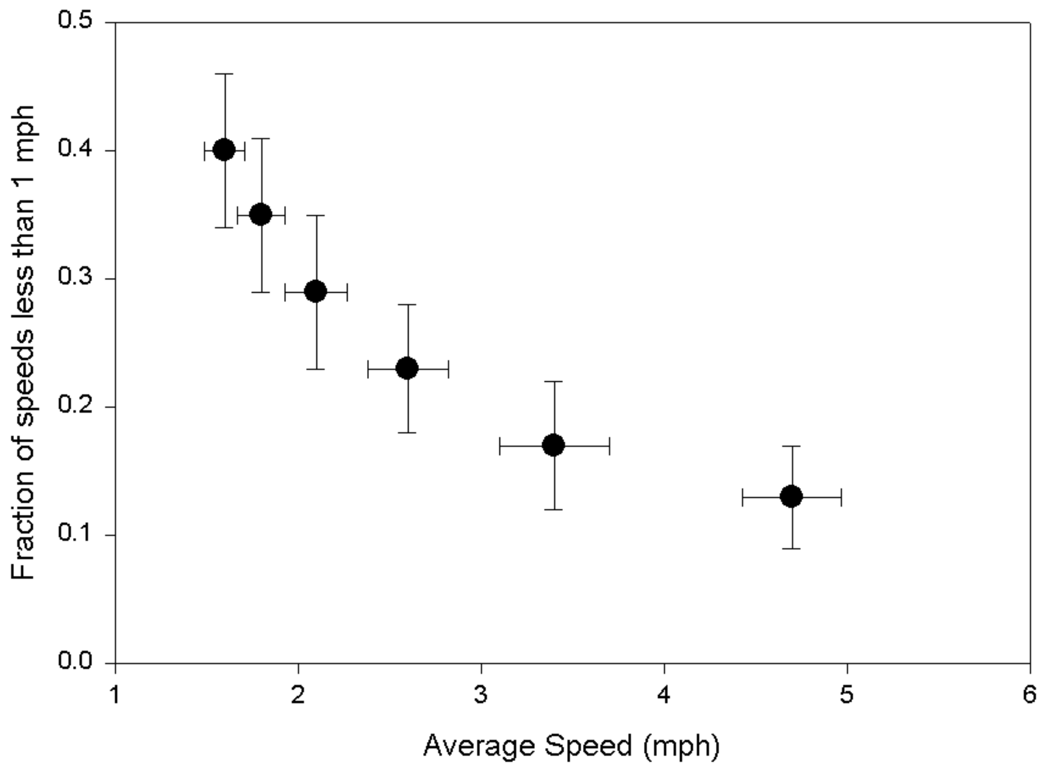



Figure Appendix2.5. Graphic summary of 6 simulations showing the average fraction (+/- 1 sd) and average speed (+/- 1 sd).

# Appendix 3. Air Resources Board Reviews of Protocol and Draft Report

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# Air Resources Board

Alan C. Lloyd, Ph.D.
Chairman
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Winston H. Hickox
*Agency Secretary*

Gray Davis
*Governor*

MEMORANDUM

TO: John Sanders, Ph.D., Chief
Environmental Monitoring and Pest Management Branch
Department of Pesticide Regulation

FROM: Raymond Menebroker, Chief
Project Assessment Branch
Stationary Source Division

DATE: June 7, 2000

SUBJECT: REVIEW OF DPR PROTOCOL "DETERMINATION OF FREQUENCY DISTRIBUTIONS OF REQUIRED BUFFER ZONES FOR DAILY CONCENTRATIONS OF METHYL BROMIDE"

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In response to your request, we reviewed the protocol "Determination of Frequency Distributions of Required Buffer Zones for Daily Concentrations of Methyl Bromide," dated April 14, 2000. We understand that the purpose of the preparation of frequency distributions is to "assess the level of protection of the proposed buffer zones" with regard to the 24-hour reference concentration of 210 ppbv (parts per billion volume). We also understand that to develop the frequency distributions, air dispersion modeling will be conducted for the four counties of highest soil application of methyl bromide. Our comments are attached.

If you have questions regarding our comments, please call me at (916) 322-6026.

Attachment

Comments on DPR Protocol "Determination of Frequency Distributions of Required Buffer Zones for Daily Concentrations of Methyl Bromide"

1. Selection of dispersion model - We understand that the DPR is establishing procedures for processing California Irrigation Management Information System (CIMIS) meteorological data for use with the ISCST3 air dispersion model. The U.S. EPA is preparing to release the AERMOD air dispersion model to replace the ISCST3 model. The DPR should be aware of these upcoming model changes that may affect their future dispersion modeling.

