2007 Beltwide Cotton Conferences, New Orleans, Louisiana, January 9-12, 2007

EVALUATION OF THE FRM PM10 SAMPLER FOR PROPERTY LINE MEASUREMENT OF PM10 CONCENTRATION

Stewart James Skloss
Department of Biological and Agricultural Engineering, Texas A&M University
College Station, TX
J.M. Lange
C. B. Parnell
BAEN-TAMU
College Station, TX
Bryan W. Shaw
Center for Agricultural Air Quality Engineering and Science
College Station, TX

Abstract

The National Ambient Air Quality Standard (NAAQS) for Particulate Matter (PM) is used to determine attainment and nonattainment. States having nonattainment areas are required by EPA to submit a state implementation plan (SIP). The SIP must describe how the state air pollution regulatory agency (SAPRA) will bring the area back into attainment. In January 2006, the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) submitted its PM_{10} plan to EPA because the area was classified as serious nonattainment. The plan indicated that significant sources of PM_{10} would be required to implement Best Available Control Measures/Technology (BACM/BACT) to reduce their emissions. Significant sources were identified for regulation using modeled property line 24-hour PM_{10} concentrations. The SJVUAPCD claimed that under Rule 2201 in 40 CFR Part 51, a source is defined to be significant if the modeled property line PM_{10} concentration exceeds an annual significance level of 1 $\mu g/m^3$ or a 24-hour significance level of 5 $\mu g/m^3$. The district's interpretation of Rule 2201 caused a dairy operation in the San Joaquin Valley to be identified as a significant source. The dairy was required to purchase $800,000 of emissions offsets to obtain an operating permit. Using dispersion modeling, this paper will demonstrate that it is unlikely that any dairy operation can meet a property line PM_{10} concentration of 5 $\mu g/m^3$ and that agricultural operations are being unjustifiably targeted for regulation.

Introduction

At the center of the federal Clean Air Act is the National Ambient Air Quality Standards (NAAQS) program. The NAAQS have been established for the following six criteria pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM), carbon monoxide (CO), ozone (O_3), and lead (Pb) (USEPA, 1999). These six pollutants were selected for regulation because of the threat which they pose to the health of the public and the environment. The PM NAAQS address two categories of particle pollution. The first category consists of particles with an aerodynamic equivalent diameter (AED) less than or equal to 2.5 µm ($PM_{2.5}$). Often, $PM_{2.5}$ is referred to as fine particle PM or "soot". In 2006, EPA modified the original $PM_{2.5}$ NAAQS by reducing the 24-hour standard from 65 $\mu g/m^3$ to 35 $\mu g/m^3$ (98th percentile). The annual $PM_{2.5}$ standard was retained at 15 $\mu g/m^3$ (arithmetic mean). The second category of particles regulated under the PM NAAQS are particles with an AED less than or equal to 10 µm and greater than 2.5 µm. This category is referred to as inhalable coarse particles (PM_c). The PM_c NAAQS uses particles with an AED less than or equal to 10 µm (PM_{10}) as an indicator of the concentration of PM_c in ambient air. The 2006 revisions to the PM NAAQS retained the original 24-hour PM_{10} standard of 150 $\mu g/m^3$ (99th percentile) for the PM_c NAAQS. EPA revoked the annual PM_{10} standard because available evidence does not suggest a link between long term exposure to PM_{10} and health problems (CFR, 2006). Hence, there is no annual PM_c NAAQS.

EPA and state air pollution regulatory agencies (SAPRAs) use the NAAQS for two purposes. The primary use of the NAAQS is to determine whether an area is in attainment. Area designations are used to describe the quality of air for a particular geographic region and are based on the number of exceedances of the NAAQS. EPA guidelines require that federal reference method (FRM) or federal equivalent method (FEM) samplers be used to measure ambient $PM_{2.5}$ and PM_c (PM_{10}) concentrations for area designations. Furthermore, guidance has been issued by EPA which lists criteria for locating samplers. When ambient $PM_{2.5}$ and PM_{10} concentrations are measured for regulatory purposes, EPA requires that the samplers be located at community-oriented monitoring sites. The location of these sites should estimate the pollutant level people encounter during their daily activities. In addition to approximating exposure, community-oriented monitoring sites must be located beyond the zone of influence of a single source. A sampler that is placed in a neighborhood adjacent to a source is considered to be a community-oriented monitoring site only if the location is at least 500 m from the fence line of the source. The guidance issued by the EPA specifically prohibits the monitoring of ambient $PM_{2.5}$ and PM_{10} concentrations at the fence line for determinations of attainment and non-attainment. The second or "special" use of the NAAQS is as a concentration not to be exceeded at the property line and beyond for permitting. Authorization for the second use of the NAAQS is not included in the Clean Air Act or the Code of Federal Regulations (CFR). In fact, the preamble to 40 CFR Part 50 (2006) includes the following language which discourages the special use of the NAAQS:

