Air Quality: Policies and Standards

The Evolution of Agricultural Air Quality Regulations

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Abstract

The federal government sets health-based standards for criteria air pollutants such as ozone, PM_{10} and $PM_{2.5}$ (particles under 10 and 2.5 microns in diameter, respectively). Historically, agricultural operations have been generally exempt from air quality regulations, including permitting. That has changed dramatically in the last few years, particularly in California. This paper traces the history of agricultural criteria air pollutant regulations. The first criteria pollutant regulations on crop farms were PM_{10} dust rules, which began in the early 1990s. Regulatory programs for volatile organic compounds (VOCs) and oxides of nitrogen (NO_x), which are ozone, PM_{10} and $PM_{2.5}$ precursors, and ammonia, which is a PM_{10} and $PM_{2.5}$ precursor, are more recent.

California Senate Bill (SB) 700, adopted in September 2003, requires California air districts to adopt specific permit and other air regulations for all agricultural operations, and livestock operations in particular. This landmark legislation removed the historical exemption of agricultural operations from air permitting. California ozone non-attainment areas have been adopting regulations that require the permitting of farm equipment and amending their rules to require Best Available Retrofit Control Technology (BARCT); farms will face required upgrading or replacement of engines, gasoline tanks, and certain other equipment. Many new and modified agricultural operations will need to analyze and implement Best Available Control Technology (BACT) for equipment and, for livestock operations, farm units such as barns, corrals, and lagoons.

In addition, the U.S. Environmental Protection Agency (U.S. EPA) has issued a Consent Agreement for participating livestock farms, designed to fund a national emissions monitoring program in exchange for certain legal protections. The flood of air regulatory programs is difficult to track, but an understanding of how they evolved can give a firmer foundation for assessing their impacts on agriculture and air quality.

Introduction

The federal Clean Air Act (CAA) requires that states adopt and implement State Implementation Plans (SIPs) to achieve federal air quality standards for the criteria air pollutants, including ozone PM_{10} and $PM_{2.5}$. Until recently (circa 2003), most states exempted agricultural operations from air quality permitting. Although air quality regulations were not generally prohibited, most odor nuisance and criteria pollutant air quality regulations had exemptions for agricultural operations. This situation has changed, particularly in the West, as non-attainment regions struggle to attain air quality standards by regulatory deadlines and urban areas increasingly encroach on traditional farming areas.

PM_{10} (Dust) Regulations

The CAA requires that all serious PM_{10} non-attainment areas establish, adopt, and implement Best Available Control Measures (BACM) for all significant PM_{10} sources in those areas. The first criteria pollutant regulation on crop farms was Rule 403.1, a PM_{10} dust rule promulgated by the South Coast Air Quality Management District (SCAQMD) in January 1993 for the Coachella Valley (e.g. the greater Palm Springs desert area). Rule 403.1 was developed in consultation with Coachella Valley farmers and required the cessation of tilling during high winds, with certain exceptions. In February 1997, the SCAQMD adopted BACM amendments to its Rule 403 – Fugitive Dust, including BACM for crop farms. SCAQMD staff (including the author) worked with local farmers and farm bureaus to develop a list of agricultural dust control options, known as Best Management Practices (BMPs) for agriculture. The BMPs covered six farm areas (on-field, off-field, farm yards, track-out, unpaved farm roads and storage piles); farmers could choose from a menu of control options for each area. BMPs included high-wind tilling restrictions, mulching, windbreaks, watering/stabilizing of unpaved roads during harvest, etc.

In May 2000, Arizona adopted an Agricultural PM_{10} General Permit. The 34 BMPs that are included in this General Permit expanded on the SCAQMD BMP control options. In addition, the General Permit required at least one BMP for each of the following categories: tillage and harvest, non-cropland, and cropland. In November 2001 (Rule 8081 – off-field agricultural sources) and April 2004 (Rule 4550 – on-field agricultural sources), the San Joaquin Valley Unified Air Pollution Control District (SJVAPCD) adopted Conservation Management Practices (CMPs) for California's Central Valley, one of the most productive agricultural areas in the nation. These CMPs are more detailed than the BMPs originally adopted in other areas, and are crop-specific. Unlike other areas, farmers must submit a CMP plan for approval. A useful handbook of the CMPs and Rule 4550 requirements can be found at www.valleyair.org/farmpermits/updates/cmp_handbook.pdf. In November 2005, California's Imperial County adopted regulations similar to those adopted by SJVAPCD. Table 1 summarizes the development of agricultural BACM regulations.

Table 1. Agricultural BACM Development

Area	Rules (Adoption Dates)	BMP/CMPs	Stakeholder Group
Coachella Valley, CA (SCAQMD)	Rule 403.1 (January 1993)	High-wind tilling restriction	Local farmers and farm bureau
South Coast Air Basin, CA (SCAQMD)	Rule 403 (February 1997, December 1998)	2 to 5 BMPs for each of six farm areas	Agricultural Working Group
Maricopa County (Arizona)	General Permit – Arizona Administrative Code R18-2-610 and 611 (May 2000)	34 BMPs	Arizona Agricultural BMP Committee
San Joaquin Valley, CA	Rule 8081 (November 2001) and Rule 4550 (April 2004)	Multiple crop-specific CMPs and off-field BACM	Agricultural Technical Advisory Committee (AgTech)
Imperial County, CA	Rule 806 (November 2005)	Same as SJVAPCD rules	Technical Advisory Committee (TAC)

Ammonia (as a PM_{10} Precursor) Regulations

After leaving Los Angeles County in the 1970s due to increasing urbanization, many dairies were established in the Chino area of Southern California, just east of Los Angeles County. In its computer modeling of air pollution in the South Coast Air Basin (SCAB, i.e. the greater Los Angeles area), SCAQMD showed that as polluted air masses from the coastal counties passed over the inland dairy areas, the reaction products of the oxides of nitrogen and sulfur produced by vehicles and industries combined with the ammonia from the dairies, creating secondary aerosol particulates that contributed to peak PM_{10} levels in the SCAB. Thus, in its 1989 Air Quality Management Plan (AQMP) and every air quality plan thereafter, the SCAQMD included a control measure to reduce PM_{10} dust, ammonia, and VOCs from livestock waste (in particular, dairy manure). After working with stakeholders for more than three years, the SCAQMD adopted Rule 1127 – Emission Reductions from Livestock Waste, which established BMPs and manure disposal requirements for local dairies. The focus of Rule 1127 was on ammonia emission reductions, as part of an overall PM_{10} attainment strategy, although the rule also requires reductions in PM_{10} dust and VOCs.

At this time, the SJVAPCD is awaiting the results of the California Regional Particulate Air Quality Study (CRPAQS) before determining the role of ammonia reductions in its attainment strategy for the PM_{10} and $PM_{2.5}$ ambient air quality standards. As stated in its 2003 PM_{10} Plan: "No ammonia controls are proposed for immediate implementation in the PM_{10} Plan; however, the District is committed to pursuing an expeditious ammonia control strategy. In light of the uncertainty regarding ammonia emission controls to achieve attainment, the PM_{10} Plan includes a strategy to further assess and develop any needed control for ammonia sources, especially dairies. Implementation of any controls would depend on further analysis of the Valley's ammonia chemistry as part of CRPAQS. As the results of that study become available, the District commits to adopting ammonia control measures that have been demonstrated as technologically and economically feasible and necessary for the San Joaquin Valley."