2. Representativeness of meteorological data - The protocol states that the DPR intends to process CIMIS data from four separate stations in the four counties of highest soil application of methyl bromide: Monterey, Kern, Ventura, and Merced. The protocol poses the question as to whether meteorological data collected in Kern and Merced Counties represent other San Joaquin Valley counties, and whether meteorological data from Monterey and Ventura Counties represent other coastal counties. The protocol concludes that these four stations "provide adequate representation of the meteorological conditions which may arise in a majority of the methyl bromide use areas." The protocol does not provide justification for this conclusion.

   In order to justify such a conclusion, we recommend the following: a) that the DPR compare meteorological data between counties where temporal distributions are simultaneous in order to establish representative meteorological data for the purpose of methyl bromide buffer zone calculations; b) that the DPR make the comparisons by modeling emissions from an area source similar to a typical methyl bromide soil application with meteorological data from other representative CIMIS stations; and c) that the DPR compare frequency distributions of wind speeds, wind directions, and stability classes between CIMIS stations. Alternatively, we recommend that the DPR narrow the scope of the representativeness of the meteorological data to only the counties in which the data were collected.

   In addition, Table 3 lists the four CIMIS stations that the DPR plans to use to represent the four counties. Station 54, Blackwells Corner, is listed as the station to represent Kern County in the San Joaquin Valley. Although Blackwells Corner is located in Kern County, it is located on the Antelope Plain, west of the Lost Hills, outside of the San Joaquin Valley, and not representative of the agricultural region of Kern County. We recommend using a more representative station in Kern County.

3. Stability calculation - The protocol describes how the stability classification was adjusted as a function of the standard deviation of the horizontal wind direction. The protocol references two U.S. EPA adjustment equations and presents the results of calculations. We recommend that the final protocol or report on the

frequency distributions include more detail on the calculation of stability classes, including the adjustment equations.

4. Final stability class results - Figure 3 in the protocol presents the stability class as calculated with the revised stability algorithm. Figure 3 is predominately bimodal for the selected period of August 27-29, 1999, in Kern County. The stability class is very unstable (stability class A) during the daytime and very stable (stability class F) during the nighttime. This is a condition that may be typical during mid-summer conditions. However, we recommend that the DPR also evaluate a few days during winter, spring, and fall, to determine if the stability class calculations provide credible results for other times of the year. We recommend that the DPR select a few cloudless days and compare the calculated stability classes with the Pasquill stability class scheme. The Pasquill stability class scheme is a function of wind speed and incoming solar radiation, and can be found in U.S. EPA's PCRAMMET User's Guide, August 1995.

5. Treatment of calm winds - The protocol describes the issue of low or calm winds in the CIMIS data as it relates to dispersion modeling. U.S. EPA modeling guidance eliminates calm winds from modeling calculations. The protocol proposes to identify CIMIS wind speeds of less than or equal to 3 mph as calms, but defers a final recommendation on treatment of calm winds to a later date. We suggest that the DPR consider two additional parameters in their evaluation: a) Gaussian based models such as ISCST3 limit the minimum wind speed to 1.0 m/s; hence, the minimum wind speed for the data set should go as low as 1.0 m/s; and b) meteorological data with excessive calms should be used cautiously in air dispersion models. Our general suggestion has been to allow up to 10% calm winds in the data. When the calms exceed 30% of the data, we recommend seeking alternative modeling approaches or data sets. Data sets with between 10% and 30% calms should be considered on a case-by-case basis.

6. Simulated flux - The protocol states that the initial flux will be 400 lbs/acre-day, "which is larger than the maximum flux rate in the buffer zone table of 225 lbs/acre-day." We recommend including rationale for using this higher flux in the report on frequency distributions.

   In addition, the protocol states that "at about 9 different fluxes spanning the range of fluxes for each selected acreage, the frequency distribution will be determined." While this sounds thorough, we recommend including rationale for selecting 9 different fluxes.

7. Methyl bromide use by county - Table 1 lists methyl bromide use by county for 1995-1997. Use information is presented for 47 counties. We assume that no methyl bromide was used in the other 11 counties of California. We recommend noting this in a footnote to this table, so that it is clear that some counties have not been overlooked.

Winston H. Hickox
*Agency Secretary*

# Air Resources Board

**Alan C. Lloyd, Ph.D.**
**Chairman**
1001 I Street • P.O. Box 2815 • Sacramento, California 95812 • www.arb.ca.gov

Gray Davis
*Governor*

MEMORANDUM

TO: John Sanders, Ph.D., Chief
Environmental Monitoring and Pest Management Branch
Department of Pesticide Regulation

FROM: Janette Brooks, Chief
Air Quality Measures Branch

DATE: January 30, 2001

SUBJECT: COMMENTS ON DRAFT DPR REPORT "DETERMINATION OF FREQUENCY DISTRIBUTIONS OF REQUIRED BUFFER ZONES FOR DAILY CONCENTRATIONS OF METHYL BROMIDE"

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In response to your request, we reviewed the draft report "Determination of Frequency Distributions of Required Buffer Zones for Daily Concentrations of Methyl Bromide," prepared by the Department of Pesticide Regulation (DPR) and dated September 2000. On June 7, 2000, we sent you comments on the protocol for determining these frequency distributions. The comments we had on the protocol were addressed in the draft report. We understand that the purpose of preparing these frequency distributions was to assess the level of health protection of the buffer zones now being implemented under a new regulation by DPR with regard to the 24-hour reference concentration of 210 ppbv (parts per billion volume). Our comments on the draft report are attached.