> EPA notes that the NAAQS do not create emissions control obligations for individual sources or groups of sources. Measured or modeled concentrations exceeding the NAAQS off-property of agricultural sources should not be used to deny permits or require reductions of PM emissions. Even if an individual source (or sources) were shown to contribute to an exceedance of the 24-hour PM_{10} standard at a community-oriented monitoring site, this should not necessarily result in regulation or required reductions of emissions from that agricultural source.

Despite this statement, SAPRAs in some states continue to rely upon the second use of the NAAQS to regulate agricultural operations. In some states, the modeled or measured concentration limit used for permitting is at the nearest occupied residence. California is the only state that limits the PM_c (PM_{10}) concentration at the property line to concentrations less than 150 $\mu g/m^3$.

SAPRAs have applied the special use of the NAAQS to regulate and permit PM emissions from cotton gins. A rural cotton gin in New Mexico was required to demonstrate that concentrations at the fence line did not exceed the PM_{10} NAAQS to obtain an operating permit. It was alleged by the New Mexico SAPRA that modeled concentrations exceeded the NAAQS. Sampling was conducted for the entire ginning season with multiple FRM PM_{10} samplers to demonstrate that the 24-hour property line PM_{10} concentrations did not exceed 150 $\mu g/m^3$ before the gin could obtain their operating permit. Several cotton gins in Missouri have faced similar regulatory action. State regulators have threatened to deny the gins operating permits unless they reduce their PM_{10} emissions. The SAPRA claims that the modeled PM_{10} concentration at the cotton gins' property line exceeds the PM_{10} NAAQS. The gins have challenged the SAPRA requirement that additional abatement devices be installed (Parnell, 2006).

Background

Recent developments in California have led to further misuse of the NAAQS. PM_{10} is a serious health issue in the San Joaquin Valley. In fact, the San Joaquin Valley has been designated a serious nonattainment area for PM_{10}. (The EPA (2006) recently announced that the San Joaquin Valley has achieved attainment status.) The Clean Air Act requires that all states which administer their own air pollution regulatory program submit a state implementation plan (SIP) to EPA. More specifically, the SIP must describe the methods that will be used by the SAPRA to bring nonattainment areas into attainment. In February 2006, the San Joaquin Valley Unified Air Pollution Control District (SJVAAPCD) submitted its PM_{10} plan to EPA as part of the California SIP. The SJVUAPCD's attainment plan indicated that the reduction of PM_{10} would occur through regulation, incentives, and voluntary programs (SJVUAPCD, 2006). Sources of PM_{10} were identified for regulation in the emissions inventory (EI) that was completed by the district. In addition to identifying sources for regulation, the SJVUAPCD used the EI to determine the level of controls that a source must implement. According to the district's PM_{10} plan, sources having significant PM_{10} emissions would be required to implement Best Available Control Measures/Technology (BACM/BACT). The SJVUAPCD used the definition provided by the EPA in Rule 2201 to identify significant sources of PM_{10} (SJVUAPCD, 2006). Rule 2201 of 40 CFR Part 51 (1986) states:

> A major source or major modification will be considered to cause or contribute to a violation of a national ambient air quality standard when such source or modification would, at a minimum, exceed the following significance levels at any locality that does not or would not meet the applicable national standard:

Pollutant	Annual	Averaging Time (hours)			
		24	8	3	1
SO_2	1.0 μg/m^3	5 μg/m^3	25 μg/m^3		
PM_{10}	1.0 μg/m^3	5 μg/m^3			
NO_2	1.0 μg/m^3				
CO			0.5 mg/m^3		2 mg/m^3

Citing the definition in Rule 2201, regulators with the SJVUAPCD identified a significant source of PM_{10} as one which contributes more than 5 μg/m^3 to a violation of the 24-hour PM_{10} standard or 1 μg/m^3 to a violation of the annual PM_{10} standard at the fence line of the source. This interpretation of the definition is incorrect. Rule 2201 does not authorize the district to use the property line as the location for identifying significant sources. Instead, the SJVUAPCD should have identified a significant source of PM_{10} as one which contributes more than 5 μg/m^3 to a violation of the 24-hour PM_{10} standard or 1 μg/m^3 to a violation of the annual PM_{10} standard at the nearest community-oriented monitoring site.