California's Senate Bill 700 (SB 700)

In November 2001, U.S. EPA approved California's Title V program for major sources (as defined in the CAA). As in many states, California farms and farm equipment were exempt from air permitting regulations. Environmental groups sued U.S. EPA on the grounds that California's Title V program did not include agricultural sources. Under a settlement agreement, U.S. EPA issued a notice of deficiency to the state's air districts and proposed to withdraw approval of California's Title V program if the agricultural exemption was not removed. SB 700, adopted in September 2003, removed the air permitting exemption, allowing California's air districts to continue implementing their Title V programs. But SB 700 went significantly beyond simply addressing the Title V deficiency. SB 700:

1. defines "agricultural source" in state law;
2. removes the state law restriction that prohibited air districts from requiring permits for agricultural sources;
3. establishes specific permitting and exemption requirements for agricultural sources;
4. requires emission control regulations in PM_{10} non-attainment areas;
5. requires permits and emissions mitigation for "large" confined animal facilities (LCAFs); and
6. requires that the California Air Pollution Officers' Association (CAPCOA) compile a clearinghouse of information about agricultural source emission controls and mitigation strategies.

Under SB 700, air districts must require permits for all "agricultural sources" on farms with emissions of more than ½ of any Major Source Threshold for that area, unless certain findings are made at a public hearing. (For example, the Major Source Threshold for NO_x and VOC in the SCAB is 10 tons/year; in the San Joaquin Valley, it is 25 tons/year). Conversely, an air district cannot require permits for "agricultural sources" at farms with emissions less than ½ of each Major Source Threshold, unless specific findings are made at a public hearing. By definition, a livestock operation is an agricultural source, subject to permitting. The individual air districts were required to adopt or amend their BARCT rules for agricultural sources and to assess and require BACT for certain new and modified farming operations. To assist air districts in implementing SB 700, CAPCOA prepared an implementation guide, which can be found at www.capcoa.org/sb_700.htm. CAPCOA's "Agricultural Source Clearinghouse of Air Pollution Reduction Methods" can be found at www.capcoa.org/Agclearinghouse/index.html. The following sections discuss how the California Air Resources Board (CARB) and the largest air districts in California have been implementing SB 700.

California Air Resources Board (CARB)

In California, individual air districts regulate stationary sources and thus are directly responsible for adopting and implementing SB 700 regulations for farms and non-mobile farm equipment. CARB has the responsibility to set emission limits on certain off-road mobile sources found on farms and is required under SB 700 to establish the definition of an LCAF. CARB has expanded its emission inventory research for agricultural sources and has also recently expanded its guidance for the Carl Moyer Program, an incentive program that funds cleaner engines and equipment, to include a wider variety of eligible agricultural projects.

CARB conducted (and continues to conduct) several agricultural research programs. The programs include dairy and poultry emission studies (VOCs and ammonia), air quality monitoring, mitigation practice evaluations, and technology assessments. CARB is also sponsoring studies of emissions and ozone impacts of pesticides and fumigants. A summary of agriculture related research in California can be found at www.arb.ca.gov/ag/research/research.pdf. In addition, CARB hosted a San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel to help determine which technologies and management techniques are most likely to improve the management and treatment of dairy manure in the San Joaquin Valley. Panel members were drawn from government, industry, academia, and environmental and conservation groups. The final dairy manure feasibility assessment report (December 2005) and other related information can be found at www.arb.ca.gov/ag/caf/dairypnl/dairypanel.htm.

In June 2005, CARB adopted its LCAF regulation, which established LCAF permitting thresholds for all animal farms (www.arb.ca.gov/regact/lcaf05/lcaf05.htm). From the CARB LCAF staff report:

Table 2. LCAF Thresholds (Attainment status is based on the federal 1-hour ozone designation as of January 1, 2004)

Livestock Category	Nonattainment Areas*	Attainment Areas*
Dairy	1,000 milk producing cows	2,000 milk producing cows
Beef Feedlots	2,500 beef cattle	5,000 beef cattle
Other Cattle Operations	7,500 calves, heifers, or other cattle	15,000 calves, heifers, or other cattle
Chickens – Broilers	650,000	1,300,000
Chickens -- Egg Layers	650,000	1,300,000
Turkeys	100,000	200,000
Swine	3,000	6,000
Sheep and Goats	15,000	30,000
Horses	2,500	5,000
Ducks	650,000	1,300,000
Rabbits, Pheasants, Llamas, Others	30,000	60,000

For non-attainment areas, LCAF permitting rules must be adopted by June 30, 2006. Complete information on CARB's agricultural programs can be found at www.arb.ca.gov/ag/ag.htm.

San Joaquin Valley Air Pollution Control District

In May 2004, dairy groups sued the SJVAPCD over the implementation of SB 700-related permitting requirements. Dairy groups contended that under SB 700, large dairies should not be required to obtain permits until emission studies were completed. In the lawsuit settlement agreement, a Dairy Permitting Advisory Group (DPAG) was formed, with members from dairy groups, academia, and environmental groups. DPAG issues included devising a new VOC emission factor for dairies based on the most recent research, assessing BACT for dairies, and developing technical guidance on what types of dairy modifications should trigger New Source Review. DPAG submitted emission factor guidance to the SJVAPCD Executive Officer in July 2005 and made final recommendations on BACT for dairies in January 2006. More information on DPAG and DPAG projects can be found at www.valleyair.org/busind/pto/dpag/dpag_idx.htm. Although the DPAG has fulfilled its charter as laid out in the settlement agreement, many of the projects it highlighted, including emission factor research and control technology assessment, continue.

Other SB 700-related rules and rule amendments adopted by SJVAPCD include Rule 4702 (Internal Combustion Engines – Phase 2), and Rule 2250 (Stationary Equipment Registration). It also amended Rule 4202 (Cotton Gins) and Rule 8081 (Off-Field Agricultural Sources) to further reduce PM_{10} emissions and adopted Rule 4103 (Open Burning) to implement SB 705 (a law related to SB 700). The SJVAPCD is currently working with livestock industry stakeholders and the public to develop Proposed Rule (PR) 4570, which would implement the LCAF provisions of SB 700. Early discussions indicate that PR 4570 will use the CMP concept contained in SVJAPCD Rule 4550. As noted above, since the San Joaquin Valley is an ozone non-attainment area PR 4570 must be adopted by June 30, 2006.

South Coast Air Quality Management District

With the adoption of SB 700, the SCAQMD formed the SB 700 Working Group, including farm bureau and other agricultural stakeholder groups. In December 2005, the SCAQMD amended several of its Regulation II permitting rules to incorporate SB 700's definition of agricultural sources and related permitting requirements. Farmers will now have to pay permit application and annual renewal fees. In June 2005, SCAQMD amended Rule 1110.2 – Emissions From Gaseous- And Liquid-Fueled Internal Combustion Engines and Rule 461 – Gasoline Storage and Transfer to remove existing exemptions for agricultural sources. (None of the other SCAQMD Regulation XI (e.g. source-specific) rules contained exemptions for agricultural sources.) Based on these amended rules, almost all non-emergency engines greater than 50 brake-horsepower on farms will have to be replaced with electrical or controlled natural gas engines and all gasoline tanks greater than 251 gallons will require service-station-type control equipment.