If you have questions regarding our comments, please call me at (916) 322-7072.

Attachment

Comments on Draft DPR Report "Determination of Frequency Distributions of Required Buffer Zones for Daily Concentrations of Methyl Bromide"

1. Objective of frequency distributions - The introduction states that the report was prepared "to determine those frequency distributions, and thereby assess the level of protection of the proposed buffer zones." Air dispersion modeling was used to develop the frequency distributions of required buffer zones in four counties of high soil application of methyl bromide. A limitation of this approach is that the necessary buffer zone distance may be exceeded in a small percentage of applications and thereby may not be adequately health protective. We recommend that this be noted in the introduction or summary.

2. Treatment of calm winds - Section 4.3, Treatment of Calms, quotes our comments on the protocol, stating that when the percentage of calm winds exceed 30%, "ARB attempts to find an alternative meteorological data set." In this report, the meteorological data sets that were reviewed for Kern County each had percentages of calms exceeding 30%. Hence, Kern County was not included in this determination.

   Our actual comment was to seek "alternative modeling approaches or data sets." When the percentage of calm winds in a meteorological data set exceeds 30%, the results from using these data in the ISCST3 air dispersion model (used by DPR to develop these frequency distributions) become suspect. We recommend alternative approaches to evaluating the impact of emissions on receptors in such cases. Alternative approaches should be discussed and agreed to before proceeding. These alternative approaches could include, but are not limited to one or more of the following suggestions: a) review monitoring data previously collected around the use of methyl bromide to assess the significance of methyl bromide emissions during hours with and without calm winds, b) if such data are not available, establish a monitoring program (with more sensitive anemometers) to study the impacts of emissions during calm winds, c) assign a minimum wind speed to hours with calm winds and randomize the wind direction so that entire data sets do not need to be disregarded (modeling results using this approach should be compared with monitoring data to ensure that modeled concentrations do not underestimate actual concentrations), or d) for areas of the state with inadequate meteorological data sets to conduct dispersion modeling, use a more health protective screening modeling approach.

3. Accuracy of emissions data - In section 5.2, Maximum Daily Distance to 815 $\mu g/m^3$, the last paragraph states that "this analysis is based on the accuracy of the flux." All of the flux estimates were back-calculated from downwind measurements of air concentrations. Because of this, there is some uncertainty associated with the flux estimates. The dispersion modeling used to determine the frequency distributions relies on the flux estimates. We recommend noting in the summary or a separate section on the limitations of this analysis, that

because of some uncertainty associated with the flux estimates, there is some uncertainty in the frequency distributions.

4. Diurnal wind shift in Salinas Valley - Section 5.6, Analysis of Outliers, states that in the Salinas Valley a diurnal wind shift "reduces overall air concentrations." This would only be true when evaluating the impact of one field on one receptor. A diurnal wind shift may direct emissions from one field away from a particular receptor, but may then direct emissions from a separate field toward that receptor. We recommend that this section be clarified.

5. Ramifications of modeling - The last paragraph of section 5.6 contains several key points regarding the ramifications of certain meteorological conditions and the limitations of air dispersion modeling. We recommend summarizing these points in the summary.

   In addition, the last paragraph of section 5.6 makes a brief reference to the AERMOD air dispersion model. In our comments on the protocol, we alerted DPR to the fact that the U.S. EPA was about to release the AERMOD model to replace the ISCST3 model. The U.S. EPA added AERMOD to the list of approved models in June 2000. We understand that DPR staff had been using the ISCST3 model in modeling simulations leading up to this report. So that it is clear to other reviewers, we recommend including reasons for conducting the modeling for this analysis with ISCST3, rather than AERMOD. We acknowledge that little validation work has been published using AERMOD with area sources such as treated fields. We recommend using both models for future modeling until our staffs have more experience using AERMOD with area sources.

Mini-Memo
To: Kean Goh
From: Bruce Johnson
Date: 2/15/01
Subject: My responses to ARB review of draft report

1. Introduction expanded. The 'limitation' cited in review probably refers to risk management decisions, not to a limitation of this evaluation approach.

2. This section reworded.

3. Additional language provided to explain limitations.

4. This section clarified by adding language.

5. Additional language provided to explain limitations. Also, introduction explains choice of ISCST3.