Due to the SJVUAPCD's interpretation of Rule 2201, a 6,000 head dairy was identified as a significant source of PM_c (PM_{10}). The district identified the dairy for regulation using the dispersion model, Industrial Source Complex Short-Term Version 3 (ISCST3). EPA has recommended that SAPRAs use ISCST3 in the past when permitting a source to predict concentrations off property. (The SJVUAPCD is currently using AERMOD) Since the PM_{10} concentration at the property line of the dairy exceeded the 24-hour standard of 5 μg/m^3, the dairy was required to purchase $800,000 of emissions offsets to obtain an operating permit (Parnell, 2006).

In addition to misinterpreting how to identify a significant source, regulators with SJVUAPCD made three other mistakes when modeling the 6,000 head dairy. EPA requires SAPRAs to permit a source based upon the source's potential to emit a regulated pollutant. The potential to emit is defined by EPA as *the amount of air pollution a source is capable of emitting if the facility were to operate continuously at peak capacity* (USEPA, 1997). While permitting the dairy, the SJVUAPCD modeled the facility on a potential to emit basis. In doing this, the district incorrectly assumed that the dairy's emergency generator, which is used strictly as an auxiliary power source, was operated continuously. Regulators with the district made a second mistake when they applied unjustifiably high emission factors to the entire dairy operation. The emission factors that were used did not accurately represent the dairy's PM_{10} emissions. The final mistake involved the meteorological data file that was input into ISCST3 to model the dairy. An inspection of the meteorological data contained in the file revealed numerous errors. These errors included impossible weather conditions and stability classes that do not exist. Ultimately, the mistakes made by the SJVUAPCD caused ISCST3 to over-predict PM_{10} concentrations downwind from the dairy.

Objectives

As a result of the regulatory action taken by the SJVUAPCD, the objectives of this manuscript are (1) to predict the property line PM_{10} concentration for a dairy and (2) to determine the distance from the property line of a dairy to a maximum PM_{10} concentration of 5 μg/m^3. The modeling was performed in ISCST3 for three hypothetical dairy operations.

Methods

Modeling Analysis

The downwind concentrations from a three thousand, six thousand, and nine thousand head dairy operation were modeled with ISCST3. These three diary operations were selected for modeling because dairies located in the San Joaquin Valley are of similar size. Since the amount of PM_{10} emitted by a dairy is affected by such factors as the feed ration of the cows, free stall and milking parlor size, animal waste management, and vegetative cover of surrounding pastures, the overall PM_{10} emission rate is site specific. To simplify the analysis, each dairy operation was modeled using an emission rate of 5, 10, and 15 pounds of PM_{10} per thousand head per day (lb/1000 hd-day). These three emission rates roughly approximate the amount of PM_{10} emitted by a dairy (Parnell, 2006). The cow spacing for the three dairy operations was assumed to 500 ft^2 per head. Furthermore, the dairy property was assumed to be square to facilitate the analysis in ISCST3. A schematic layout of the dairy is shown in Figure 1. Since ISCST3 requires that the emissions from a fugitive source be input as a flux, each emission rate was converted using Equation 1 where flux is in μg/s-m^2 and emission rate is in lb/1000 hd-day.

$$\text{Flux} = \text{Emission Rate}\left(\frac{1\text{ day}}{24\text{ hr}}\right)\left(\frac{1\text{ hr}}{3600\text{ s}}\right)\left(\frac{1\text{ hd}}{500\text{ ft}^2}\right)\left(\frac{10.76\text{ ft}^2}{1\text{ m}^2}\right)\left(\frac{453.6\text{ g}}{1\text{ lb}}\right)\left(\frac{1\times10^6\ \mu\text{g}}{1\text{ g}}\right) \qquad \text{Equation 1}$$

The modeling parameters for the three dairy operations are shown in Table 1. Annual meteorological data for the Texas Panhandle was obtained from the Texas Commission on Environmental Quality and input into ISCST3. Receptors were placed around the perimeter of the dairy to estimate the maximum 24-hour PM_{10} concentration at the property line. Note that the dairy is located in the center of the property.