As required by SB 700, SCAQMD is now imposing permit requirements on all livestock operations emitting over 5 tons/year of VOC or NO_x. With the current emission factors, this includes all dairy farms

with more than 780 adult cows and all poultry operations with more than 390,000 birds. These farms may be assessed from $2,000 to over $10,000 a year in emission fees, based on current emission factors and SCAQMD regulations. All SCAQMD livestock operations, including LCAFs, are subject to the SCAQMD permitting, BARCT rules (including Rule 1127 – Emission Reductions from Livestock Operations) and BACM Rules (e.g., Rules 403 and 1186). Through the SB 700 Working Group, SCAQMD staff is working with industry stakeholders on PR 223, the SCAQMD's LCAF rule, which must be adopted by June 30, 2006.

U.S. EPA's Consent Agreement

The criteria pollutant rules and regulations discussed above are based on federal CAA requirements. As a result of court cases, livestock farms (also known as animal feeding operations, or AFOs) are also being required to comply with various other environmental laws, such as the hazardous substance release notification provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, also known as "Superfund") and the emergency notification provisions of the Emergency Planning and Community Right-to-Know Act (EPCRA). Beginning in 2002, U.S. EPA worked with multiple stakeholders, including farming representatives, air agency organizations, environmental groups, and the scientific/technical community to address the issues arising from these court cases. As a result, the EPA issued its air quality Consent Agreement in the Federal Register on January 21, 2005. The consent agreement can be found at www.epa.gov/compliance/resources/agreements/caa/cafo-agr-050121.pdf. According to U.S. EPA, the goals of the Agreement are to reduce air pollution, ensure compliance with applicable CERCLA and EPCRA provisions, monitor and evaluate AFO emissions, and promote a national consensus on methodologies for estimating emissions from AFOs.

Under the agreement, livestock farms that sign the Agreement will need to pay a civil penalty ranging from $200 to $100,000 (depending on size) and provide up to $2,500 per farm location to support the EPA's data collection and emissions monitoring program. The farm must be available for emissions monitoring, apply for applicable air permits and conditions, install BACT on sources above the Major Source Threshold, and report certain releases of ammonia and hydrogen sulfide. In exchange, U.S. EPA covenants not to sue the farm for past violations of certain provisions of the CAA, CERCLA, and EPCRA, subject to certain limitations.

The sign-up period to accept the Agreement ended August 12, 2005. To date, U.S. EPA has received more than 2,600 signed Agreements, which must be ratified by the U.S. EPA's Environmental Appeals Board. Applicants are located in more than 37 states and include representation from the pork, egg layers, meat birds, and dairy industries. The monitoring program began in early 2006 and will continue for approximately 24 months. Pollutants to be monitored include particulate matter, hydrogen sulfide, VOCs, and ammonia. The latest information on the Consent Agreement program can be found at www.epa.gov/compliance/resources/agreements/caa/cafo-agr-0501.html.

Conclusions

Agricultural air quality regulations have developed rapidly from the simple dust control provisions of the early 1990s. Federal, state, and local air agencies are promulgating many different rules, regulations, programs, and policies. This brief summary of the evolution of agricultural air quality regulations is intended to provide a foundation of understanding as the science and regulation of agricultural air emissions goes forward.

References

All internet references in this paper were accessed on February 14, 2005.

Agriculture and the Clean Air Act

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Abstract

This presentation will address the implications of Clean Air Act regulations and policies for farms. It will include a discussion of the potential impacts of proposed revisions of the Particulate Matter standards and the guidance and policies which will be developed to implement these standards. It will also include a discussion of the potential obligations of animal feeding operations under the Clean Air Act as well as the EPA's ongoing activities to try to look at farming operations from a cross-media perspective.

Regulating Air Pollutants Emitted by Agricultural Operations

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Abstract

We have a system of regulating emissions of air pollutants that is the envy of the world. It consists of a federal agency (USEPA) that provides the direction and over-sight for state air pollution regulatory agencies (SAPRA). The system includes federal and state rules and regulations. EPA's authority to regulate emissions of air pollutants is provided by federal law in the form of the clean air act (CAA). State's authority to regulate and enforce emission limits is derived from state laws. States usually perform the permitting and enforcement regulatory functions although USEPA periodically will take enforcement actions such as in the Buckeye Egg case. EPA provides over-sight of the state actions. States monitor and report ambient concentrations of criteria pollutants. USEPA promulgates National Ambient Air Quality Standards (NAAQS) for criteria pollutants and designates non-attainment areas. Non-attainment areas are areas where the ambient concentrations are higher than the NAAQS for a specified criteria pollutant. States develop and submit to USEPA state implementation plans (SIP) designed to bring non-attainment areas into attainment.

The goal of the system of regulating emissions of air pollutants from all sources is to protect the public. Are we regulating agricultural sources of air pollutants correctly? Some would argue that all sources of air pollutants should be regulated equally. Others would argue that rural sources of air pollutants should be treated differently. Can we ignore the location of the public? Should USEPA/SAPRA use the same emission limitations for agricultural sources located miles from the nearest occupied residence as that used for similar sources in an urban area? For example, the NAAQS for PM_{10} is 150μg/m^3 (24-hour average concentration). NAAQS are most often used to determine whether areas are classified as non-attainment. USEPA and many SAPRA are limiting PM_{10} concentrations at the property line (fence line) to the NAAQS for permitting purposes. (This is a special use of the NAAQS according to an EPA representative.) The concentrations used in this "special use" of the NAAQS may be the result of modeling and/or sampling. Rural sources may be located at a considerable distance from the nearest occupied residence but because the SAPRA has used this policy for non-rural sources, this same policy must be used to regulate rural sources. Some would argue that this use of the NAAQS is inappropriate. This paper will address controversies associated with regulating emissions from agricultural operations. The topics will include (1) the proposed PM coarse (PMc) NAAQS and the proposed subtraction method for determining concentrations, (2) use of TSP (rather than PM_{10}) for requiring Title V and PSD Permits, (3) CERCLA, (4) PM_{10} and $PM_{2.5}$ sampler bias, and (5) use of dispersion modeling results for permitting and enforcement of agricultural operations.

Voluntary Versus Regulatory Agricultural Air Quality Management Policies: Proactive Is Better Than Reactive

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Abstract

As the stewards of more than half the US land mass, those engaged in agriculture are key to the future success of incentive based environmental management. Farmers and producers should realize though that the best time to act to develop voluntary approaches to problem resolution is before regulatory actions are in the wings. When regulatory programs are inevitable, it is in the interest of agricultural get to the table early to make sure the programs are effective both economically and technically.

Discussion

Frequently cast as the first environmentalists, most farmers and livestock producers would readily take the actions needed to reduce their environmental footprint if it could be done in an economical way. Unfortunately, controlling losses to the environment typically costs more than when such control costs are externalized. How then can the problems of agricultural atmospheric emissions be controlled without giving away the farm? The answer may be that agriculture needs to take proactive steps to embrace new approaches and new allies. For example, traditionally, the federal Farm Bill has contributed money to help farmers achieve price stability for crops and, to a lesser extent, to help pay for actions on the farm which lead to improved environmental performance. However, in current international debates, trading concerns over Farm Bill crop subsidies are increasingly a problem. A proactive approach for the agricultural industry to simultaneously resolve this problem as well as many of its environmental concerns might be to join with the broad coalition of groups supporting the restructuring the Farm Bill towards increased funding for conservation practices and habitat protection.

In addition, the agricultural industry will likely be more successful in getting voluntary incentive based control programs if its members step up to the plate in other areas before regulatory actions are looming. A prime example of such an opportunity currently exists for green house gases. For example, a voluntary green house gas registry and a transferable credit system has been recommended to President Bush by the Secretaries of Energy, Commerce, and Agriculture and the Administrator of EPA. Even though agriculture's role in green house gas emission reductions are solely as a sink, fear of potential mandatory reductions if any green house gas emissions are acknowledged seem to be paralyzing many in the agricultural industry. Might mandatory reductions of green house gases fall upon agricultural activities in the future? Yes, but an effective program with farmers providing carbon credits would not speed such regulations and the experience gained will serve farmers well if regulations do come about.

It is understandable that agriculture also wants certainty in existing regulatory programs. Efforts such as the EPA AFO Consent Agreement and Final Order are driven by those desires for certainty. But such efforts must be developed in an open forum, and be adequate to achieve their goals if they are to have wider support. Furthermore, frustration from all interested parties over the air emissions regulatory programs such as CERCLA have led to a very nonproductive situation. Eventually, emissions of gases such as ammonia from agricultural activities will need to be directly addressed. If new regulations mandate controls, will they be misguided and inappropriate for agriculture? Chances are much greater that they will be unless representatives from the agricultural industry are at the table working to create control programs that make sense for farmers and are effective in controlling emissions.

Implications of PM Coarse Federal Air Quality Standard for Agriculture

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Abstract

The EPA is proposing a revised particulate matter (PM) national ambient air quality standard (NAAQS), which establishes a dual standard that parses the current PM_{10} standard into fine ($PM_{2.5}$) and coarse ($PM_{10-2.5}$) fractions. In arid western regions of the U.S., multiple factors converge causing emissions and transport of airborne PM from cultivated agricultural fields that have caused numerous exceedances and violations of the PM_{10} standard. Violations of the NAAQS can lead to EPA sanctions and extensive planning efforts associated with declared non-attainment status. The proposed $PM_{10-2.5}$ NAAQS lowers the bar for exceedances and violations with a proposed level of 70 $\mu g \bullet m^{-3}$. Implicit in this level is the assumption that the $PM_{2.5}$ to PM_{10} ratio is approximately 0.50. However, this ratio is not independent of total concentration ($\mu g \bullet m^{-3}$) of PM in the airborne dust, the mechanism of entrainment, or source characteristics. Data for the arid region of the Columbia River Plateau in eastern Washington State shows that during a wind erosion event the $PM_{2.5}$ to PM_{10} ratio tends to decrease (approaching 0.04) as PM_{10} concentration increases. This variance of the ratio coupled with the reduced concentration threshold of the $PM_{10-2.5}$ standard indicates a significant probability that exceedances and violations of the federal standard will increase from 4- to 15-fold, which falsely gives the appearance of serious air quality deterioration.

The EPA's Natural Events Policy (NEP) issued in 1996 addresses violations of the federal PM_{10} standard from high wind soil erosion events, which are generally beyond reasonable management control. The latter includes cultivated agricultural fields that have best management practices (BMP) or best available control measures (BACM) in place but are overwhelmed by wind erosion events. The NEP calls for documentation of a natural event to characterize an exceedance that occurred as a consequence of overwhelmed BACM. Acceptable documentation means that such exceedances can be excluded from counting toward a violation. Adverse consequences and significantly more complications in implementation of the NEP may result as the $PM_{10-2.5}$ standard increases the frequency of exceedances by several-fold. As the number of exceedances significantly increases, so does both the documentation workload and burden of proof as a natural event. These factors coupled with a perceived worsening of the problem may decrease EPA's regulatory tolerance beyond that which can be addressed with the Natural Events Policy. Many questions arise from the $PM_{10-2.5}$ NAAQS proposal.

Introduction

The geological history of the area includes catastrophic flooding from build up of water behind ice dams during the ice age, which subsequently were catastrophically breached. The ensuing floods sent several hundred feet of water carrying massive amounts of sediment that was deposited in various areas across the Columbia River Plateau. The soils that we have today are a result of subsequent re-working and re-depositing by water and wind. The soil texture is dominated by silt and sand-sized particles with low clay and organic matter content, which causes inherently low aggregate stability. These soils are inherently vulnerable to wind erosion. The immediate aftermath of catastrophic floods was massive aeolian or windblown sediment transport (major dust storms) amounting to many tens of feet of deposition downwind from the flood deposits.

The general precipitation level varies from approximately 5 inches to 25 inches across the Columbia Plateau with the most vulnerable areas to wind erosion in the lower precipitation areas. Natural vegetation of shrub-steppe eventually stabilized the landscape but frequent natural fires made the landscape vulnerable to dust storm conditions without significant anthropogenic influence. Every era of history after the flooding saw dust storm events in which overall landscape stability varied with weather and climate patterns, which in turn further interacted with landscape stability to produce windblown dust events.

Anthropogenic factors were active even in early native settlement. The low native population generally produced only a low degree of anthropogenic disturbance but included area burning deliberately set for various cultural reasons. Subsequent settlement brought ranching and crop production and increasing population with associated increase in landscape disturbance and perturbation. Consequently the probability increased for wind events that produced dust storms. Dryland and irrigated cropping have become a significant percentage of land use complimented by rangeland, nearly native areas, and some largely undisturbed native areas. Land uses in this region of Eastern Washington include native shrub steppe, rangelands, dryland agriculture, and irrigated agriculture. Today small urban areas with cities of substantial population density also exist as a land use within the Columbia Plateau.

Modern management practices on cropland with the goal of maintaining vegetative cover on the soil surface have been developed and annual landscape stability is relatively good. However, there are a few windows of vulnerability that occasionally correspond to wind events capable of producing dust storms. These dust storms impact people in the urban areas.

Discussion

History of Windblown Dust Exceedances of PM_{10} NAAQS

Ambient air quality in Kennewick Washington, located in the southwestern portion of Columbia Plateau, is measured and represented by a PM_{10} federal reference method (FRM) monitor. Another PM_{10} FRM site is located approximately 135 miles to the northeast in Spokane Washington. Both these FRM sites have recorded numerous windblown dust exceedances of the PM_{10} national ambient air quality standard (NAAQS) since this standard was established in 1987. Both Kennewick and Spokane are small urban areas and are located downwind from several thousand acres of non-irrigated and irrigated agricultural fields. The airborne PM measured at the air quality monitoring sites comes principally from a combination of wind erosion from upwind agricultural fields and active construction sites in the urban area. Other sources such as re-entrained paved road dust, unpaved roads, and dust from other dust-generating sources also contribute.

In addition to its downwind location, Kennewick is generally vulnerable to windblown dust for a number of reasons, including an arid climate, soils with inherently high potential for wind erosion, periods of low overall landscape stability, and a sufficient frequency of high winds to drive severe wind erosion. Figure 1 shows the exceedances from agricultural windblown dust measured from 1985 through 2005 at Kennewick. The long-term frequency of PM_{10} NAAQS exceedances at Kennewick is approximately one every 7 months (37 exceedances in 20 years). The PM_{10} NAAQS form in 40 CFR Part 50 Appendix K allows only 1 exceedance per year and the frequency of observed exceedances causes the Kennewick area to be in violation of the NAAQS.