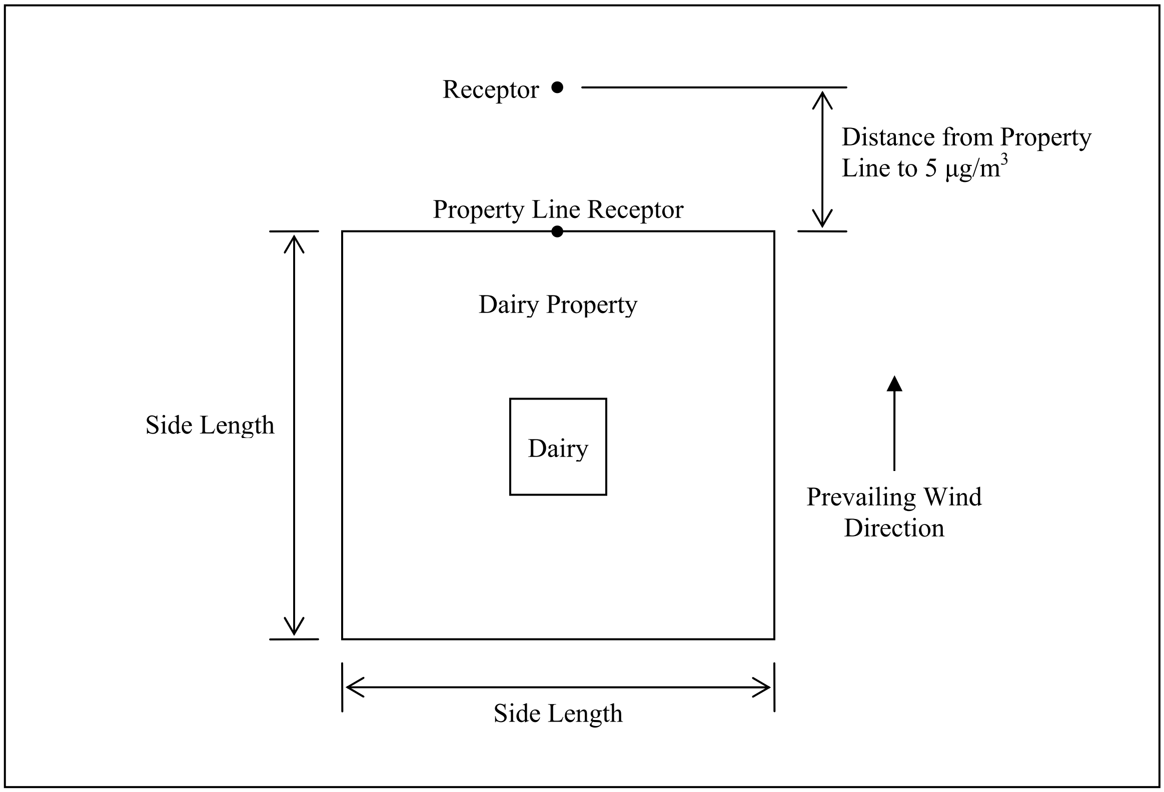

Figure 1. Schematic layout of the dairy modeled in ISCST3.

Table 1. ISCST3 modeling parameters for the three dairy operations.

Number of Head	Dairy Area (ft^2)	Dairy Area (m^2)	Side Length (m)	Emission Rate (lb/1000 hd-day)	Flux ($\mu g/s\text{-}m^2$)
3,000	1,500,000	139,350	373	5	0.566
				10	1.13
				15	1.70
6,000	3,000,000	278,700	528	5	0.566
				10	1.13
				15	1.70
9,000	4,500,000	418,050	647	5	0.566
				10	1.13
				15	1.70

Once the maximum 24-hour property line PM_{10} concentration had been determined for each dairy operation, the receptors were progressively moved outward from the dairy in a concentric array. This process was repeated until the maximum downwind PM_{10} concentration was found to be 5 µg/m^3. At this the location, the distance to the property line was measured and recorded.

Results

The results listed in Table 2 demonstrate that it is unlikely that any of the dairies considered in this analysis will meet a property line PM_c (PM_{10}) concentration of 5 µg/m^3. The results also indicate that the distance from the property line to a maximum PM_{10} concentration of 5 µg/m^3 is substantial for large dairy operations. This means that only those dairies which are located at the center of a large tract of land can meet a property line PM_c (PM_{10}) concentration of 5 µg/m^3.

Table 2. PM_{10} concentrations downwind from the three dairy operations.

Number of Head	Emission Rate (lb/1000 hd-day)	Concentration at Property Line (µg/m^3)[a]	Distance from Property Line to 5 µg/m^3 (m)[b]
3,000	5	21.2	128
	10	22.6	206
	15	23.9	272
6,000	5	42.3	366
	10	45.3	569
	15	47.8	748
9,000	5	63.6	576
	10	67.9	922
	15	73.7	1215

[a] Listed concentrations are maximum 24-hour PM_{10} concentrations.
[b] 5 µg/m^3 was the maximum 24-hour PM_{10} concentration downwind from dairy.

Finally, it must be emphasized that while none of the dairy operations considered in this analysis were able to meet a property line PM_c (PM_{10}) concentration of 5 µg/m^3, all had property line PM_c (PM_{10}) concentrations less than the 24-hour NAAQS of 150 µg/m^3.

Conclusion

The SJVUAPCD misinterpreted the definition of a significant source in Rule 2201 of 40 CFR Part 51. Had the district used the nearest community-oriented monitoring site to determine the contribution of PM_{10} from the dairy, it is highly probable that the dairy would not have been identified as a significant source. Instead, the SJVUAPCD chose to regulate the dairy as a significant source because the modeled property line PM_{10} concentrations exceeded a 24-hour significance level of 5 µg/m^3. As a result of the district's indiscretion, the dairy was required to purchase $800,000 of emissions offsets in order to obtain an operating permit.
In addition to dairies, other agricultural operations are located in the San Joaquin Valley. The three major crops that are harvested in this area are cotton, almonds, and tomatoes (Umbach, 2002). Currently, the cost of emissions offsets in the San Joaquin Valley is approximately $50,000 per ton for PM_{10} with a requirement that an additional 50% is added to the cost if the origin of the PM_{10} credits is not within a specified radius of the facility needing the offsets; however, the cost is expected to increase as offsets become less available (Parnell, 2006). It is for this reason that agricultural operations need to be aware of the regulatory action that is being taken by the SJVUAPCD. This issue is of particular concern to cotton gins that are located in the San Joaquin Valley. Since cotton gins are required to obtain an operating permit, gin managers must understand that Rule 2201 does not authorize the use of the significance levels at the property line. As such, a cotton gin should not be required to meet a modeled property line PM_{10} concentration of 5 µg/m^3 to obtain a permit. Furthermore, gin managers should be discouraged from selling the PM_{10} emission credits allocated to the facility under their current operating permit. Although there is an economic incentive to selling credits, cotton gins that engage in this practice could be forced to cease operation if

their PM_{10} emissions were to exceed their permit allowable emissions. Ultimately, fewer gins could lead to less acres of cotton being grown by producers in the San Joaquin Valley.

References

Code of Federal Regulations (CFR). 2006. *National ambient air quality standards for particulate matter; final rule*; 40 CFR, Part 50, 2006.

Parnell Jr., C.B. 2006. *Personal communication*. Department of Biological and Agricultural Engineering, Texas A&M University, College Station, TX, December 2006.

San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD). 2006. *2006 PM_{10} Plan: Executive Summary*. Available at http://www.valleyair.org/Air_Quality_Plans/docs/Executive_Summary.pdf. Accessed 13 November 2006, 2006.

U.S. Environmental Protection Agency (USEPA). 2006. *U.S. EPA finalizes attainment finding for the San Joaquin Valley*. EPA Environmental News, Region 9, San Francisco, CA, 2006.

U.S. Environmental Protection Agency (USEPA). 1999. *National primary and secondary ambient air quality standards*; 40 CFR, Part 50, 1999.

U.S. Environmental Protection Agency (USEPA). 1986. *Requirements for preparation, adoption, and submittal of state implementation plans*; 40 CFR, Part 51, 1986.

U.S. Environmental Protection Agency (USEPA). 1997. *Terms of environment*; EPA/175/B-97/001; US Environmental Protection Agency, National Source Center for Environmental Publications: Cincinnati, OH, 1997.

Umbach, K.W. 2002. *San Joaquin Valley: Selected Statistics on Population, Economy, and Environment*; California Research Bureau, Sacramento, CA, 2002.

Watson, J. G., J. C. Chow, D. DuBois, M. Green, N. Frank, and M. Pitchford. 1997. *Guidance for network design and optimum site exposure for $PM_{2.5}$ and PM_{10}*. Desert Research Institute, Cooperative Agreement CX824291-01-1. US Environmental Protection Agency, National Center for Environmental Assessment-RTP Office: Research Triangle Park, NC, 1997.