The distribution of exceedances in time varies with weather patterns such as periodic droughty conditions. Figure 2 shows the distribution of exceedances among months in which they occurred as well as the relationship to the annual precipitation pattern. Based on analysis of historical weather data an aridity or drought index, which combines temperature and precipitation data, shows a periodicity of roughly 10 to 12 years (data not shown). Twenty years of PM_{10} FRM monitoring at the Kennewick site reflects this in the periodicity of PM_{10} NAAQS exceedances (Figure 1) and very roughly confirms this observation.

Addressing Windblown Dust since PM_{10} NAAQS was Promulgated

The Columbia River Plateau is centered in Eastern Washington and extends into western Idaho and northeastern Oregon. Several other FRM monitoring sites are located in the Columbia Plateau region and also frequently record PM_{10} NAAQS exceedances. Many of these exceedances happen on the same dates region-wide across the Columbia Plateau. The coincidence of these exceedances is indicative of large region-wide wind events and corresponding dust storms. The passage of weather fronts on a regional scale drives strong gusty winds and causes the windblown dust events that, given unstable landscape conditions, result in PM_{10} NAAQS exceedances. The peaks in March and September (See Figure 1) are associated with agricultural tillage and planting operations that coincide with winter-spring and summer-fall weather transition periods that are characterized by front passages with attendant high wind speeds and gustiness.

Figure 1

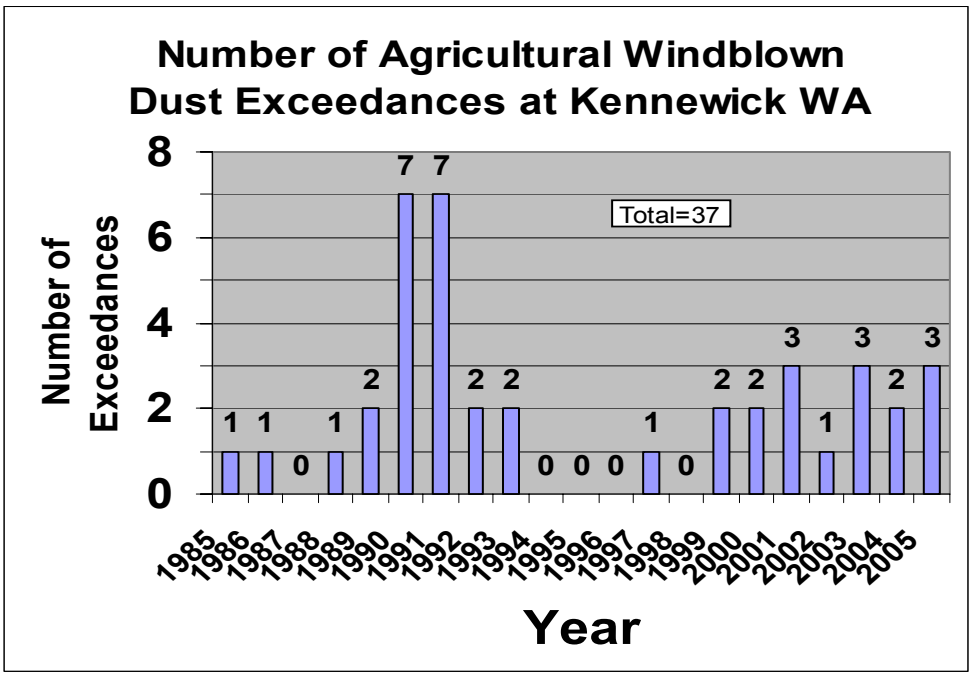
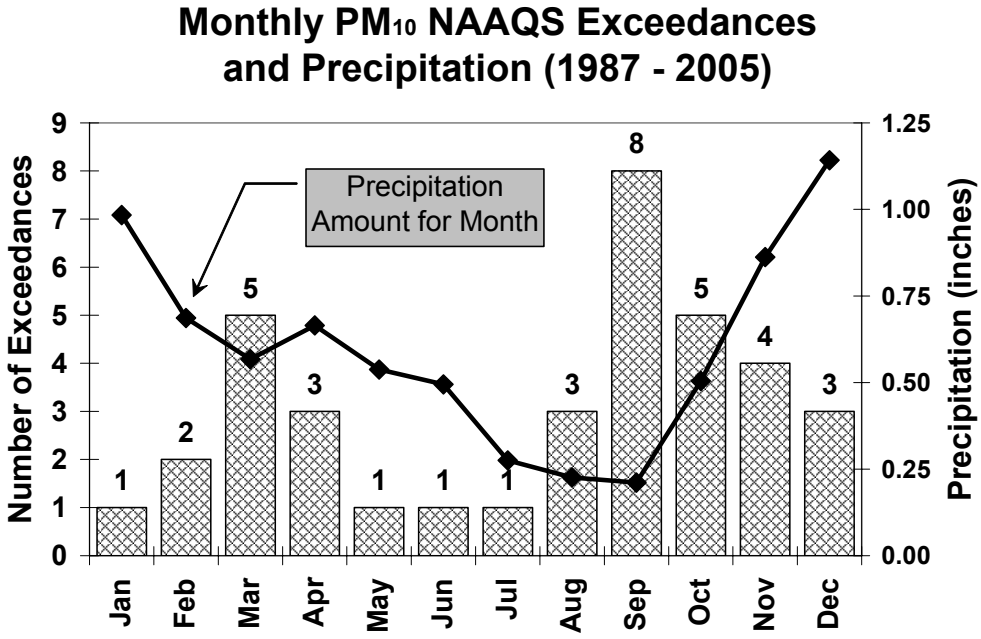


Figure 2



To address the PM_{10} NAAQS exceedances at Kennewick through 1993 a Memorandum of Agreement (MOA) was used as precursor to the current EPA Natural Events Policy (NEP) for windblown dust, which allows PM_{10} NAAQS exceedances to be discounted from contributing to a NAAQS violation. The period before the 1996 adoption of the NEP was covered by the MOA among the Benton Clean Air Authority (BCAA), Washington State Department of Ecology (Ecology), and the EPA. All parties mutually agreed that major wind events could overwhelm even best management practices. Therefore, the traditional non-attainment procedures would not correctly target or bring about demonstrable control of windblown dust. From 1996 forward, the requirements of the NEP have been implemented by the BCAA and Ecology to deal with windblown dust PM_{10} NAAQS exceedances. To date in Eastern Washington Natural Events Policy documentation has been used to exclude 15 PM_{10} NAAQS exceedances from counting toward a violation of the standard.

Transition from PM_{10} to the Proposed $PM_{10-2.5}$ NAAQS

After the promulgation of the 1997 $PM_{2.5}$ NAAQS, both the $PM_{2.5}$ NAAQS and the PM_{10} NAAQS have been under intense scrutiny by stakeholders on both sides of the issue. The result has been a parsing of the original PM_{10} fraction into "fine" ($PM_{2.5}$) and "coarse" ($PM_{10-2.5}$) fractions. The basis for this division is the fundamentally different physical and chemical makeup of the two fractions. The fine fraction, $PM_{2.5}$, originates predominately from combustive processes plus formation of aerosols of inorganic salts such as ammonium nitrate, sulfate, and chloride. The coarse fraction, $PM_{10-2.5}$, is of different origin coming principally from such sources as windblown dust generated from the mechanical disturbance of soils and mining activities, which frequently involves crushing of rock and other activities that generate dust. The majority of $PM_{10-2.5}$ consists of crustal material or minerals found in rock and soil.

Previous to the announcement setting the proposed level, analysis of the frequency of exceedances of a range of estimated $PM_{10-2.5}$ concentrations revealed that when the ratio of $PM_{2.5}$ to PM_{10} is low the number of $PM_{10-2.5}$ exceedances would be several-fold that observed for current PM_{10} NAAQS (See Table 1). That is, a low $PM_{2.5}$ to PM_{10} ratio in effect makes $PM_{10-2.5}$ concentration nearly equivalent to PM_{10} concentration, which then naturally would more frequently exceed the lower threshold (below 150 $\mu g \bullet m^{-3}$) concentration for exceedances in proposed $PM_{10-2.5}$ NAAQS.

Table 1: Estimated Increase in Number of NAAQS Exceedances at Various Threshold Levels of the Proposed $PM_{10-2.5}$ Standard

Selected $PM_{10-2.5}$ Daily NAAQS Value	Estimated $PM_{10-2.5}$ Exceedances (1999 – 2002)	Observed PM_{10} Exceedances (1999-2002)	Estimated Increase (fold)
75	29	8	3.6
65	36	8	4.5
55	48	8	6.0
45	71	8	8.9
35	120	8	15.0

When the details of the new proposed PM national ambient air quality standard (NAAQS) were revealed on 20 December 2005 it perhaps raised more questions than it answered regarding implications of the standard for areas where windblown dust is significant or even the sole contributor to the monitored PM levels. The proposed $PM_{10-2.5}$ concentration level is 70 $\mu g \bullet m^{-3}$. Frequency analysis was preformed on 20 years of PM_{10} data collected at Kennewick from 1985 through 2005. In this period there were 37 exceedances of the PM_{10} NAAQS at 150 $\mu g \bullet m^{-3}$. Estimated $PM_{10-2.5}$ concentrations were calculated from a $PM_{10-2.5}$ to PM_{10} ratio of 0.96. The latter ratio was determined from asymptote and linear regression analyses from x-y plots of PM_{10} concentration against $PM_{2.5}$ to PM_{10} ratios and $PM_{10-2.5}$ concentrations, respectively (See Figures 3 and 4). The ratio estimate is valid only at PM_{10} concentrations above 70 $\mu g \bullet m^{-3}$

Figure 3

PM_{10} Concn µg/m³	$PM_{2.5}/PM_{10}$ Ratio Mean	Std Dev	N	Coefficient of Variation
>=75	0.062	0.035	34	56%
<75	0.36	0.22	1220	62%

PM_{10} Concn µg/m³	$PM_{2.5}/PM_{10}$ Ratio Mean	Std Dev	N	Coefficient of Variation
>=37	0.19	0.17	182	89%
<37	0.37	0.22	1072	58%

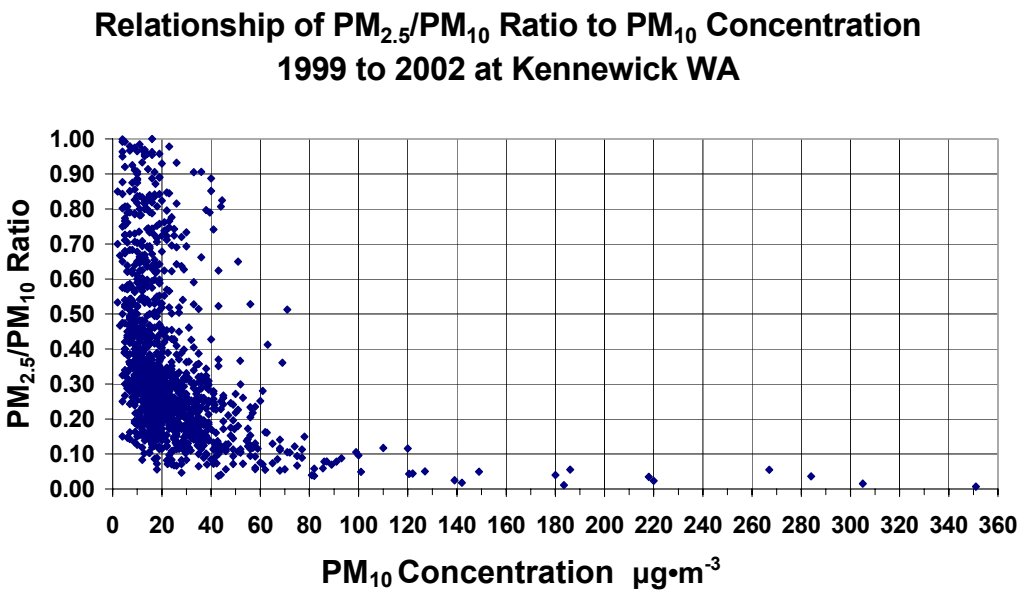
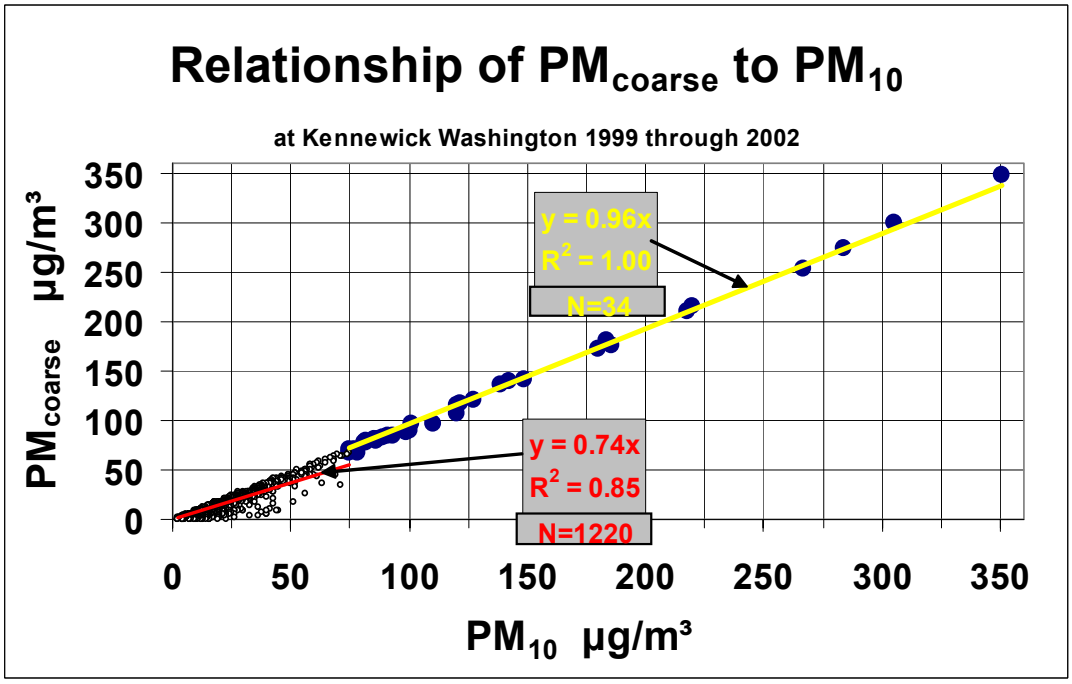
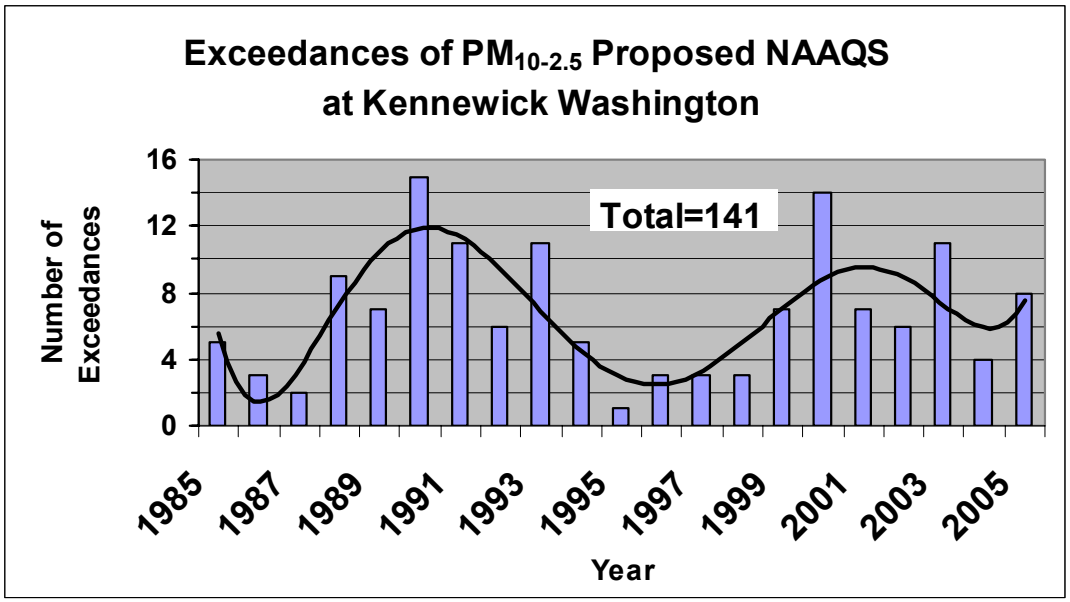


Figure 4



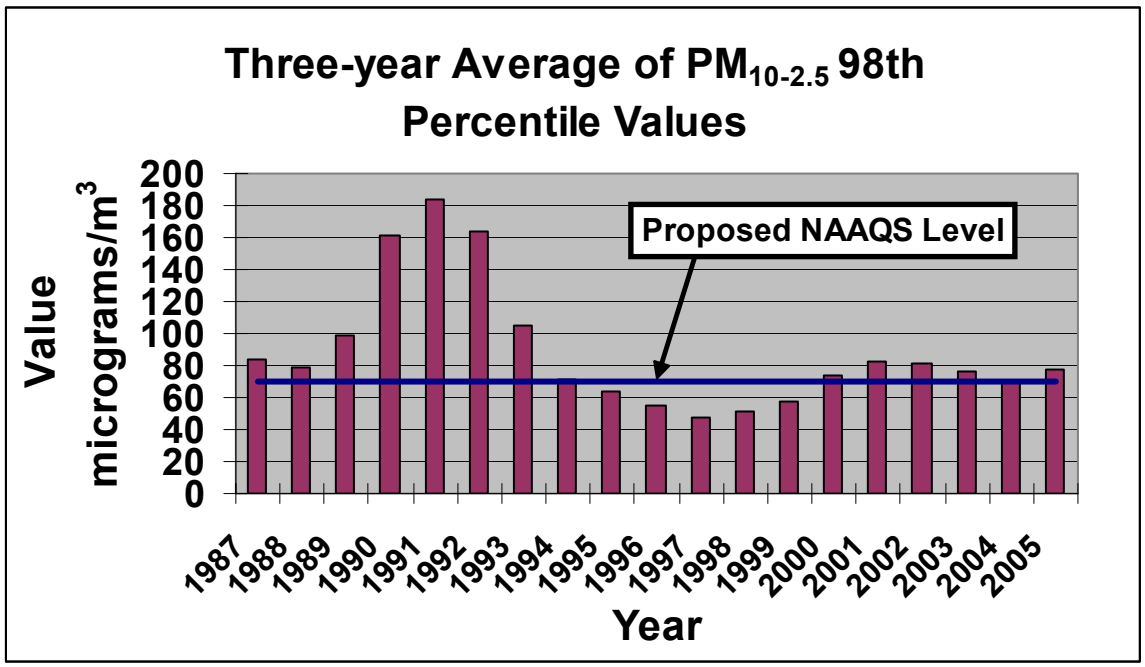
The calculated $PM_{10-2.5}$ values exceeded the proposed level of 70 µg•m^{-3} a total of 141 times from 1985 through 2005, which is 3.8 times the number of recorded PM_{10} exceedances (See Figure 5).

Figure 5



The form of the daily (24-hour average) for $PM_{10-2.5}$ NAAQS is the three-year average of 98th percentile values compiled and calculated annually. If the proposed $PM_{10-2.5}$ NAAQS is implemented in the latter form the Kennewick area could nearly be in perpetual violation of the standard. Figure 6 shows the years in which $PM_{10-2.5}$ NAAQS violations (as opposed to exceedances) would have occurred in the period of 1987 through 2005. Each value in a particular year is the average of the 98th percentile value for that year and the previous two years. The larger peak in 1991 occurred when prolonged drought and winter-kill of dryland wheat in the agricultural fields upwind of the Kennewick monitor progressively depleted crop residues at the soil surface until the stability of the landscape decreased to a point that it was extremely vulnerable to wind erosion. The resulting estimated $PM_{10-2.5}$ exceedances would have kept the area in violation of the NAAQS from 1987 through 1994. Normal to above average precipitation that actually began in 1992 and continued through 1998 caused the violations to cease in the period 1995 through 1999. Another period of deficit precipitation began in 1997 and continued through 2005 and predictably $PM_{10-2.5}$ NAAQS violations again resumed from 2000 through 2005. Note that the occurrence of violations reflects several years of lag time of the effects of the droughty periods that are associated with the time required to deplete or build up crop residue. This is a result of the 2-year summer fallow winter wheat growth cycle that dominates the agricultural fields upwind from the Kennewick monitoring site.

Figure 6



Implications of the Proposed $PM_{10-2.5}$ for Agriculture

The only thing that is certain about the situation regarding implications for agriculture from the proposed $PM_{10-2.5}$ NAAQS is uncertainty. The complicating aspect of the proposed $PM_{10-2.5}$ NAAQS with respect to agriculture is the unprecedented categorical exemption from the standard that is a proposal to exclude windblown dust from agricultural fields. Dust from mining activity was also included in this exemption. At first it appears that there are no implications to agriculture because of the categorical exemption. However, depending on the view taken, this exemption could be a desirable outcome or a snake in the grass some time in the future. This is the first time that a NAAQS has been proposed that did not apply nationwide. The origin of this exemption is apparently principally because of lack of evidence for significant health effects and mortality associated with exposure to the coarse fraction of inhaled $PM_{10-2.5}$. One possible problem with this approach is that lack of epidemiological evidence does not necessarily mean no health effects exist, but presently there is simply not sufficient statistical power to detect the effects because of lack of a sufficient population in the sample. What will be the position of EPA if at some future time health effects are found to be significant from exposure to agricultural windblown dust?

There is also the potential loss of credibility from suddenly abandoning the long standing PM_{10} standard that for 20 years has been a concern and attributing any health effects only to the embedded $PM_{2.5}$ fraction. The implicit assumption in the current proposal is that rurally-derived $PM_{10-2.5}$ is pristine and only urban-derived dust is contaminated with harmful components. There are pesticides, some of which are classified as toxic, persistent, and bio-accumulative, that may be associated with rural dust and may be adsorbed to the particles and carried along to distant receptors. Soils in fields adjacent to heavily traveled paved roads through rural areas may have accumulation of lead carried over from the use of lead additives in the past. There may also be some as yet undetected direct effect from the physical and chemical interaction of coarse particles within the respiratory system.

There is also what is known as “welfare” effects of ambient air quality standards, which are deleterious effects other than health effects. Visibility is one of these effects, which includes degradation of long-distance visibility of desirable vistas. Also there is degradation of short-distance visibility adjacent to agricultural fields that obscures roadways and causes safety hazards to traffic and road closures. Deposits of dust on public and private property, into adjacent bodies of water, on sensitive equipment are other examples of welfare effects. These are all effects that can be a result of windblown dust from agricultural

fields that can be close to the source or hundreds of miles away as even $PM_{10-2.5}$ can be entrained and remain airborne for many hours to days.

There is a momentum and forward movement in rural areas to take responsibility for wind erosion and resulting long-distance transport of coarse fraction PM. Resources have been and are being allocated to conservation of soil and water resources related to wind erosion and windblown PM. The EPA agricultural exemption in the proposed $PM_{10-2.5}$ NAAQS takes away some of the incentives to pursue these efforts and continue development of good management practices for wind erosion control. Similarly, if global scale and international transport of PM from overseas dust storms, which is coming from unprotected rural landscapes in other countries, proves to be a significant contributor to air pollution in the U. S. then this categorical exemption of agricultural sources here may adversely affect getting cooperation to mitigate these remote sources.

There may also be other factors because the swarms of expected exceedances at monitoring sites in areas such as Kennewick would overwhelm the current Natural Events Policy (NEP). Multiple NEP documentation submissions would result. For Kennewick these exceedances and NEP documentations would be clustered in March and September but the lower concentration threshold for NAAQS exceedances will also increase the number observed at other times of the year. Estimated frequency on average could approach once per month. Of course, the exemption of windblown dust from applicability of the proposed $PM_{10-2.5}$ NAAQS would eliminate having to deal with the current NEP requirements for windblown dust.

In addition to the NAAQS itself, there are two other aspects of the revised NAAQS package, which are a revised ambient air monitoring strategy and a proposed overhaul of the exceptional event and natural events policies that will be captured in rule form. An exceptional and natural events rule will cast the approach to these situations in concrete. As of this writing the proposed monitoring rule is published and the exceptional/natural events rule is pending. Therefore, how this pending rule will interact with the NAAQS and monitoring pieces cannot be evaluated.

The intent of the monitoring strategy for $PM_{10-2.5}$ is to concentrate the effort on urban-generated particles that will capture dust from construction sites, re-entrained from paved roads, and any direct emissions of $PM_{10-2.5}$ from industrial sources. There are five criteria for siting of FRM monitors for $PM_{10-2.5}$ as are follows:

1) The site must be in a U.S. Census Bureau-defined urbanized area that has a population of at least 100,000 people, which is intended to measure an ambient mixture of $PM_{10-2.5}$ dominated by PM generated from re-suspended road dust from high-density traffic on paved roads, industrial sources, and construction sources.
2) The site must meet a minimum density threshold of 500 persons per square mile for the Census block group containing the monitor, which is intended to minimize the ambient impact from rural dust, agriculture, or mining.
3) The monitor must be population oriented, which is intended to locate sites in residential areas, recreational areas, industrial areas, or other areas where a substantial number of people may spend a significant fraction of their day.
4) A monitoring site must not be adjacent to a large emissions source or in an area affected by a large source, which would make the $PM_{10-2.5}$ NAAQS more community-oriented with the appropriate degree of stringency. EPA intends the $PM_{10-2.5}$ NAAQS to have the same stringency as the current PM_{10} NAAQS, which is reflected in the fact that all or most of the current PM_{10} monitoring sites are not adjacent to large emission sources.
5) A site-specific assessment must show that the ambient mix of $PM_{10-2.5}$ would be dominated by PM generated from re-suspended dust from high-density traffic on paved roads, industrial sources, and construction sources. The intention is also that ambient mix at the monitoring site would <u>not</u> be dominated by PM generated from rural windblown dust and soils, other agricultural sources, or mining sources.

These criteria are problematic for the Kennewick monitoring site because, while it meets some of these requirements, avoiding impact from agricultural dust is not possible. The major source of windblown dust at Kennewick is directly upwind of the urban area and no place could be found that simultaneously satisfies all of these criteria. Despite not meeting all these criteria, it is likely that an urban area the size of

Kennewick including the near-by cities of Richland, Pasco, and West Richland will qualify for official federally approved and certified monitoring for purposes of compliance with of the $PM_{10-2.5}$ NAAQS. In the foreseeable future, the combined population of this quad-cities area will approach 250,000. Furthermore, there are even smaller urban areas in the arid western region of the country that are heavily impacted by airborne PM. This brings up environmental justice issues with regard to whether people in these smaller urban need protection of their ambient air.

A corollary problem for the Kennewick monitor results from the probable inability to meet the criterion of avoiding the influence of rural windblown dust while simultaneously capturing the construction and other urban dust sources. Separating or allocating the measured dust from these multiple sources and deducting the overwhelmingly large component coming from the windblown agricultural dust presents a challenging technical problem. It is not at all clear if such methodology exists and if it does exist is it economically and technically feasible to use it?

The emphasis on the concept that agricultural $PM_{10-2.5}$ is solely associated with dust emitted from agricultural fields also potentially ignores the fact that there is also this size fraction in smoke from vegetative burning. The many potential harmful compounds that are products of combustion vegetation as well as the fundamentally different composition of PM from combustion raises more questions about a blanket exemption of $PM_{10-2.5}$ from agricultural sources that characterizes this PM as only from crustal sources. Agricultural burning could also be a source of $PM_{10-2.5}$?

Other locations in the arid west may have situations similar to that described in this paper but attempting to address other areas was beyond the scope of this paper. This paper should be considered as a case study and hopefully there are some lessons, commonalities, and principles that could be applicable in similar situations. The uncertainty leads to many questions.

References

Proposed Rule Changes in National Ambient Air Quality Standards for Particulate Matter. Environmental Protection Agency. 2006. 40 CFR Part 50 National Ambient Air Quality Standards for Particulate Matter; Proposed Rule. *Federal Register* 71(10) Tuesday, January 17, 2006:2620-2708.

Environmental Protection Agency. 2006. 40 CFR Parts 53 and 58 Revisions to Ambient Air Monitoring Regulations; Proposed Rule. *Federal Register* 71(10) Tuesday, January 17, 2006:2710-2808.

Documents on EPA Natural Events Policy. Environmental Protection Agency June 6, 1996 FACT SHEET EPA'S NATURAL EVENTS POLICY FOR PARTICULATE MATTER TODAY
URL: http://www.epa.gov/ttncaaa1/t1/fact_sheets/nefact.pdf (Accessed 15 Feb 2006)

Washington Department of Ecology Air Program. Search for “natural events” for various documents on specific windblown dust events documented under the EPA Natural Events Policy.
http://www.ecy.wa.gov/programs/air/airhome.html